ADB

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People's Republic of China: Pilot Implementation of the Drought Management Strategy

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For Ministry of Water Resources

Asian Development Bank

Final Report

TA8185: Pilot Implementation of the Drought Management Strategy

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Abbreviations

ADB	Asian Development Bank
BP	Basin Plan
CDTA	Capacity Development Technical Assistance
DFID	Department for International Development (UK)
DID	Drought Information Dissemination Team
DMI	Drought Management Implementing and Drought Damage Assessment Team
DMF	Design and Monitoring Framework
DMP	Drought Management Plan
DRA	Drought Risk Assessment
DRM	Drought Risk Management
DRR	Drought Relief Regulation (2009)
DSG	Drought Service Group
DST	Drought Specialist Team
DWR	Department of Water Resources, Province Level
EA	Executing Agency
FCDRH	Flood Control and Drought Relief Headquarters (various levels)
GEF	Global Environment Fund
IA	Implementing Agency
IWRM	Integrated Water Resources Management
O&M	Operation and Maintenance
OFWM	On-farm Water Management
M&E	Monitoring and Evaluation
MoA	Memorandum of Agreement
MoU	Memorandum of Understanding
MWR	Ministry of Water Resources
NCC	National Climate Center
POM	Program of Measures (Spain)
PRC	People’s Republic of China
RRP	Report and Recommendations for the President
SFCDRH	State Flood Control and Drought Relief Headquarters
SPI	Standardized Precipitation Index
TA	Technical Assistance
TAO	TA Management Office
WAB	Water Affairs Bureau (local government MWR offices)
WAP	Water Abstraction Permit
WB	World Bank
WFP	World Food Program
WMS	Water Management Station
WRD	Water Resources Department
WRDMAP	Water Resources Demand Management Assistance Project
WSC	Water Supply Company

Executive Summary

The Project

The ADB Technical Assistance Project (TA 8185-PRC: Pilot Implementation of the Drought Management Strategy) is an important project to maintain the momentum of helping the Ministry of Water Resources (MWR) and related provincial and local government agencies move toward managing potential droughts proactively through a risk-based approach. Although many drought-management plans, guidelines, rules, and regulations have been prepared in the past, these have mainly been drought-relief actions and are generally passive responses to droughts, after they have already occurred. China has also focused on supply-side water infrastructure development, but such structural measures cannot meet all requirements for drought management. Other measures such as drought monitoring, forecasting and warning, and demand management including enhanced water conservation remain to be fully explored and implemented. Drought risk management (DRM) can be defined as "*the systematic process of using administrative directives, organizations and operational skills and capacities to implement strategies, policies and measures for improved coping capacities in order to lessen, i.e., prevent, mitigate and prepare for, the adverse impacts of drought and the possibility of disaster.*" [UNISDR, 2009]: DRM is a key component of the move in China towards integrated water resource management (IWRM)

The project was designed to strengthen the capacity of the State and Provincial Flood Control and Drought Relief Headquarters (FCDRHs) in three pilot provinces, including:

i. review of historic and current activities for managing drought risk and water saving,
ii. assess capacity of relevant staff in drought risk management and related issues;
iii. assess the awareness and enthusiasm of water users for water saving;
iv. prepare an institutional capacity building and public awareness program
v. establish data sharing system and protocol between different agencies and inter-agency cooperation
vi. build on the 2011 outputs from TA7261:Strategy for Drought Management to prepare pilot drought management plans, and
vii. assist with study tours, workshops and disseminating outputs of this project.

Institutional Structure and Capacity

The Flood Control and Drought Relief Headquarters (FCDRH) at National, Provincial, Municipality and County levels are the key organizations for drought management although many other organizations are involved. During flood and drought emergencies, the FCDRHs command operations and emergency responses, while the Civil Affairs Bureaus manage post-disaster recovery. Coordination between organizations is relatively good during an emergency but there is little coordination or data-sharing before droughts occur which constrains the introduction of DRM.

A survey was undertaken by the TA team in the three pilot provinces to gauge the level of knowledge and gaps in capacity, and found that:

- Personnel engaged in drought management have insufficient understanding of DRM.
- Knowledge is better at provincial than municipal or county level.
- Those in relatively dry areas are more aware of DRM than those in wetter areas
- China is in a transition phase from emergency response to risk management.

Although staff capacity needs to be strengthened, this must take account of other constraints:

- The lack of specific laws and regulations related to drought management in most areas.
- Incomplete or non-existent technical standards for monitoring, assessment and early warning.
- Drought management staff numbers are not sufficient, especially at county level.
- The lack of drought monitoring and early warning methods.
- Weak cooperation between agencies, especially for sharing access to the hydrological, meteorological and agricultural information.
- Lack of funding for drought management activities before drought occurs, which is also overlapped with the role of water resources department in the IWRM and makes the inter-agency cooperation and collaboration more significant.

These findings were confirmed in more detail in provincial workshops held in each province and it is apparent that many aspects need to be strengthened in China in order to meet the needs of drought risk management.

Water Uses and Water User Survey

The three pilot provinces have each initiated work on establishing a water savings society, including two national pilot projects, and good progress is reported in these areas.

Water user surveys, however, show that there are many constraints to water-saving. These vary between sectors, but in all cases a major constraint for installing water saving equipment is that the cost is too high. There are inadequate policies for water saving in all sectors, economic incentives are weak and there is also believed to be a widespread lack of public awareness.

In additional to save total water abstraction, there is potential to save water when a drought is forthcoming, to build up the strengthened temporary drought resilience and reduce drought impacts. The temporary water abstraction reduction and reallocation will require further public awareness raising program and the enhanced management and enforcement of the water abstraction permitting system in China.

Prototype Drought Database

Liaoning has set up an advanced drought database, under the control of the hydrology bureau within the water resources department, mainly covering hydrological data, with around 1300 monitoring stations. Based on which, the TA established an integrated model drought database in Liaoning Province and made recommendations for how to establish similar databases in Sichuan and Gansu provinces.

Some of the general conclusions are as follows:

- In Sichuan, where no data are being collected/stored in a database at provincial level. National Climate Center (NCC) daily meteorological drought data could be used.
- In Gansu, situation is similar to Sichuan but some drought relief data are collected by other departments during crises. Agreements to share data need to be developed.
- Liaoning province has a dedicated drought database that has been improved based on research and international best practice for the model integrated drought database.
- The integration of NCC meteorological data into the prototype Liaoning drought database shows potential promise and has been further investigated, but is not yet put into practice.

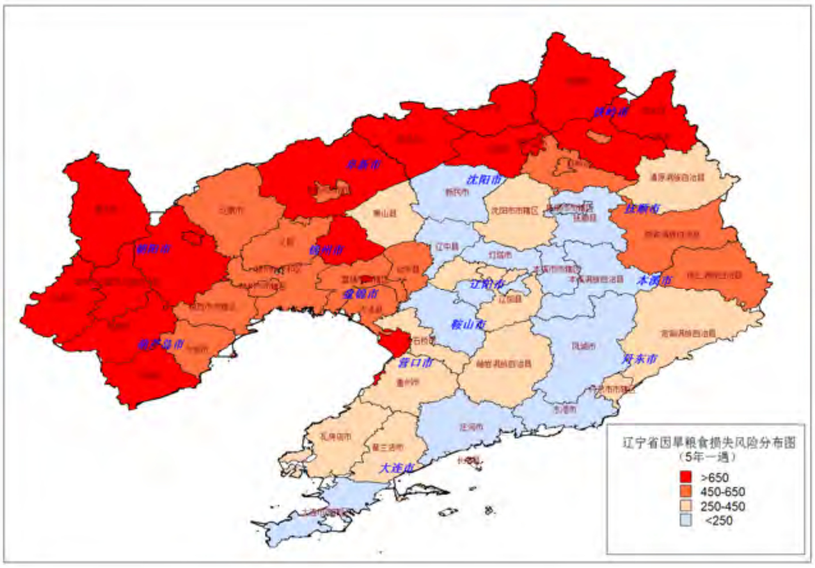
The integrated drought database developed by the TA is intended to be used for early warning of potential or actual drought conditions so that this can be informed to local jurisdictions. In the interim period until local drought management plans are developed and capacity improved, the provincial drought management plan may be the key guiding document for these triggered actions, using the database. The TA demonstrated the establishment of the integrated drought database but significant additional work would be required to make the database fully operational. Besides the data sharing issues outlined above, a decision support framework using computer programs would simplified the calculation of daily drought indices, results evaluation and ways to report results. If the database is functioning as a management tool to a comprehensive DMP, then the specific triggered risk reduction and mitigation methods must be identified and be ready to implement.

Drought Risk Mapping

Based on a review of current efforts at vulnerability assessments and drought risk mapping in China, the TA team has prepared a framework for some basic drought risk maps for the three pilot provinces while recognizing that more work is required to develop more sophisticated maps.

Drought risk maps were prepared in all three pilot provinces as shown in the drought management plans prepared for the provinces. One drought mapping for integrated agriculture drought risk is shown in Figure S.1, taking Liaoning as an example.

Figure S.1: Agricultural Drought Risk Map for Liaoning Province



Proposed Drought Forecasting System

The TA team assessed the current drought forecasting systems in place in the three pilot provinces as well as international forecasting systems. The "Standard of Classification for Drought Severity SL424-2008," provides grading criteria, indicators and classifications.

Although the daily work of the provinces does not include drought prediction or a rigorous early warning system, officials use an informal process, and research in this project can serve as important reference material for their work. Thus, the provinces first need to be introduced to early warning drought prediction research, and then begin to implement provincial drought early warning system and startup programs. The most appropriate indicators are:

- **SPI index -** internationally widely recognized for drought monitoring and early warning
- **Runoff anomaly index** - which reflect whether water resources are abundant or deficient.
- **Reservoir level anomaly index** - reservoirs are generally regulating and important for water supply during drought.

Relative soil moisture will also be important in the future when the national program to improve the soil moisture monitoring network has been implemented. It is closely related with crop growth and is considered the most accurate analysis indicator, which is more applicable for short-term drought early warning.

Proposed Decision Making for Triggering Actions

A tiered approach of decision making was proposed by the TA, where the drought management offices at provincial level will inform lower level offices about the abnormal being monitored and the decision of moving into pre-drought and actual drought stages would be made at the lower level, as well as triggering actions. This will coupled with the development of locally appropriate indicators to supplement the provincial indicators and to reflect local knowledge. The local database and technical strength are important for enabling this.

As noted, many of the local indicators can be found and used directly from SL424-2008, but complementary triggered risk reduction and mitigation measures are required. Depending on the severity of the potential drought, additional triggers for re-allocation of water abstractions may be considered with the Water Affairs Bureau based on the drought risk assessments and triggers outlined in the local DMPs. Although there appears to be somewhat comprehensive reporting during Normal operations, little is actually done with this information unless the drought begins to cause damage and an actual drought is declared (Level IV moving up to Level I). Given this background, the TA is not simply proposing improvements to an existing decision support framework for drought relief but is in fact proposing a completely new way of doing business with drought risk management activities at all stages of the drought cycle (Normal, Pre-Drought, Drought, and Post-Drought).

Institutional and Capacity Development Program

There are many institutional and capacity constraints for implementing DRM. A capacity-building programme is needed and has been planned on the basis of surveys in pilot provinces:

- There is weak capacity, especially at low levels. Most training has been related to general aspects of water management, with little detailed attention to droughts and little capacity even to implement current guidelines let alone DRM;
- There are many other institutional and other constraints, but even if these are relieved, the desired impact will not be achieved until capacity is raised;
- Funding for capacity-building is critical, as training is under-resourced. Additional training is needed and yet this will have to be funded from existing budgets;
- Implementation of guidelines and DMPs will not be possible until these are resolved.

Provincial workshops have had a significant impact on high level understanding of some key aspects of drought risk management, and the changes needed to implement it. An international study tour to Spain and Portugal led to an understanding of international approaches to solving key problems: water-savings and water infrastructure can reduce the risk of drought occurring, but there is a need for drought monitoring, data sharing; drought management plans and better public understanding of risk; drought insurance and potential reallocation of supplies to high values uses (with compensation) are valuable.

A capacity building programme, for state, provincial, city and county-level FCDRHs has been planned and designed to address the key issues identified in the capacity needs assessment. Provincial Workshops were a critical part of the TA capacity building. Three provincial workshops have been conducted in all three pilot provinces during the implementation of this TA.

The future capacity development program aims to:

- Further improve the management competence of drought management staff at all levels
- Enhance the drought management capacity of FCDRH at different levels
- Increase the drought **risk** management skills and knowledge of staff
- Ensure drought management staff fully understand drought monitoring and triggering, and drought management regulations, policies, and related technical standards

It is anticipated that a rolling program of 10 days training for around 600 people in the three provinces will be required. In order to avoid disruption to daily work, it should be undertaken in two day blocks. In additional to initiate separate training courses, existing training programs to water professionals can also be used to add in some section or slides to present drought management issues. Incorporating drought risk management courses into the online learning system would be a good start to raise the issue.

Public Education and Awareness Program Plan

There is a need to improve the awareness of water-saving (in general and during drought conditions) and of droughts in the whole society, recognizing the different groups of people with different water use behaviour, and different water-saving methods.

World Water Day and China Water Week campaigns provide some opportunities to enhance water saving public education, but more detailed programs are also needed:

- Farmers: through radio and television programs, focusing agricultural water -saving knowledge and technology, combined with distribution of an agricultural water saving manual.
- Children and students: primary and secondary water-related education is essential, from a long-term perspective, to ensure future public awareness of water conservation.
- Urban residents: Water saving education through newspaper articles.

The program needs both regulatory and financial support. Although the benefits are long lasting from both social and environmental perspectives, this is not a profitable activity in the short term. Therefore, the government must issue related policies and develop financial support means to guarantee the implementation of water saving propaganda and educations in order to improve the public awareness of water saving gradually and better react to the drought events.

The Water Education Centre within the MWR would be the key organisation to work with on the public awareness raising.

Prototype Drought Management Plans (DMPs)

Existing drought relief plans only apply to the actual Drought scenario although the proactive monitoring and early warning is required by the regulations. The project DMPs include approaches during the Normal and Pre-Drought scenarios to reduce risks and magnitudes of future damages. The provincial DMP has been developed under a presumed “future tiering” of drought management responsibilities (see Figure S-2). The lowest level would be sectorial DMPs of the water companies, industries and agricultural interests. Their drought management activities are coordinated by the county level and municipal level drought plans, which are in turn managed and coordinated by the provincial plans, and the entire process has had guidance and oversight from the national level drought management process.

There are also a variety of potential constraints to implementing these, including:

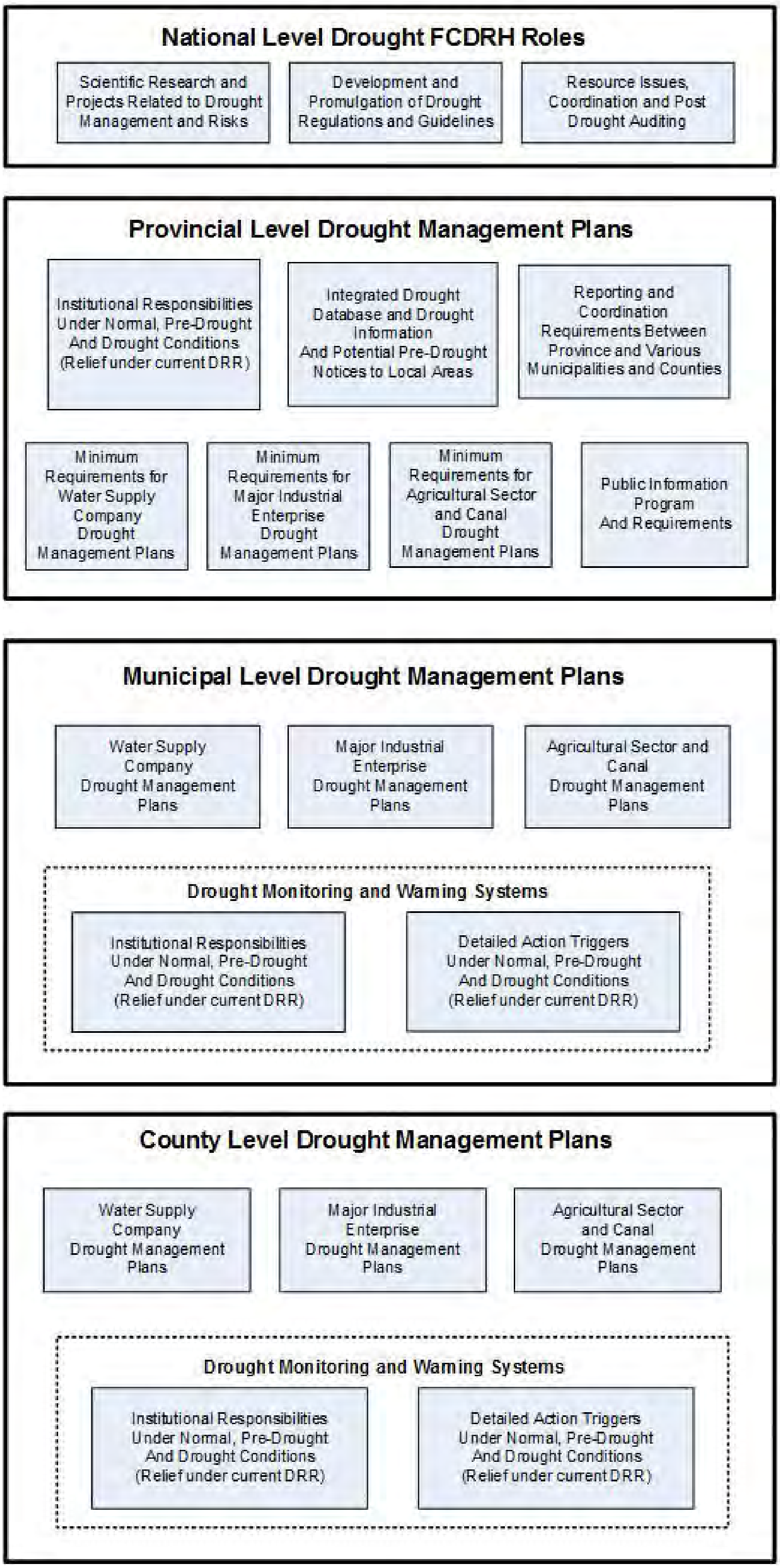
- Drought funding and budgets are tied to drought relief activities and there is insufficient budget and staff to perform drought management activities in Normal and Pre-Drought time periods.
- Collaboration and cooperation between agencies remains problematic, especially when there is not a specific crisis.
- Additional training will be needed for water management staff at municipal and county levels below the provincial government to manage the DMPs adequately.
- It will take time for municipal and county level FCDRHs to develop and implement adequate DMPs so there must be a planned phasing to share of responsibilities from the provincial DMP with local jurisdictions as the local plans are developed.
- Municipality and county officials will require time to work with the various sector water management officials (urban water supply, industry, agriculture) on their sectorial drought management plans so that they can be connected to the municipal/county level DMPs.

Based on this review, the TA team has proposed a provincial DMP prototype document (using international examples and best practice documents) which have been used by the team to prepare actual drought management plans for the three pilot provinces, while keeping the basic configuration of the drought relief plans.

The TA team has also assembled a prototype local DMP using a template from the United States as well as lessons learned from the WRDMAP project, including the municipal drought management plan produced for Chaoyang Municipality in Liaoning Province during the project.

The TA team proposes to overlay a drought risk planning approach on the front end of the existing drought risk planning protocols, not propose immediate replacement of these existing systems. As the drought risk management processes mature, some of the triggered actions in these plans will also focus on risk reduction, but this is a long term proposition. A Guidelines document has been produced to illustrate how to prepare the DMP for different levels.

Figure S-2: Tiered structure for drought management proposed by this TA



- Develop research, regulations and guidelines or drought risk reduction and management
- Coordinate planning and response levels on major multi-province or widespread concerns
- Determine resource needs with PRC State Council

- Send provincial meteorological information/ indices
- Review and coordinate area monitoring, triggers, and risk reduction and mitigation measures found in DMPs of all municipalities and counties
- Coordinate and report activities to province and public, as well as SFCDRH

- Receive provincial meteorological information/ indices
- Coordinate area monitoring, triggers, and risk reduction and mitigation measures found in detailed DMPs of major water user groups
- Coordinate and report activities to province and public
- Manage risk reduction activities for major water user groups under municipal level management and control.
- Coordinate and oversee work of county level DMPs under their jurisdiction.

- Receive provincial meteorological information/ indices
- Coordinate area monitoring, triggers, and risk reduction and mitigation measures found in detailed DMPs of major water user groups
- Coordinate and report activities to province and public
- Manage risk reduction activities for smaller water user groups under county level management and control.

Recommendations

The TA Draft Final Report contains a series of recommendations for moving drought risk management forward in China. The following sections summarize some of these issues.

Moving China from drought relief to drought risk management

Although the concept and importance of drought risk management is understood to some degree at the national level in China, it has not been fully implemented because of constraints embedded in current institutional structures and operational mechanisms, as well as because of limited human and financial resources. To accomplish such a move requires a re-evaluation of the drought management institutional structure and operational mechanisms – including financial and human resources. Unlike drought relief which can be a top-down activity, DRM involves all levels of government and society The FCDRH and MWR will then need to recommend to the State Council to make appropriate policies and instructions. Initially Provincial FCDRHs will drive DRM on a command and control basis, but Municipality and County FCDRHs will need to develop their capacity to prepare DMPs and implement DRM locally as soon as possible under the guidance of the Provincial FCDRH.

Improving data-sharing and collaboration on drought

Institutional reforming and restructuring would complement the efforts in trans-agency cooperation in promoting data sharing. However, the incentive for stimulating data-sharing needs to be created in FCDRHs and water resources departments.

Proactive drought risk management including drought monitoring and prediction, and early action on risk reduction and mitigation measures all require a much more aggressive and regular program of data sharing prior to actual emergency situations. There are two areas of cooperation urgently needed to facilitate drought risk management:

- Provincial Level Integrated Drought Database
- Local Municipal and County Level DMPs

Improving technical aspects of drought management planning

It is recommended that the national government promote research on drought forecasting and early warning, and then systematically emphasize methods and techniques that are found to be both scientifically sound and practical. The production of drought risk maps and vulnerability assessments should be undertaken in all locations using readily available data, and expanded with more scientific systems (such as IWHR Liaoning research protocols) as time allows.

New policies and regulatory needs for drought risk management

Drought relief regulations have been issued but need to be upgraded to drought management law. Implementation of the regulations needs to be strengthened, and this will depend on issuance of new provincial regulations to incorporate the requirements of DRM.

The development of related additional technical standards should be initiated. Due to the complexity of identifying features affecting drought and the government pays less attention on the unstructured drought impacts, few studies have been funded in the past. The investment in theoretical studies and related codes and standards preparation is not sufficient.

Increasing public involvement in drought risk management activities
The drought risk management approach involves all levels of society in the development and implementation of the DMPs and related risk reduction and mitigation measures. As such, awareness of drought issues is critical for all stakeholders and the general public. Drought management implies the involvement of all stakeholders in the process in a completely different manner than top-down drought relief activities.

Use of drought insurance and potential drought banking by urban users
The TA project has identified the potential of drought insurance and drought banking as having important roles in the future of drought management. There is an urgent need to develop a drought insurance system according to the characteristics of drought risk and based on insurance theory to support drought disaster prevention and mitigation, to **share the risk of disaster loss** by the insured person, insurance company and the government.

The principle of “higher value water use sectors (urban and industrial) could pay into a fund to compensate lower value use (some agriculture types) to reallocate water during drought as a risk reduction measure” is very reasonable and could be applied to China. In addition, the drought management departments on different levels could accept this, but it is not effectively implemented in PRC. Such a water allocation system during droughts also implies a high degree of technical and management competency in the water permitting system and the issuance and management of water abstraction permits. In some cases, the **water abstraction permitting system** will need significant strengthening in order to apply such approaches.

Conclusion

The TA project is complete and all expected outputs have been achieved. In summary, the TA project successfully developed and organized the necessary tools and “building blocks” necessary to move forward with DRM in China, but there are structural issues related to funding and management direction that will likely delay any move toward full implementation of the concepts. The use of the TA products can go a long way to raise awareness of national and provincial officials on the need to move into this direction under follow-up training programs.

1 Introduction

1.1 Pilot Implementation of the Drought Management Strategy

1.1.1 Overview

Like many growing and developing countries, China is facing increasing pressure on water resources from continued economic development, increasing population, urbanization, environmental degradation and climate change impacts. Water scarcity as an overall long-term condition is related to shorter-term drought conditions and can lead to conflict and competition between water users and relatively small changes in rainfall can have an increasingly large impact on supply availability. As can be expected, the need to maintain food security and social stability is very important in China and increasing drought or water scarcity can negatively affect this stability.

Drought has been a recurring feature of the climate in China; severe droughts with major social impacts have occurred throughout recorded history. These have led to significant loss of agricultural productivity, loss of livestock, and in some cases loss of human life. Climate change is likely to exacerbate and increase these drought conditions.

From 1991 to 2011, droughts in China inflicted water shortages on an annual average of 27.8 million people. From 2006 to 2011, droughts caused RMB 50 -150 billion per year damage in direct economic losses, amounting to 0.17% - 0.46% of the gross domestic product. From 1950 to 2011, drought annually affected an average of 214,700 square kilometers of farmland, reducing grain production by an average of 16.2 million tons (0.75 Mt/ha).

About 60.7 million people experienced drinking water shortages during a severe drought in 2000 and 2001 that affected more than 620 cities and towns in 18 provinces, driving water supplies to very low levels, especially in large cities. The 2-year drought event reduced grain production by 114.7 million tons, raising concerns about food security. In 2006, China again suffered a severe drought, inflicting water shortages to 35.8 million people and reducing grain production by 41.7 million tons. From 2009 to 2010, an unusually severe drought spread across an area of south-western China as large as Western Europe and forced 20 million people to line up for drinking water.

China has invested an enormous effort into supply-side development of water capture, storage and management systems to improve system reliability, but droughts continue to be problematic, particularly the intensity of widespread multi-year drought events. The current legal structure and management efforts in China manages drought as part of an emergency and disaster relief process that is adequate for short term emergency needs but is less suited to coping with multi-year widespread drought or predicting and reducing impacts of droughts prior to their occurrence.

Water scarcity is causing conflict and competition between water users, and relatively small changes in rainfall are having increasing large impacts on availability of water. Drought-relief plans, guidelines, rules and regulations, and emergency plans have been prepared by the national, provincial, and local governments. However, a major shortcoming of these measures has been that they are responses to crises caused by droughts after they have already occurred, despite some pre-planning for drought relief (such as emergency supplies, stockpiling of relief materials, etc.)

ADB provided the Ministry of Water Resources (MWR) with a first phase technical assistance (TA) project for development of the Strategy for Drought Management. This initial TA, which ended in 2011, produced a national strategic framework for drought management and an action plan for implementing integrated drought risk management. A knowledge product on drought risk management incorporating lessons learned from the TA was published. Following these TA recommendations, the MWR prepared a national anti-drought plan that included a drought management strategy and an action plan.

Managing drought risk is the principle of new focus on full-time drought risk management. The key 2011 recommendation was to shift from reactive emergency response to proactive risk management, although the institutional constraints to achieving such proactive drought risk management may not have been sufficiently explored. To achieve this, the 2011 TA recommended that:

- Flood control and drought relief headquarters (FCDRHs) take a leading role in proactive drought risk management, and
- FCDRHs undergo institutional and organizational reform and capacity development.

The FCDRHs are the main organisation for drought management in China, although they are based with MWR offices who are focused on data collection and synthesis. During emergencies, the FCDRHs command operations, and emergency responses. The State FCDRH is located in the MWR. There are also river basin FCDRHs located in river basin commissions, provincial FCDRHs in provincial departments of water resources (DWRs), and city and county FCDRHs in city or county bureaus of water resources. All FCDRHs are much less active when there is no actual drought or flood emergency and, although they work closely with other departments during emergencies, there is little cooperation at other times.

Following the recommendations of the 2011 Phase 1 TA, the government requested that ADB initiate a Phase 2 TA to pilot and develop tools for managing drought risk management; strengthen the capacity of officials involved in drought management; prepare a detailed and tailored plan to manage drought risk for pilot provinces; and prepare guidelines for implementing the national drought management strategy across China. Gansu, Liaoning, and Sichuan were selected as the pilot provinces, as they have been seriously affected by drought and offer a range of locations that allow scaling up the piloted and developed models and methodologies.

The current TA aligns with the Twelfth Five-Year Plan and ADB’s country partnership strategy to improve livelihoods and promote inclusive and environmentally sustainable growth. The TA also aligns with the priorities of ADB’s water policy by promoting a national focus on water sector reform and fostering the integrated management of water resources. It is consistent with the key pillar of ADB’s Operational Plan for Sustainable Food Security in Asia and Pacific in improving the resilience of the agriculture and rural sectors against the impacts of climate change and associated climate variability and food price volatility.

1.1.2 The Pilot Provinces

Figure 1.1 shows China and the three pilot provinces. Figure 1.2 to Figure 1.4 show the three pilot provinces maps in more detail. Figure 1.5 shows the existing organizational structure of the FCDRHs, which was revised slightly following a new report in May 2013. Table1.1 shows a comparison of the basic features of the three Pilot Provinces.

Figure 1.1: China and the Three Pilot Provinces

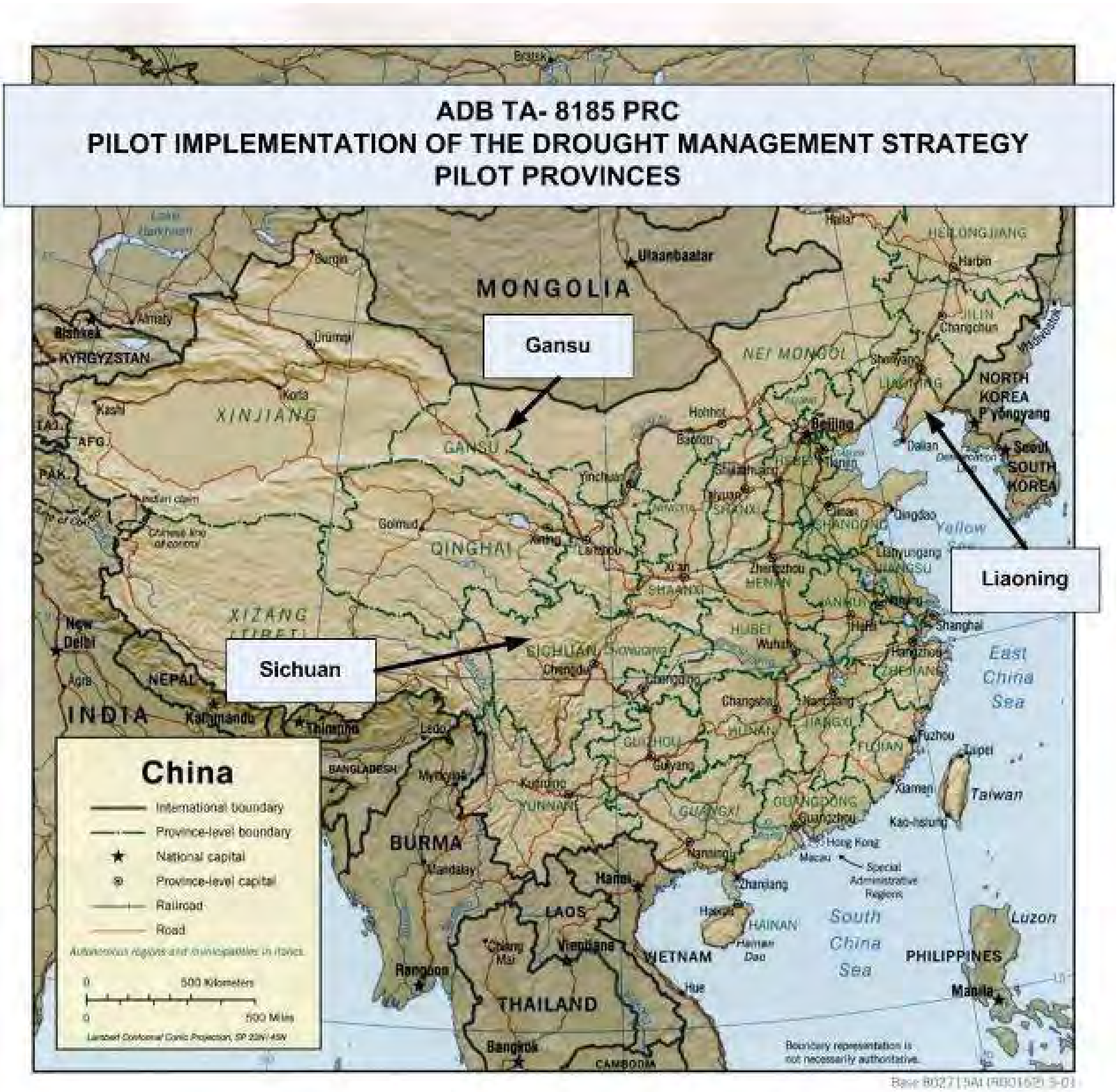


Figure 1.2: Liaoning Province

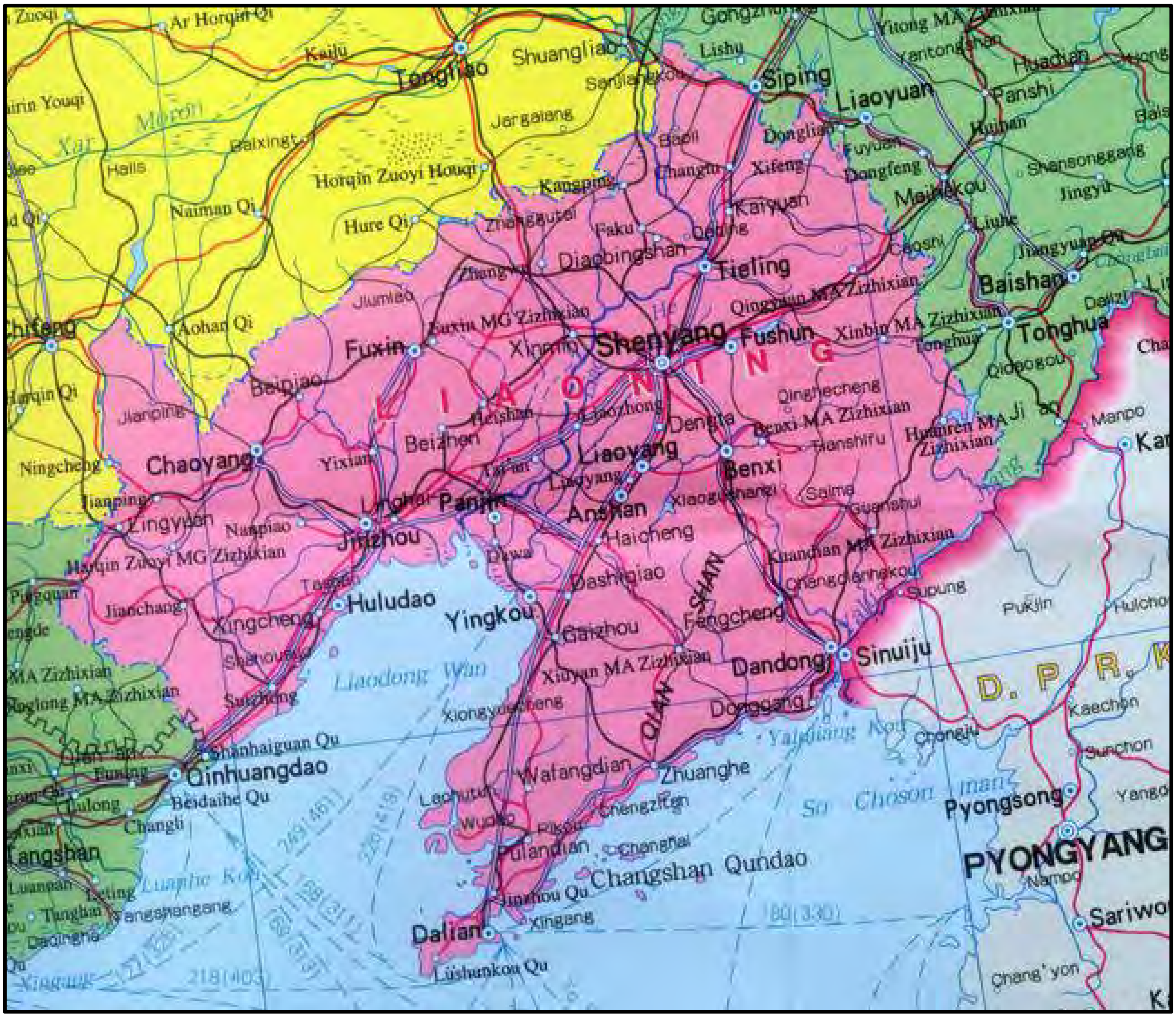


Figure 1.3: Sichuan Province

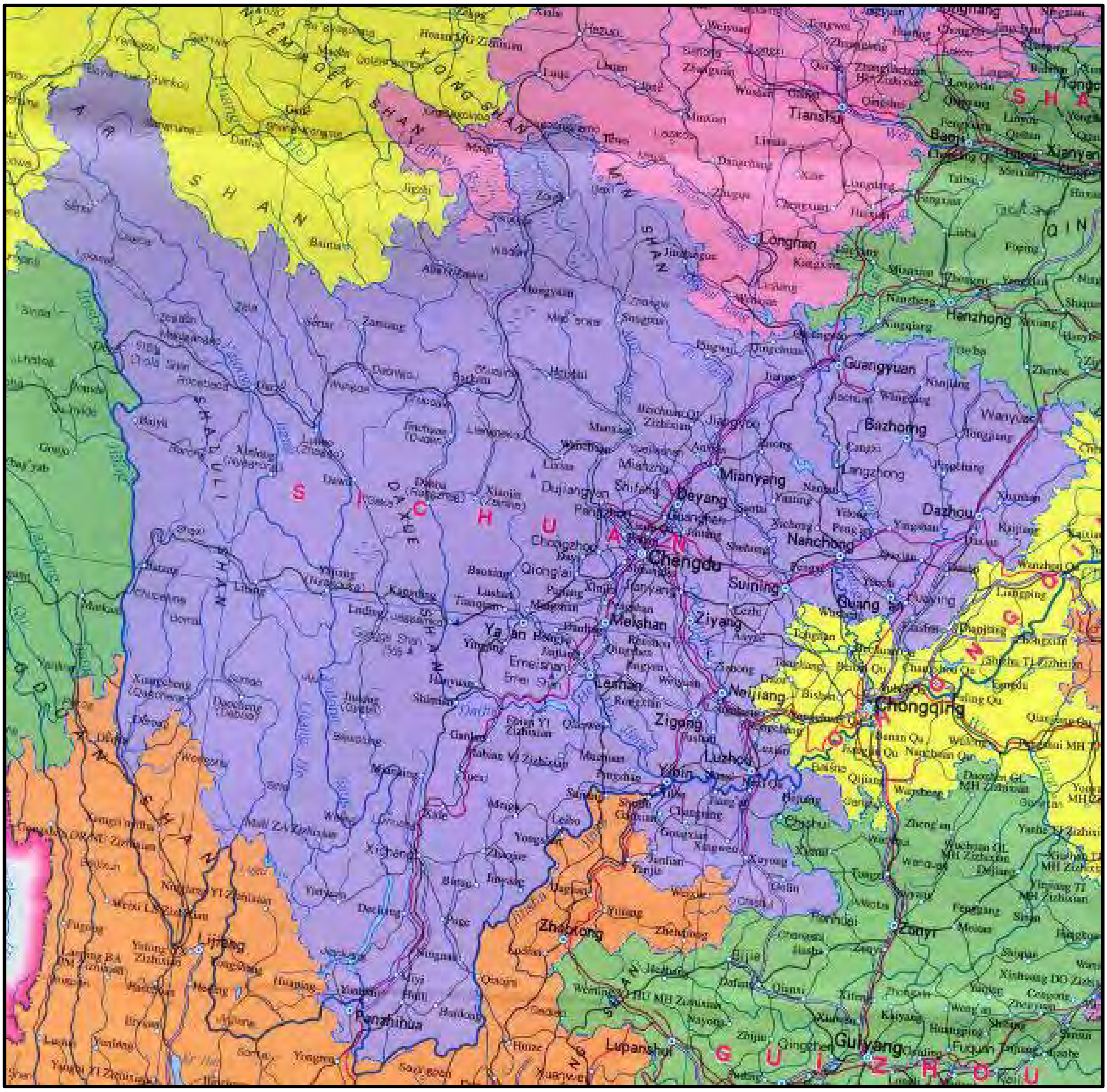


Figure 1.4: Gansu Province

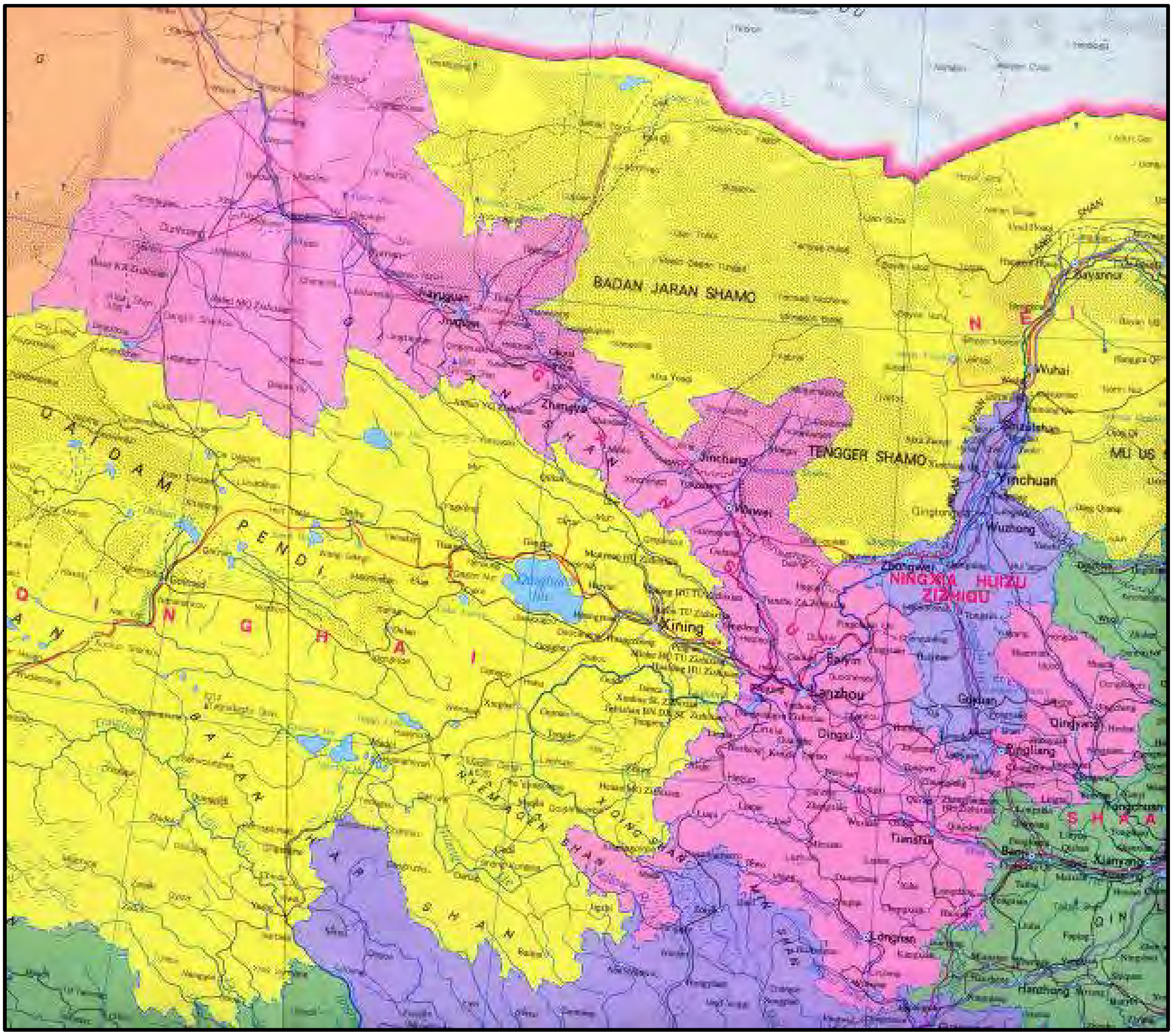


Figure 1.5: FCDRH Organisational Structure

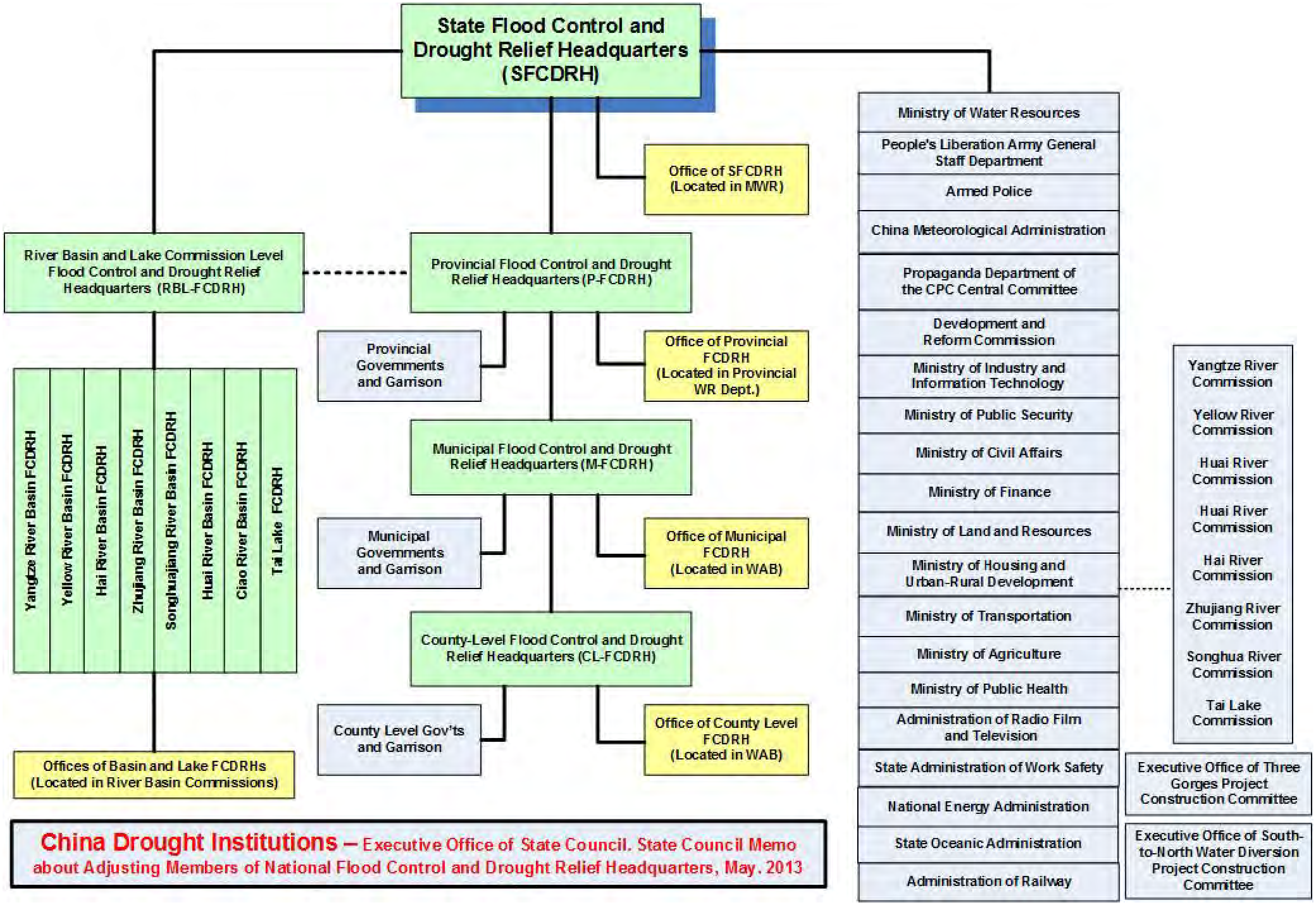
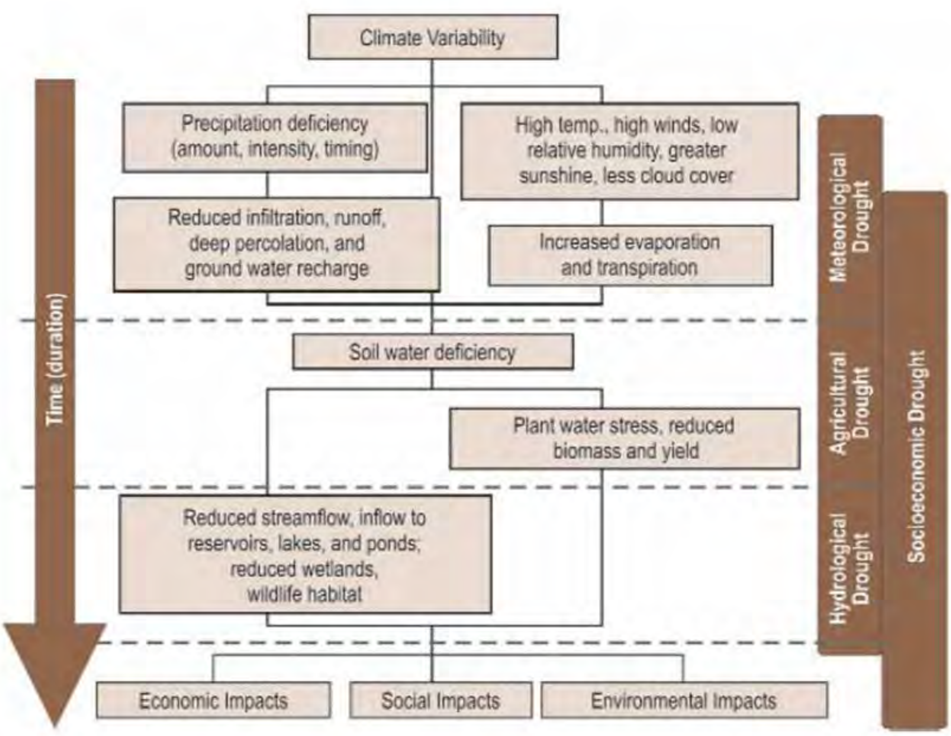


Table 1.1: Comparison of TA Pilot Provinces

Features	Liaoning Province	Gansu Province	Sichuan Province
Location in China	Northeast, bordering sea and North Korea	Northwest, landlocked with Gobi Desert to North.	Southwest, landlocked with Yangtze River to south
Area in km2	145,700	450,000	488,000
Population	43.75m (2010)	25.58m (2010)	87.26m (2007)
Elevations	0 to1,300m, with vast majority at lower levels in plain	500m to 1,000m with the vast majority of province near 1,000m	Above 4,000min mountains to 200-500m in plain. Vast majority of people in Sichuan plain.
Geography	The coastline is 2,178 km long - nearly 12 percent of China's total. The hilly regions in east Liaoning are the main area for forest. Adjoining the long, narrow coastal plains (called the Liaoxi Corridor) is the main road for Northeast China, linking with North China. Liao He Plain in Central Liaoning, as a part of the North eastern China Plain, and has sedimentary deposits.	3.53 million hectares of cultivated land or 0.14 hectare per capita, 16.64 million hectares of grassland, and 4.26 million hectares of forests with a standing timber reserve of 200 million m3. In addition, there are 1.0 million hectares of wasteland suitable for agriculture, 6.66 million hectares of wasteland suitable for forestation, and 4.76 million hectares of mountain slopes suitable for livestock breeding.	In China's western hinterland, the province covers most of the Sichuan Basin. It is surrounded by mountains and is situated in the southwest of China, embracing the eastern part of Qinghai-Tibet Plateau and the Sichuan Basin. The population consist of several different nationalities such as Han, Yi, Zang (Tibetan), Miao, Hui and Qiang. There are 32 cities, 3 minority nationality autonomous prefectures, and 120 counties.
Climate	Liaoning Province has a continental monsoon climate with distinct seasonal variations. It has an annual rainfall of 715 mm	Very dry with desertification annual average precipitation is 280 mm	Subtropical monsoon climate in the eastern basin; temperate or subtropical plateau climate in the western, while the southern part shows marked variation between mountains and valleys. Frost-free period in the basin is 280-330 days per year, but on the plateau is less than 90 days. The average annual precipitation is 500-1,200 mm, of which the basin has much larger share than the plateau.
Water Resources	There are 392 rivers of a total length of 160,000 km with a drainage area of 145,000 km2 in Liaoning Province. Liao He River, one of the seven longest rivers in China, is 512 km long and has a drainage area of 69,000 km2 in the province. The average runoff of rivers in Liaoning has reached 32.5 billion m3, or a 223 mm runoff depth. Total water resource is36billion m3.	Nine river systems in the Yellow, Yangtze, and inland river drainage basins with an annual discharge of 61.4 billion m3 and a combined hydropower potential of 17.24 million kW. Acute shortage of water resources, sparse vegetation, and serious water and soil loss. Large scale technical measures to bring water and soil loss under control. Effort also taken to improve ecological environment on Loess Plateau.	The reserves of hydropower resources in Sichuan come to 150 million kw, second only to Tibet, and the exploitable potential is over 100 million kw, more than any other area in China.
Economy and Industrial Sectors	Liaoning Province has a total forestry area of 4.185 million hectares. It is the home of Anshan, the "Steel Capital" of China. Also, chemicals, electric power, oil extraction and processing and sea-salt production. It is also China's leading apple producer and, its city Dalian is a nationally known fishery center. It produces many agricultural crops.	Nearly 3,000 deposits of 145 kinds of minerals have been found and the reserves of 94 kinds of minerals have been ascertained, including nickel, cobalt, platinum family elements, selenium, casting clay, finishing serpentine, and five other minerals. The proven reserves of coal are 8.92 billion tons, and those of petroleum, between 600 and 700 million tons.	Rice is the main gain crop of Sichuan and its output ranks first in China. The principal cash crops are rapeseed, citrus fruit, natural silk and tong oil. Sichuan's sugar cane, ramie, camphor, varnish, wax trees, tea and bamboo are also important. Cattle production is high. Nature reserves are set up in many places, as there is high number of unique flora and fauna in mountains.

1.1.3 Drought Risk Management Conceptual Framework

It is important to grasp the theory behind drought risk management, as recommended for adoption by the 2011 TA Project. Drought should not be viewed as merely a physical phenomenon or natural event. Its impacts on society result from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand people place on water supply. Human beings often exacerbate the impact of drought. Recent droughts in both developing and developed countries and the resulting economic and environmental impacts and personal hardships have underscored the vulnerability of all societies to this “natural” hazard.



Source: National Drought Mitigation Centre, University of Nebraska-Lincoln, USA

Drought risk management can be defined as “*the systematic process of using administrative directives, organizations and operational skills and capacities to implement strategies, policies and measures for improved coping capacities in order to lessen, i.e., prevent, mitigate and prepare for, the adverse impacts of drought and the possibility of disaster.*” [UNISDR, 2009]

Vulnerability analysis provides a framework for identifying the social, economic, and environmental causes of drought impacts. It directs attention to the underlying causes of vulnerability rather than to its result, the negative impacts, which follow triggering events such as drought. Although drought is a natural hazard, society can reduce its vulnerability and therefore lessen the risks associated with drought episodes. In addition to drought planning at the state and national level, planning has also become more prevalent at the regional and local levels. These entities use information provided by scientists, and combine it with their

own knowledge and experience to produce a drought plan that meets their needs. Preparing for drought before it strikes will make them less vulnerable to it when it does eventually occur.

1.1.4 Components of Drought Risk Management

A new paradigm for drought management uses risk as the driving factor as follows:

Risk = Hazard (Natural Event) x Exposure x Vulnerability (Socio-economic Factors)

The hazard aspect of the risk could involve several factors including:

- Severity or magnitude
  - Intensity and Duration
- Frequency - probabilities
- Spatial extent
- Trends
  - Historical
  - Future projections
  - Impacts

The exposure represents the probability of drought occurring and the number of people and resources affected. It is sometimes shown as a factor of the hazard.

The vulnerability side of the equation involves a comprehensive review of socio-economic factors and requires the production of drought risk maps and vulnerability assessments. Drought risk is based on a combination of the frequency, severity, and spatial extent of drought (the physical nature of drought) and the degree to which a population or activity is vulnerable to the effects of drought. The degree of a region's vulnerability depends on the environmental and social characteristics of the region and is measured by their ability to anticipate, cope with, resist, and recover from drought. The following figure from the US National Drought Mitigation Center shows the relationship between risk management and crisis management:

1.1.5 Vulnerability Assessments

Society's vulnerability to drought is affected by (among other things) population growth and shifts, urbanization, demographic characteristics, technology, water use trends, government policy, social behavior, and environmental awareness. These factors are continually changing, and society's vulnerability to drought may rise or fall in response to these changes. For example, increasing and shifting populations put increasing pressure on water and other natural resources - more people need more water.

Although drought is a natural hazard, society can reduce its vulnerability and therefore lessen the risks associated with drought episodes. The impacts of drought, like those of other natural hazards, can be reduced through mitigation and preparedness (risk management). Planning ahead to mitigate drought gives

decision- makers the chance to relieve the most suffering at the least expense. Reacting to drought in "crisis mode" decreases self-reliance and increases dependence on government and donors.

People's vulnerability to drought is complex. Drought results in substantial effects in both developing and developed countries, but the characteristics of these effects differ considerably. The ability to cope with drought also varies considerably from country to country and from one region, community, or group to another. Therefore, a vulnerability profile, including analysis of vulnerability factors, is an invaluable tool in assessing local risk. The vulnerability profile is a cornerstone of drought risk reduction planning. "Vulnerability" consists of a variety of socio-economic factors such as:

- Population growth
- Population shifts
- Urbanization
- Technology
- Land use practices
- Environmental degradation
- Water use trends
- Government policies
- Environment awareness

The pilot province DMPs first employed drought risk analysis which is the study of potential effects on the drought-threatened areas based on likely drought probabilities and drought intensity. In general, when the intensity of meteorological droughts is greater, the frequency is higher, which means the greater hazard, the risk is also greater.

1.1.6 Drought Indices and Triggers

In principle, drought indices provide a measure of the difference between needed and available water resources and can be part of the "decision support systems" relating to drought. A local water company might use a drought index to trigger water use restrictions and to inform the public about the availability of water supplies. A river basin authority might use an index to inform about and coordinate the use of water throughout a basin. A province might use an index to measure the availability of water resources in entire province. At each of these levels indices can be used for reporting, research or management actions. Different users of indices will have different decision support requirements. In general, water managers need indices to measure climatic and hydrologic trends and fluctuations.

To water managers drought means problems in meeting demand. In that sense, drought means not having sufficient water to meet demands because supplies fall below expected levels. The "expected levels" are socio-economic because expectations can be adjusted. Due to this linkage with socio-economics for a drought index to be useful to management it must incorporate aspects of demand; that is, how adequate are supplies to meet demand? A key aspect of drought risk management is the setting of appropriate "triggers" for action based on monitoring of indices such as the application of pre-identified risk reduction and mitigation measures, including potential reallocation of available water supplies to higher value uses with compensation.

1.2 The Technical Assistance

1.2.1 Outputs

The Project outputs were determined in the ADB TA Report of October 2012[1] and were to prepare:

- Tools for managing drought risk developed by end of 2013
- A program for agencies on institutional and capacity development for managing drought risk and saving water prepared and implemented by end of 2014
- An educational and public awareness program for water users on saving water prepared by end 2014
- A plan for managing drought risk prepared for each of the three pilot provinces by end of 2014
- Guidelines for implementing drought risk management across China prepared by end of July 2014

In addition this final report provides an overview of the TA, including the main findings and recommendations.

1.2.2 The Project Team

The project team is largely unchanged from that described in the inception report, but some minor reallocation of inputs and responsibilities have been made to suit the needs of the project. The current arrangement is:

International:

- Lawrence Quinn (USA) - Drought Risk Management Specialist and Team Leader
- Marieke Nieuwaal (NL) - Water saving Specialist (April 2013 to April 2014)
- Simon Howarth (UK) – Water saving Specialist (May-August 2014, due to Marieke Nieuwaal maternity in mid-June)

National:

- Juan Lv (PRC) - Drought Risk Management Specialist and Deputy Team Leader
- Yan Sun (PRC) - Capacity Development Specialist
- Yan Wang (PRC) - Economic and Finance Specialist
- Yucheng Wu (PRC) - Water Saving Specialist
- Zhicheng Su (PRC) - Software Specialist

All inputs are intermittent over the implementation period of 18 months, and thus we have provided for a longer input by a national technical coordinator/project management assistant (Mia Yu and Zhang Yi) to ensure that activities are coordinated effectively and that close contact is maintained with the PPMO and CPMOs throughout the implementation period – including times when no specialist staff are present on the project.

[1] Technical Assistance Report, Project Number: 46085, Capacity Development Technical Assistance (CDTA), October 2012, People's Republic of China: Pilot Implementation of the Drought Management Strategy, (Co-financed by the Multi-Donor Trust Fund under the Water Financing Partnership Facility)

1.2.3 Summary of Project Activities

The following activities have been completed on the project:

- Institutional and water saving surveys have been completed in all three pilot provinces and the information has been analysed relative to impacts on other project activities, especially capacity building and public involvement programs.
- Prototype drought database for Liaoning Province has been developed. Socioeconomic data may be added to assist with risk mapping and vulnerability assessment. Recommendations have been made for how to improve databases in other two pilot provinces.
- A combined provincial level workshop was held in Gansu province on 5 September. There were approximately 30 people in attendance including representatives from Sichuan and Liaoning provinces.
- Workshops were held in Sichuan and Liaoning Provinces in March 2014 to present the draft drought management plans for the provinces. There were approximately 30 people in attendance including representatives from Sichuan and Liaoning provinces.
- A tiering of drought management planning levels and responsibilities was developed. A prototype municipal or county level drought management plan has been prepared and the model provincial DMP has been prepared for use in the pilot drought management plans with clear links to municipal and county level DMPs developed, as well as links to sectorial DMPs.
- A linked set of drought information indices at provincial level and drought warning systems at lower levels has been developed and tested.
- Proposed drought risk mapping systems for the three provinces have been developed.
- Drought risk management plans have been prepared for the three provinces.
- Capacity building and public involvement programs have been developed.
- Draft Drought Risk Management Guidelines have been prepared.

1.3 Report Structure

The Final Report highlights the work and findings of the TA project, with technical details of all project activities contained in the attached Appendices.

- Chapter 1 – introductory
- Chapter 2 – main activities and processes followed during the TA
- Chapter 3 – recommendations and conclusions for drought risk management
- Chapter 4 – lessons learned from the TA
- Chapter 5 – work plan and staff

The detailed findings are included in the pilot province drought management plans and the Drought Risk Management Guidelines, which are separate standalone reports as well as appendices to this final report. All project deliverables are being provided to MWR in Chinese with the exception of some Appendices which are only in English. The Liaoning provincial DMP was prepared in both English and Chinese while the Sichuan and Gansu DMPs are in Chinese only.

2 Main Components of the Project

2.1 Institutional Structure and Capacity

2.1.1 Regulatory Structure

National level regulations for drought mitigation include the "China Water Law", "China Drought Regulations" and the "China Water Pollution Prevention Law." At the provincial level, regulations are generally based on the national level or related to other local regulations, such as in the Liaoning Province "Groundwater Protection Ordinance," "Regulations Prohibiting Groundwater Extraction," "Water Metering Management Approach," and "Water Permits and Water Resources in Liaoning Province Fee Collection and Management Implementation Method" and so on.

In 2004, the Ministry of Water Resources proposed "two transformations on flood control and drought relief," i.e., shifting from flood control to flood management and changing from single drought relief to comprehensive drought relief. Comprehensive drought relief referred to expanding the scope and content of drought relief according to requirements of social and economic development. In the past, drought relief mainly served agriculture and rural economy.

Since 2000 and in response to the increasingly serious drought situation, the MWR strategically put forward agricultural drought relief in the comprehensive drought resistance plan. In 2008, MWR published the first Standard of Classification for Drought Severity, which was then enacted in 2009 as regulations on the drought resistance of the People's Republic of China. "National drought planning" was approved in 2011 by the state council. By 2020, the work content of the "national drought planning" is scheduled to be completed so that by that time drought engineering and non-engineering facilities will be greatly improved all over the country and drought mitigation ability will be enhanced.

In 2008, comprehensive "national drought planning" work was approved by the State Council and entered the implementation stage in 2011. Drought planning in their respective provinces was initiated by the provinces to mitigate droughts, focusing on drought engineering and non-engineering measures:
- The drought emergency water project construction plan,
- Drought monitoring and early warning system construction planning,
- Drought dispatching system planning,
- Drought mitigation management system planning.

The three pilot provinces Liaoning, Gansu and Sichuan include both engineering and non-engineering facilities in their comprehensive plans, with a total budget of 45 billion RMB (7.935bn, 18.90bn and 18.20bn, respectively), and a planned completion date for construction of 2020.

A new guidance document (Compilation Guidelines for Drought Response Plan (SL 590-2013), was issued by Ministry of Water Resources on 2013-01-22 and came into force in 2013-04-22. Provinces and their municipalities are currently updating their drought relief plans to comply with these directives, but this planning still falls short of a drought risk management approach. Table 2.1 provides a summary of related laws, regulations and standards.

Drought-management plans, guidelines, rules, and regulations, such as drought relief guidelines and emergency relief plans have been prepared by the national, provincial, and local governments and there is some active pre-planning for drought relief (such as emergency supplies, stockpiling of relief materials,

etc). The major shortcoming of these measures has been that drought-relief actions are generally passive responses to crises caused by droughts, after they have already occurred.

Table 2.1: Summary of National Regulations and Standards for Drought Management in China

Name	Date/agency	Major content
Provisional Rules of the Use of Subsidy for Major Flood Control and Drought Fighting	Dec 1994 Ministry of Finance, Ministry of Water Resources	Sets forth the use of subsidy for major flood control and drought resistance, the approval and application procedure, supervision methods etc. The subsidy will mainly be used for purchase of materials for construction of simple drought relief facilities and tools for water pumping and transfer.
Provisional Rules on Management of Organization and Construction of Drought Fighting Organizations	10th May 1996 Ministry of Finance, Ministry of Water Resources	Defines the nature of drought relief service organization, its function, goal, service method, capacity building etc, to guide the drought relief organization to develop in a formal way.
Rules of the Use of Subsidy for Major Flood Control and Drought Resistance (Revision)	1st January 1999 Ministry of Finance, Ministry of Water Resources	Amendment to the Provisional Rules of the Use of Subsidy for Major Flood Control and Drought Resistance and expands the usage of the subsidy, to support construction of emergency drought relief facilities, purchase of water pumping and transferring equipment and to cover the running costs.
Flood and Drought Disaster Statistical Form System (Revision)	2004 The State FCDRH The State Statistics Bureau	It makes amendment to the 1999's Flood and Drought Hazard Statistical Form System and adds regulation on urban drought hazard statistics. The additional statistical forms include: statistics on status of urban water shortage and water sources, statistics on urban water shortage and drought relief situation, basic information of water shortage cities and water usage statistics and basic information of water sources of water shortage cities.
China National Flood Control and Drought Relief Emergency Plan	11th Jan 2006 The State Council	Sets forth the structure and function of flood control and drought relief organization, prevention and alarm system (prevention and alarm information, prevention and alarm actions, alarm supporting system), emergency response (four-level emergency response start up, action and completion, information release etc), emergency security (communication and information exchange security, emergency support and equipment security, technology security etc) and after-disaster work
Terms of Reference for Drought Relief Plan Formulation	27th Feb 2006 State FCDRH Office	Provides guidance on principle and scope of drought relief plan, organization system, prevention and alarm, emergency response, guarantee measures, approval and revision of plan.
Classification of Meteorological Drought Category	1st November 2006 China Meteorological Bureau	Calculation method and classification criteria of some meteorological drought indicators such as precipitation anomaly percentage, relevant humidity index etc, and identification of drought process and evaluation method.
Soil Moisture Monitoring Standards	1st June 2007 Ministry of Water Resources	Presents the monitoring elements, plan and spread of soil moisture monitoring station network, site visit to and construction of the monitoring stations, monitoring method of soil moisture, soil moisture measurement system and reporting method, aiming at standardizing soil moisture monitoring.
Standard of Classification for Drought Severity SL424-2008	29th December 2008 Ministry of Water Resources	Presents the drought assessment indicators and corresponding classifications for agricultural drought, pasture drought, urban drought and drinking water difficulty caused by drought. Regional drought can also be evaluated.
Drought Mitigation Regulation of the People's Republic of China, Decree No.552	26th February 2009 The State Council	Presents the requirements (Article 14) for the development of drought management master plans with mitigation measures for different severities of drought. Sets out activities, roles and responsibilities in the event of drought and post drought restoration. Sets out the legal obligations and responsibilities of organizations and individuals in complying with the regulations for drought mitigation and penalties for

Name	Date/agency	Major content
		non-compliance.
Compilation Guidelines for Drought Response Plan	22nd April 2013 Ministry of Water Resources	Provides guidance on principle and scope of drought response plan, organization system, prevention and alarm, emergency response, guarantee measures, approval and revision of plan.
Cartographic symbols for flood control and drought relief maps	Forthcoming/ Ministry of Water Resources	Provides specifications on symbols, classifications and scale of maps for flood control and drought mitigation.

2.1.2 Organizations involved in Drought Risk Management

2.1.2.1 Flood Control and Drought Relief Headquarters (FCDRH)

During flood and drought emergencies, national and lower-level FCDRHs command operations, and emergency responses, while Civil Affairs manages post-disaster recovery. The Drought Relief Regulations of 2009 (DRR) indicate that lower level drought plans of a FCDRH are subject to requirements of higher level FCDRHs but linkages and command and control structures between these levels are not always totally clear.

The drought relief system in China is an administratively-led system that includes a unified command-coordination system among various departments and hierarchical responsibilities. Figure 1.5 shows the FCDRH structure with detailed descriptions of responsibilities as follows:

- **Central level**. The State Flood Control and Drought Relief Headquarters (SFCDRH) is responsible for organizing and guiding drought relief national wide. Its office is organized by the Ministry of Water Resources (MWR), and is mainly responsible for preparing policies, legislations and regulations; organizing development of flood defense program and water diversion schemes crossing provincial administrative boundaries; obtaining timely flood and drought information and organizing flood/drought relief mitigation at national level; regulating water consumption for water resources and hydropower facilities at national level; flood and drought management; organizing post-disaster recovery and coordination.
- **River basin level**. The FCDRH of major rivers and lakes is composed of relevant provincial governments and river/lake commissions, and is responsible for coordinating the drought relief within the scope of jurisdiction; developing contingency water regulation scheme based on the approved response plan and regulating reservoirs, hydropower, dams and lakes within its jurisdiction. The river basin commission is responsible for the specific work on flood control and drought relief of the river basin. However, work of basin FCDRH appears to be more of a coordination function of related provincial drought management activities rather than detailed drought management.
- **Local level**. The provincial, municipal and county level FCDRHs are responsible for organizing and leading drought relief work within their administrative boundary under the guidance of higher level FCDRH and government. Responsibilities include: organizing improvement of drought relief information system, organizing preparation of drought relief response plan, reviewing and disclosing drought information, initiating drought response plan in line with its authority, developing contingency water regulation schemes, organizing drought relief services providers to solve drinking water problems in rural areas and providing technical advice; mobilizing relevant institutions and individuals to participate in drought relief and requisition of drought supplies during emergency; organizing relevant authorities to verify and investigate drought situations and evaluate the impacts and losses, and effectiveness of drought relief.

As can be seen in these descriptions of the various levels of FCDRHs, the hierarchy is clear but the roles and responsibilities for drought forecasting and drought risk management are less clearly defined. Historically, the FCDRHs have mainly focused on relief efforts for droughts already underway, and on summarizing their work to the next higher level FCDRH. The SFCDRH is the major authority for drought management in China, and they are also the focal point for coordination with meteorological and agricultural and other relevant agencies. This is important since application of risk-based drought management naturally integrates meteorological and hydrological factors, as well as socioeconomic and environmental issues. The Meteorological Administration (and their National Climate Center) will be important partners in the prediction of droughts using agreed indices as they are developing and taking early triggered actions on a risk-based approach.

2.1.2.2 Other Organizations

The Ministries of Water Resources and Civil Affairs also have important roles, for development of new or expanded water supply sources and for drought relief efforts, respectively. However, as the potential for new temporary or long term structural solutions becomes exhausted, drought risk management and early action programs for risk avoidance and mitigation will become more important.

It is evident that drought management in China is a complex process involving many ministries. The National Office of FCDRH has representatives from many agencies: these are mobilized during an emergency or disaster situation but do not operate in a coordinated way under Normal conditions. However, data sharing and cooperation between government institutions has been problematic in the past and will need to be improved. Recommendations supporting increased cooperation have been made many times in the past such as in the 2002 Comprehensive Report of Strategy on Water Resources for China's Sustainable Development (Qian et al 2002). The DFID WRDMAP project also investigated methods that could be employed for better data sharing and cooperation among agencies as well as demand management techniques and drought management.

2.1.2.3 Institutional coordination

There are three issues in relation to coordination between national level and provincial level, provincial and municipal level, municipal and county level: (1) commanding and dispatching during actual drought periods, (2) relationships between different administrative levels in drought emergency plans; and (3) relations and differences between different organisations involved in drought management.The agencies and their current roles in drought management are shown in Table 2.2.

Drought risk reduction and mitigation activities can involve multiple agencies or departments of the system working collaboratively. The various agencies or departments of the water and drought management system must find ways to cooperate for drought risk management activities. The project's research work combined with China's current management practices and drought mitigation indicates that forecasting and early warning of drought monitoring work is still relatively weak. As an example, the drought early warning forecasting method only covers parts of the provinces. Therefore, the relevant institutions or inter-sectorial cooperation should be strengthened. Memorandum of Understanding (MoU) and Memorandum of Agreement (MoA) could be used as tools to spur cooperation and collaboration amongst agencies for drought risk management activities. The use of formal MoUs and MoAs may not be the only way to spur collaboration and cooperation but the principles embodied in these concepts could be used to facilitate

improved data sharing and cooperation in the water management agencies, which would greatly enhance the opportunities for drought risk management concepts to be implemented.

Table 2.2: Current Roles and Responsibilities of the FCDRH Offices and the Related Agencies

Agency	Major Responsibilities
Flood Control and Drought Relief Office	Carry out state guidelines, policy and regulations in relation to drought relief; organize prepare and implement preparedness scheme for drought relief; collect data on the latest rainfall, water, drought, disaster and meteorological situations; understand short-term and long-term analysis of water and meteorology; organize drought relief supervision; responsible for storage and management of drought relief materials; drought relief fund planning; collection of data on drought disaster conditions; develop and manage drought communication and warning system; carry out drought relief education and training; promote advanced techniques and new products.
Ministry of Water Resources	Coordination daily drought relief works; Intelligence of precipitation, river flow, drought, operations; safe operations of flood control, water resources, water and power projects; organization of management of drought relief projects; Organize and direct construction and management of drought relief projects; supervision and management of drought situation and safety of drought relief projects; Propose financial, logistic, communication plan for flood control and drought relief work.
People's Liberation Army General Staff Department	Organization of flood control and drought relief dispatching team; Participate in flood control and drought relief work including rescuing civilians, transferring goods, delivering and sending water for civilians, etc.
Armed Police	Organization of flood control and drought relief dispatching Armed Police team, based on the needs of flood control and drought relief work; Participate in flood control and drought relief work including rescuing civilians, transferring goods, delivering and sending water for civilians, etc.
China Meteorological Administration	Monitoring and forecasting of weather; issuing forecasts and meteorological data for flood control and drought relief, disaster relief; issuing forecasting and triggering meteorological information when appropriate.
Propaganda Department of the CPC Central Committee	Coordination and direction of propaganda and news coverage of flood control, drought relief and disaster relief work
Development and Reform Commission	Guidance to drought relief planning and development; risk mitigation and strengthening of drought relief facilities and important engineering; coordination and supervision of drought relief plan.
Ministry of Industry and Information Technology	Primary and secondary flood and drought damage mitigation; ensure industrial property security and economic stability.
Ministry of Public Security	Maintain social order; crack down on criminal activities according to the laws, including theft of drought relief materials, and deliberate destruction of drought relief facilities; assist relevant departments in dealing with mass security events triggered by drought relief.
Ministry of Civil Affairs	Organize and coordinate drought disaster relief; provide the latest disaster information to headquarters; organize and coordinate the rescue of rescuers and victims; manage and supervise disaster relief materials and fund; organize and distribute donations.
Ministry of Finance	Allocation of flood control and drought relief budget and fund, in coordination with national flood control and drought relief headquarter office; supervise the use of flood control and drought relief fund
Ministry of Land and Resources	Exploration, monitoring, and preventive work of geological disasters including landslides, collapse; organization and coordination of groundwater exploration and exploitation to ensure emergency water supply.

Agency	Major Responsibilities
Ministry of Housing and Urban-Rural Development	Responsible for urban flood control, water supply, and urban drainage; Participate in directing urban residents to prevent mountain flood.
Ministry of Transportation	Flood control and drought relief for engineering facilities including highway, waterway, etc.; Organize rescue squad to repair highway and waterway to ensure safety of engineering facility; Coordinate transportation means including vehicles and ships require for disaster relief to transport victims, rescue squad and goods.
Ministry of Agriculture	Collect, analyse, and report agricultural drought and disaster conditions in a timely manner; provide guidance in agricultural drought relief, disaster relief and production recovery; special subsidy fund allocation and management; issue policies to compensate drought impact area.
Ministry of Public Health	Epidemic prevention, medical care, and sanitary examination of source water.
Administration of Radio Film and Television	Organization of radio and television to report flood control and drought relief work
State Administration of Work Safety	Supervise and direct the work safety of key engineering facilities including, during flood including hydropower station, mining site, and tailings dam, etc. during flood period based on regulations.
National Energy Administration	Ensure energy supply during flood control and drought relief
State Oceanic Administration	Monitoring and early warning of oceanic storm
Administration of Railway	Railway safety, priority transportation disaster victims, rescue personnel and relief supplies.
Executive Office of Three Gorges Project Construction Committee	Work safety of Three Gorges Project Safety during Flood Control and Drought relief as well as Water reallocation
Executive Office of South-to-North Water Diversion Project Construction Committee	Work safety of North-to-South Water Diversion Project during flood control and drought relief as well as water reallocation

Source: Executive Office of State Council. State Council Memo about Adjusting Members of National FCDRH, May. 2013

2.1.3 Institutional Survey

Refer to Appendix A, Institutional Survey Results and the separate capacity building program

The TA Team undertook a survey in three pilot provinces related to drought risk management in order to assess the capacity of drought management and associated personnel and their awareness of drought risk management. A short questionnaire with 30 questions was used to assess their knowledge and capacity at all levels. The survey questionnaire was distributed to the management of the relevant offices (including FCDRHs of the pilot provinces, agriculture and meteorology departments, research institutions) for issuing the survey questionnaire to municipality (city) level and the main office of the county administration. A total of 74 questionnaires were returned: 16 from the provincial offices, 23 from cities, and 35 from the counties, see Table 2.3. The full results of the survey can be found in Appendix A.

Table 2.3: Institutional Survey Respondents

Pilot province	Number of completed survey questionnaires	Administrative levels		
		Province-level	City-level	County-level
Liaoning	19	2	9	8
Gansu	21	6	7	8
Sichuan	34	8	7	19
Total	**74**	**16**	**23**	**35**

The main conclusions of the survey are that:

- Personnel engaged in drought management have insufficient understanding of drought risk management.
- Provincial drought management personnel have a higher consciousness of risk than equivalent municipal and county personnel.
- Those who are in relatively dry areas have a higher consciousness of drought risk management than those in relatively wet areas. The awareness in Gansu province, which is relatively dry and suffers from water shortage, is greater than in Liaoning province and Sichuan province which have relatively abundant water resources.
- The drought management proficiency level in most areas is not high, and the management departments are in a transition phase from emergency response to risk management.

Although staff capacity is weak and needs to be strengthened, this must be undertaken in the context of other constraints to drought management:

- Specific laws and regulations related to drought management are lacking in most areas. In most cases they depend on national laws and regulations, but lack the corresponding local laws and regulations which are needed for them to be able to give specific instructions on drought risk reduction and mitigation work.
- Technical standards on drought monitoring, assessment and early warning are lacking or incomplete.
- Drought management staff numbers are not sufficient, especially at county level.
- The three pilot provinces generally lack drought monitoring and early warning means and methods.
- Cooperation between agencies, including water resources, agricultural and meteorological departments is weak. A mechanism for information sharing is needed to ensure that drought management staff have timely access to the hydrological, meteorological and agricultural information needed for drought assessment and decision making.

2.1.4 Provincial Workshop on Institutional Capacity, Gansu

Refer to Appendix H, Provincial Workshops and Field Trip

With the support of the state FCDRH and MWR, and assistance from FCDRH of Gansu Province, the TA team organized an initial provincial workshop in Lanzhou, Gansu Province in early September 2013. Representatives from Liaoning and Sichuan provinces also attended. The TA team discussed drought management with the three pilot province management personnel, to assess the status of drought risk management and the need for drought risk theory training.

The purpose of this workshop was to introduce the concepts and planning processes for drought risk management and risk-based drought management, obtain more information and perspective from

provincial and local levels, and gain agreement on how to introduce risk-based management methods into existing systems.

Nearly 50 people attended the workshop, including one director from national FCDRH; two personnel from the Liaoning province FCDRH; one from FCDRH of Sichuan province; more than 30 people from province, city and county level of the Gansu FCDRH, and other related departments of Gansu province; three from foreign affairs office of the MWR; and the TA consultants (seven Chinese and two international experts of the project team).

Through the workshop discussions, it became apparent that many aspects need to be strengthened in order to meet the needs of drought risk management. The main conclusions were:

- Drought management system in the three administrative levels is complete, but there are too few drought management staff at county level.
- The pilot provinces generally lack drought monitoring and early warning means and methods.
- Drought management personnel at all levels suffer from limited knowledge of drought risk management, and relevant policies, regulations and the technical standards of drought are incomplete and should be developed.
- Regulatory agencies at municipal levels need to be improved in two respects:
  - Municipal drought management offices require at least two staff dedicated to drought management;
  - Cooperation mechanism for the municipal office should be established with agricultural and meteorological sector for the non-drought period (Normal stage), and this should even be strengthened in the drought period in order to ensure more comprehensive information related to droughts.

Current capacity development programs are facing the following main constraints:

- The past training focused on increasing the overall capacity of water resources management staff and helped ensure a good understanding of basic water resources management. But the drought-related technical content of the training provided has been relatively limited. Because the specialized technical aspects are not emphasized, the capacity of drought risk management staff is not high enough and the understanding of drought risk management is limited.
- The current drought-related aspects of the training focuses on drought response and emergency relief, rather than on drought risk management. Drought training is *ad hoc* and not part of a structured program of drought-related capacity building. This needs to be augmented with additional material on drought risk management.
- Approaches for drought management are changing, and the capacity to implement even the earlier approaches is weak, and thus training is needed in both the current systems and proposed new developments. The current provincial drought management plans are drought relief plans prepared in accordance with the Drought Relief Regulations (DRR) and Drought Classification Rules of 2009. They have not yet been updated in accordance with the new “Compilation Guidelines for Drought Response Plan (SL 590-2013)” was issued by Ministry of Water Resources on 2013-01-22 and came into force in 2013-04-22. This guidance provides a blueprint for comprehensive planning and management of droughts once they are underway. FCDRH staff are not used to working even with these guidelines, but now it is proposed that a drought risk planning approach should be added to the front end of the existing drought relief planning protocols. Staff need to be trained not only on the new drought risk management aspects but also on the requirements of the 2013 Compilation Guidelines. For simplicity of implementation of drought risk management, it is not recommended that the 2013 guidelines be replaced but that they should be supplemented by risk-related provisions.

- Additional capacity development and training will be necessary to enable water management staff at municipal and county levels to manage the drought management plans adequately. It will take significant time for municipal and county level FCDRHs to develop adequate DMPs so there must be a transition time, and indeed training will be needed in order to prepare and manage the local DMPs. Local officials will also require time to work with the various sector water management officials (urban water supply, industry, agriculture) on their sectorial drought management plans.
- There is a significant turnover in staff at all levels, and thus there needs to be a continued rolling program of capacity-building.

This workshop itself included a significant element of capacity-building as described in Section 2.8.2, and following this workshop and the institutional survey referred to earlier, a longer-term capacity-building program was designed (see Section 2.8).

2.2 Water Uses and Water User Survey

Refer to Appendix B, Water User Survey Results

2.2.1 Water Uses, Water Saving and Drought Management

2.2.1.1 National overview

According the 2030 Water Resources Group[2] (2009), "*China's water demand in 2030 is expected to reach 818 billion m^3, of which just over 50 percent is from agriculture (of which almost half is for rice), 32 percent is industrial demand driven by thermal power generation, and the remaining is domestic. Current supply amounts to just over 618 billion m^3. Significant industrial and domestic wastewater pollution makes the "quality-adjusted" supply-demand gap even larger than the quantity-only gap: 21 percent of available surface water resources nationally are unfit even for agriculture. Thermal power generation is by far the largest industrial water user, despite the high penetration of water-efficient technology, and is facing increasing limitations in the rapidly urbanizing basins*"[3].

Agricultural productivity is a fundamental part of the solution but efficiency in industry and municipal systems is also critical. "*Although agriculture still makes up more than 50 percent of the total demand, industrial and urban water uses are the fastest growing (at ~3 percent per annum). China can mitigate this rapid growth in a cost-effective way by instituting aggressive, water-conscious, "new build" programs and enacting water-saving regulatory reforms. If it does so, the cost to fill the gap is negative, implying net annual savings of approximately US$22 billion. Most of the cost-saving levers on the left of the cost curve for China are industrial efficiency measures. These have the potential to close a quarter of the gap and result in net savings of some US$24 billion. The savings are distributed between the thermal power, wastewater reuse, pulp and paper, textile, and steel industries. This potential results from significant savings in energy and other operational expenditures, leading to overall productivity gains. The net capital*

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[2] 2030 Water Resources Group. 2009. *Charting Our Water Future: Economic frameworks to inform decision-making*. Washington, DC. World Bank.

[3] *Op cit*, p10

expenditure to close the remainder of the gap amounts to US$8 billion, or less than 0.06 percent of projected 2030 GDP"[4].

The concept of a Water Saving Society has been strongly promoted in China since 2000, when it was put forward by the Central Committee of CPC in the 10th Five-year Plan, reflecting the severe water shortage in many regions which has become a bottleneck for economic development and has resulted in serious environmental degradation. The 2002 Water Law (Article 8) requires "*that the state shall carry out water saving and devote major effort to implementing water saving measures, popularizing new water–saving technologies and processes, and developing water saving industry, agriculture, and services*". Water-saving means simply that water users consume less water. This is done for several reasons – for example, so that water can be transferred to other more beneficial uses, so that the environment can be protected, or so that costs can be reduced. A water-saving society (WSS) is, however, broader than this and covers the concept of society itself and the relations of production - ownership and control of assets, and socio-economic dependencies. The concept was introduced in recognition of the fact that there appears to be considerable waste of water, and many opportunities for increasing the productivity of water but that this requires society as a whole to change.

MWR has promoted a program for establishing a water saving society throughout China, with implementation plans are prepared at municipality level. This program aimed to ensure that by 2010:
- all systems (preliminary) of legislation, administration, economic and technical policies, and advocacy and education for a water-saving society would be established;
- good progress will be achieved in water-saving technology and management levels;
- water-saving awareness of all people will be significantly improved;
- wastage of water resources will be effectively controlled;
- the water use per 10,000 RMB of GDP will be reduced by 20%,
- agricultural irrigation water efficiency will be increased from 0.45 to 0.5, and there will be no increase in total agricultural irrigation water use;
- the water use per unit of added industrial water output will be reduced by 30%; and
- water use efficiency of service trades will approach the level of global best practice.

2.2.1.2 Pilot Provinces

Water supply and demand

Because the economic development conditions vary to a large extent, the water resources utilization situations in each provinces and different areas, and water demand in each sector are different. For example, the urbanization rate in Liaoning is as high as 70%, while the rates of urbanization in Gansu and Sichuan are only 29%. Despite this urbanisation, agriculture is very important for livelihoods in all three provinces, with the greatest proportion of industrial use in Sichuan. Liaoning has the highest proportion of domestic use.

As shown in Table 2.4, the agriculture water demand comprises the major part (65%) of the total water demand, especially in Gansu where it accounts for almost 80% of the total water demand. The percentages of water demand in other sectors are also summarised below.

[4] *Op cit*, p12

Table 2.4: Percentage of water demand in each sector for the three pilot provinces (2012)

Province	Agriculture (%)	Industrial (%)	Domestic (%)	Ecological (%)
Liaoning	65	17	16	2
Gansu	80	11	6	3
Sichuan	58	31	11	0
Average	65%	22%	11%	2%

The intensifying gap between water supply and demand is a fundamental condition in the country. After the National Drought Relief Plans are implemented, the gap between supply and demand in each province including the three pilot provinces should be reduced significantly. Nevertheless, with the increase in populations and the rapid social and economic development of each pilot province, the gap would still exist.

Table 2.5, Table 2.6 and Table 2.7 indicate the water supply and demand balance for different frequencies in Liaoning, Gansu and Sichuan. The frequencies refer to the probability level for the water supply and for the various water demands and the deficit (difference between supply and demand), although in the case of Liaoning only the resulting deficit is presented.

Table 2.5: Water Deficit in Liaoning in 2010 (10 thousand m^3)

County-level administration	Water deficit (10 thousand m^3)			
	average of several years	75%	90%～95%	≥97%
Shenyang			2,391	5,539
Dalian	5,191	7,591	18,414	20,756
Jinzhou		1,932	7,230	8,119
Yingkou			706	2,249
Fuxin		2,594	4,002	5,230
Panjin			5,784	8,522
Tieling			5,481	6,807
Chaoyang		397	4,834	5,356
Hu Ludao				214
Total	5,191	12,515	48,841	62,792

Table 2.6: Water Balance for Gansu for 2020 (100 million m^3)

Freq. (%)	Water supply				Water demand						Water deficit quantity	Water deficit (%)
					For life		For production					
	Surf. water	Ground -water	Other	Total	Urban	Rural	Agric-ulture	Service & industry	Eco-logy	Total		
75	125.41	26.65	5.64	157.70	6.76	3.45	136.39	29.66	3.88	180.15	22.45	12.46
90	120.14	26.65	5.58	152.37	6.76	3.45	149.11	29.66	3.88	192.87	40.50	21.00
97	117.79	26.65	5.54	149.98	6.76	3.45	153.87	29.66	3.88	197.63	47.65	24.11

Table 2.7: Water Balance for Sichuan for 2020 (100 million m^3)

Year	frequency	water available	water demand	water deficit	Water deficit(%)
2020	75%	253.92	282.16	28.24	10.0
2020	95%	240.37	287.45	47.08	16.4
2020	97%	223.51	290.42	66.91	23.0

Based on the economic and social development goals prescribed in the twelfth Liaoning Five-year plan (2011-2015), under current water saving conditions, the provincial total water demand would be 18.54 billion m^3 in 2015. The water allocation plan for Songliao river basin and Hai river basin indicates that the total water supply in Liaoning would only be 16.38 billion m^3. Among these the water supply from surface water is 8.79 billion m^3, from groundwater is 6.17 billion m^3, and from non-conventional water resources is 1.42 billion m^3. The deficit at 97% reliability is therefore 0.63 billion m^3 (about 3% of demand) in 2015, but there are significant temporal and geographical variations in the deficit across the province. The deficit is much greater in Gansu (24% per year averaged over the province), although this is for 2020 with a significant projected increase in demand. Even at 75% reliability the average deficit is 12% in Gansu, indicating a severe water shortage even in non-drought periods. Curiously a similar percentage deficit is projected for Sichuan, again with a large increase in demand.

Drought relief planning and water savings society development

In the *Drought Relief Plans*, the pilot provinces have planned for drought management from both an engineering and non-engineering perspective. From 2010 to 2020, the three provinces have planned to invest RMB 7.935 billion in Liaoning, RMB 18.899 billion in Gansu, and RMB 18.204 billion in Sichuan. The investment would be used mainly on drought contingency water conservancy projects, with smaller amounts on drought monitoring and triggering systems, drought response dispatching systems, and drought mitigation management system. The investments in different categories are listed in Table 2.8, and summarised by source of funding in

Table 2.8: Summary of investments for drought planning and management (2010-20) (10,000 RMB)

Administrative Unit	Drought contingency water conservancy projects	Drought monitoring and triggering system		Drought response dispatching systems	Drought mitigation management system	Total
		Drought monitoring infrastructure	Monitoring &triggering system			
Liaoning	684,960	13,112	500	650	94,247	793,469
Gansu	1,637,780	13,493	3,900	3,500	231,205	1,889,878
Sichuan	1,700,200		23,000	1,200	94,000	1,820,000

Table 2.9: Drought relief facilities planned investment for Pilot provinces to 2020 (100 million RMB)

Pilot province	Total investment	central government	local government
Liaoning	79.35	63.48	15.87
Gansu	188.99	151.19	37.80
Sichuan	182.04	145.63	36.41

The three pilot provinces have each initiated work on establishing a water savings society:

- Liaoning's water saving society building is the most detailed. The eleventh five-year Water Saving Society Building Plan was completed in 2008 and twelfth plan in 2012. This prescribed the provincial water saving objectives, and sectorial objectives for agriculture, industrial, and urban domestic sectors. A national pilot water saving society has been established in Dalian.
- Gansu compiled the twelfth five-year Water Saving Society Building Plan and Gansu Hexi National High-Efficiency Irrigation Demonstration Area Project Implementation Plan in 2011 and 2012 respectively, prescribing the water saving objectives, tasks, and projects, and launching the Hexi water saving demonstration project. Since agricultural water use is close to 80% of total water consumption in Gansu, high efficiency irrigation is very important for the water saving society. A national pilot water saving society has been established in Zhangye.
- Sichuan is one of the major provinces where water resources are abundant, so it is relatively lagging on efforts to building a water saving society. However, substantial efforts are still being made in relation to water savings, with the Sichuan Urban Area Water Saving Directive published and implemented in 1992. The provincial government published the Sichuan Provincial Government Memo about Fully Promoting Water Saving Society Building in 2011, and now the provincial plan for building a water saving society in Sichuan is under preparation.

Water savings measures under Normal conditions

There are a wide range of water savings measures described in various official documents. These are summarized in the context of international experience in various donor-supported projects such as WRDMAP (MWR/DFID)[5] and the Shanxi Climate Change Adaptation Project (ADB TA0188-PRC). There are many individual actions which can be taken, but a comprehensive approach requires higher level actions.

One of the most important aspects of water saving is the use of administrative instruments such as water rights and water abstraction permits (WAPs). Such permits will also provide the basis for reallocation before or during droughts in future. In the past abstraction permits have not been actively used for irrigation demand management, but they are more widely used for industrial and urban water management. The WAPs must be consistently and strictly enforced, and audited. The entire system of managing permits (including the costs of monitoring the water resources as well as administering the permit process) needs to be well-financed.

According to the 2010 Hydro Yearbook, 13.689 billion m^3 water of the total supply of 14.367 billion m^3 (95%) in Liaoning Province was covered by abstraction permits. The distribution of water abstraction permits over different sectors is presented in the table below in Table 2.10. Such data were not presented for the other two pilot provinces.

[5] http://www.wrdmap.com/brochure/index.asp?id=160

Table 2.10: Water abstraction permits

Sectors	Number	Permitted Water Amount (100 million m^3)
Total Coverage	13,700	136.89
Surface water	-	78.38
Groundwater	-	58.51
Industrial	5,900	33.47
Domestic	1,700	15.52
Agriculture	6,100	87.90

There are, however, some practical difficulties which can mean that water abstraction permits need additional work, such as the accuracy of water resource assessments and return flow estimates, administrative procedures, audit arrangements, impact on livelihoods, etc. Environmental flow requirements are also yet to be integrated into the systems to any large extent.

Economic instruments such as water tariffs and service charges are widely seen - in China as in the rest of the world - to play a critical part in achieving water savings. They have had a useful impact in the urban and industrial sectors, but have had a much smaller impact in the irrigation sector. However, in general, water prices are still below the requirements for financial cost recovery and are generally too low to reflect its scarcity value and therefore do not have sufficient impact on demand for water. Normally, water price in the commercial sector is higher than that of the industrial sector, and industrial water price is higher than domestic water price.

Agricultural water-saving technologies in the pilot provinces include spray/drip irrigation, micro-irrigation, pipe irrigation and canal lining, as well as choice of drought-tolerant crops, land levelling, and cultivation techniques. The "big double ridge" cultivation techniques seen during the field visit in Gansu Province can preserve soil moisture and save water. Mulching cultivation is also widely used as water-saving technology. However, water-saving measures have very different impacts at local level and on water resources in the basin as a whole. It is necessary to reduce water consumption and not just water abstraction. For this reason, the concept of ET (evapotranspiration) management has been introduced in parts of China.

Urban uses of water are generally smaller in volume than irrigation uses, so the potential for saving is less. But it is important, and with rapid urbanisation it is growing in importance. Savings can be achieved for example through leakage reduction, reusing water and installing water saving equipment. The value of the water saved in economic terms is normally higher, since in most situations it is treated and potable water that is being ‘saved’. Additionally, in many countries urban water saving has received more attention since it is linked to private sector investments and associated financial returns. Industrial water saving measures include process improvements, leakage control, recycling, treatment and reuse of wastewater and water efficient equipment.

Additional / enhanced water saving measures for pre-drought and drought conditions

Water saving measures in China currently proposed are mostly applicable under Normal conditions (long-term measures) and are aimed at alleviating the problems of chronic water shortage and maximising the productivity of the limited resource. For predicted drought situations, additional water-saving measures need to be triggered, such as voluntary or compulsory limits to water abstraction permits, reallocation to

prioritized users or areas, and water transfers to redistribute water from areas of surplus to area of local deficit.

The basis for this reallocation is set out in State Council Decree No. 460 under Water Law (2002) which lays down requirements for managing abstraction permits during droughts and how these may be revised. However, although this decree does set out procedures to follow *during* a drought, the provisions for reductions or reallocation *before* a drought are not clearly defined. Article 4 stipulates exceptions to water abstraction permits including temporary emergency water abstraction that must be done to combat drought in agriculture or protect the ecology and environment. Article 41 sets out how the requirements for abstraction permits may be restricted during a drought: *'If a major drought occurs, the competent authority may implement emergency limitation to the amount of water drawing by units and individuals*.' No definition of a 'major drought' is given. In addition, the process for managing water allocations through the use of abstraction permits has not yet been fully implemented in practice; as described elsewhere in this Chapter 3, there are many constraints, particularly for agricultural uses, in some parts of the country. Expansion of the decree may be necessary to allow reallocation of water during the Pre-Drought stage as a risk reduction measure.

International experience related to water saving at times of drought

There is good international experience which can be drawn on for water savings in times of drought. Water reallocation from low value uses to higher value uses with compensation is widely used in the USA and use of agricultural water banks has also been explored. Experiences in Colorado are described below.

Much of the urban water use in the US State of Colorado goes to watering of landscaping and grass, and this is usually the first area of curtailment and limits. Municipal owned parks and other lands are restricted as well as individual customers. As drought levels progress, there are specific percentage reductions associated with all municipal and industrial users. Drought surcharges to water rates are used to encourage additional conservation. Other measures involve limits on vehicular washing, fountains and swimming pool restrictions, changes in use of potable water on construction sites, and limits on restaurant use of water. All of these measures include enforcement programs and fines for non-compliance.

In Colorado, there are also programs that involve municipal leasing of agricultural water back to farmers except during drought years and State programs to provide loans or grants to farmers during drought years. In addition, municipal drought management plans prescribe a wide variety of water saving measures to be imposed during drought years. Water resources in most areas throughout Colorado are fully allocated. While conservation will become increasingly important, continued growth in municipal and industrial (M&I) water demands, will undoubtedly require reallocating water from agriculture to M&I users. When transferring water from agriculture to M&I use, the past practice has been to permanently transfer water from agriculture. This approach has shown to have significant impacts on the agricultural sector and rural economies from which the water has been permanently transferred. Newer alternative plans have been formulated by some Colorado cities whereby cities purchase water rights and lease back the water to the farmers for agricultural use except during drought years. The farmers obtain an economic benefit of the sale of water rights but are able to keep farming for non-drought years (e.g., 9 out of 10 years on average.) Additional research work is underway to capture the complexity of the decision environment faced by producers; taking into account the stochastic nature of the water decision process (e.g., crop prices, climate, etc.). Failure to capture this issue limits the potential usefulness of these tools to agricultural

producers and inhibits the ability of policy makers to identify efficient and effective alternatives in which both cities and producers would be willing to participate.

The Colorado Agricultural Emergency Drought Response Program provides funding assistance to agricultural organizations, in the form of loans or grants, for emergency drought related water augmentation purposes. The Program provides grants for the lease of augmentation water during drought years and loans for the purchase of water rights for augmentation purposes. The Program also provides loans for the construction of structures necessary for the delivery of augmentation water back to the river. Additional work remains on the overall methods for allocating water during droughts between agriculture and M&I uses, and weighing the benefits and costs of water savings in agriculture versus urban users.

In the United Kingdom, drought orders (and emergency drought orders) and drought permits[6] are used to manage water use and supply in pre-drought and drought periods. These are the principal management techniques used during droughts by the Environment Agency (EA - the water regulator). The procedures, including consultation processes, are fully detailed in official documents. The 'order' is a temporary government measure which forces *restrictions* on specific water users during emergencies, i.e. reduces demand. The 'permit' is a temporary EA authorisation for abstractors to over-ride their license conditions during water shortages; i.e., it *increases* the supply at the expense of the environment. For example, in February 2012 after the driest 12 months since 1976, Bewl Water [reservoir], in Kent, was only 40 per cent full, in comparison with the normal figure of 90% full for at that time of year. Southern Water was granted emergency powers to help refill it, by taking more water from the River Medway.

The Water Act 2003 made it a statutory requirement for water companies to prepare, maintain and publish drought plans. Drought plans cover the range of actions necessary to deal with various drought situations. They set out how a water company will continue to meet its duties to supply water during drought periods with as little recourse as possible to drought permits or drought orders. The EA expects water companies to develop and agree Drought Contingency Plans that confirm measures to be taken during a drought. The EA will not issue a temporary drought permit unless the water company demonstrates that reasonable measures have been taken to reduce demand.

Before a water company applies for a drought permit or drought order, it is expected to have taken the necessary measures to limit demand on the affected sources. In particular such actions include publicity campaigns, temporary restrictions on water uses under water companies' own powers, leakage control and pressure reduction. The company must also have communicated publicly its intention to reduce demand in advance.

- Drought orders
  - To restrict water use in certain areas or uses, typically non-essential uses
- Drought permits
  - To enable additional supplies to be provided to certain users during droughts.
  - To meet critical needs (e.g. water for hospitals).

For drought orders, the UK Secretary of State must be satisfied that either:

- a serious deficiency of supplies of water in any area, exists or is threatened, or
- such a deficiency in the flow or level of water in any inland waterway to pose a serious threat to any flora or fauna which are dependent on those waters, exists or is threatened; and that

[6] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69441/drought-permits-drought-orders.pdf

- the reason for the deficiency is an exceptional shortage of rain.

Emergency drought orders have the additional requirement that the deficiency is likely to impair economic or social well-being.

In the case of drought permits, the Environment Agency must be satisfied that:
- a serious deficiency of supplies of water in any area exists or is threatened; and that
- the reason for the deficiency is an exceptional shortage of rain.

2.2.2 Water User Surveys

The water user surveys were undertaken in the three provinces in August 2013 and analyzed in September 2013. These aimed to determine the current state of knowledge and awareness of water-saving methods and have been used to help design the capacity building and public awareness programs. A questionnaire (25 questions) was designed and distributed with support from provincial FCDRH to relevant staff in the FCDRH, water resources, hydrological, meteorological and agriculture departments and research institutions at provincial level, and to FCDRH at municipal/county-level. In total, 74 questionnaires were returned and analyzed as summarized below in Table 2.11.

Table 2.11: Numbers of Water User Survey Respondents

		Number by administrative level		
Pilot province	Total	Province-level	Municipal-level	County-level
Liaoning	19	2	9	8
Gansu	21	6	7	8
Sichuan	34	8	7	19
Total	74	16	23	35

The results are tabulated in Appendix B. These show that there are many constraints to water-saving: these vary between sectors, but in all cases a major constraint for installing water saving equipment is that the cost is too high. There are inadequate policies for water saving in all sectors, and there is also believed to be a widespread lack of public awareness.
- For agriculture, arable land holdings are small, agricultural incomes are low and the affordability of water saving techniques is a major constraint; the water price is also low and therefore the cost-effectiveness of water saving is low. There are also many practical constraints which make it difficult for individual farmers to apply these techniques, as described in Chapter 3
- The main constraint for industrial water saving is also perceived to be economic, so the water saving techniques improvements have not been fully implemented and there is little enforcement of the requirements. There is little perception that water saving can actually be advantageous to companies as well as a compliance requirement – for example by reducing water-related risks, or improving their reputation.

Despite these observations, the major driving force for introduction of water-saving techniques is believed to be progressive water price. Greater awareness of the wider issues around drought and water risk is thus important, and there is a need to encourage a range of measures in addition to enforcing price signals to water users.

2.3 Prototype Provincial Drought Databases

2.3.1 Liaoning

Refer to detailed Appendix C, Liaoning Prototype Drought Database

Liaoning has set up an advanced drought database, which is under the control of the water resources department, mainly comprising hydrological data. As of 2010, there were variously 1,300 monitoring stations under the control of water resources department, including 120 hydrological stations, 648 precipitation stations, 65 water quality stations, 528 ground water stations, 37 evaporation stations, 77 basic soil moisture stations and 91 telemetry moisture stations. Some stations have multiple functions, such as the hydrological stations where water flow, water level, precipitation, evaporation, soil moisture, ground water, sediment, water quality, water temperature and so on are monitored. That means the hydrological station and the precipitation station are often located in the same place.

Table 2.12 shows the cities and counties in Liaoning Province and the number and types of monitoring sites department situation. Rainfall data are collected by the Provincial Meteorological Department and MWR departments, evaporation data by the meteorological department, and river water levels and reservoir levels are entirely by water sector. Soil moisture data is mainly controlled by the agricultural sector, and agricultural condition data is basically monitored by the agricultural sector.

Table 2.12: Monitoring Sites in Liaoning Province

Region	Precipitation	Evaporation	River water levels	Reservoir level	Soil moisture data	Agricultural condition
Liaoning Province	648(MWR 292, Met 356)	38(MWR)	94(MWR)	396(MWR)	77(MWR)	
Dalian City	238(MWR)			41(MWR)	24(MWR)	
Shenyang City	43 (Met 23、MWR 20)	1 (Met)	5(MWR)	4(MWR)	1(Met)	23(Met)
Benxi City	(MWR)		(MWR)	(MWR)		
Chaoyang City	311(MWR)	3(MWR)	8(MWR)	39	12(MWR)	
Dandong City	157(MWR)		9(MWR)	27(MWR)	4(MWR)	
Hulu Dao	78(MWR)	1(MWR)	3(MWR)		7(MWR)	
Liaoyang City	(Met)	(Met)	(MWR)	MWR)	(Met MWR)	(Agric)
Tielin city	155(MWR)	12(MWR)	12(MWR	56(MWR)	9(MWR)	
Tuchang county	70(MWR)	1((Met)	5(MWR)	56(MWR)	1 (Met)	
Donggang City	80 (Met.)	1(Met.)	8(MWR)			
Henren county	73(MWR、Met.)	3(MWR, Met.)	7(MWR)	11(MWR)	6(MWR,Met.)	
Lianshan District	Met.	Met.	MWR	MWR	MWR	
Liaoyang County	32 (Met.)	2 (Met.)	2(MWR)	2(MWR)	15(Agric)	15(Agric)
Pu Landian city	58(MWR, Met.)		30(MWR)	13(MWR)	27(MWR,Met.)	
Su Jiatun District	23+20(Met.、MWR)	1 (Met.)	5(MWR)	4(MWR)	1 (Met.)	23 (Met.)
Tieling county	27(MWR)	(MWR、Met.)	(MWR)	12(MWR)	6(Agriculture)	Agriculture)

Note: MWR – Ministry of Water Resources. Met. – Meteorology Department

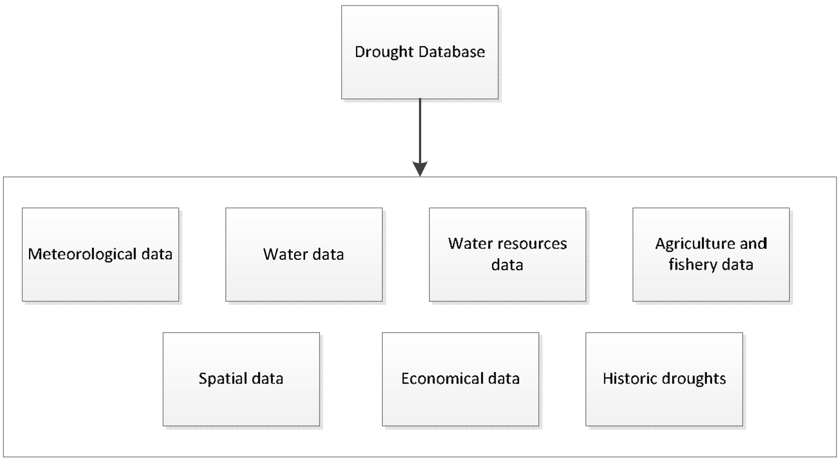
For the 648 precipitation stations managed by Water Resources Department of Liaoning Province, each station covers an average 249 km^2. All these stations automatically transfer the data into the data center.

Moreover, Water Resources Dept. shares data with provincial Meteorological Department., which has another 786 precipitation stations data available. The daily drought monitoring mainly relies on the 648 MWR stations.

There are also some national meteorological stations managed by NCC. They provide daily temperatures and precipitation. But, according to our survey, these data could not be conveyed in real time. Usually, you need administrative power and negotiation to get the recent data (past data of a couple of days, weeks or months), or you can get the historic data in a hard copy or download from NCC or provincial Meteorological Department websites. Effective data sharing is important for the future of drought management so it is important that daily real time data is made available from all departments.

Figure 2.1 below shows the structure of the Liaoning drought database.

Figure 2.1: Structure of Current Drought Database in Liaoning Province



Some of the general conclusions are as follows:

- Liaoning province had a dedicated drought database which has been improved on basis of research and international best practice for the model integrated drought database.
- The integration of NCC meteorological data into the prototype Liaoning drought database shows promise and has been further investigated, but is not yet put into practice.

In the theoretical approach of the TA, the integrated drought database is used for giving early warning of potential or actual drought conditions to local jurisdictions. In the interim period until local drought management plans are developed and capacity improved, the provincial drought management plan may be the key guiding document for these triggered actions, using the database.

The TA demonstrated the establishment of the integrated drought database but significant additional work would be required to make the database fully operational. Besides the data sharing issues outlined above, a decision support framework using computer programs is required to extract the related data from the database to calculate the daily drought indices, evaluate the results and ways to report results. If the database is functioning as a management tool to a comprehensive DMP, then the specific triggered risk reduction and mitigation methods must be identified and be ready to implement. If the database serves as data source to lower level DMPs, then the reporting and feedback systems must be developed.

2.3.2 Sichuan and Gansu Provinces

Sichuan Province has no regular database related to drought at present; the WRD is mainly relying on the water situation and meteorological database, and informal agricultural sector data sharing for periodic drought analysis and assessment, but not prediction. Gansu Province is in a similar situation with some informal data sharing.

- In Sichuan, where no data are being collected/stored in a database at provincial level, NCC daily meteorological drought data can be used.
- In Gansu, situation is similar to Sichuan but some drought relief data are collected by other departments during crises.

In both cases agreements to share data need to be developed, as indicated in section 2.1.2.3.

2.4 Drought Hazard and Mapping Drought Risk

Refer to Appendix D, Drought Risk Mapping Scheme

As outlined previously, vulnerability analysis provides a framework for identifying the social, economic, and environmental causes of drought impacts. It directs attention to the underlying causes of vulnerability rather than to its result, the negative impacts caused by events such as drought. For example, the direct impact of a lack of precipitation may be reduced crop yields. The underlying cause of this impact, however, may be that farmers did not use drought-resistant seeds because they did not believe them to be useful, the costs were too high, or because of some commitment to cultural beliefs.

Society's vulnerability to drought is affected by (among other things) population growth and shifts, urbanization, demographic characteristics, technology, water use trends, government policy, social behavior, and environmental awareness. These factors are continually changing, and society's vulnerability to drought may rise or fall in response to these changes. For example, increasing and shifting populations put increasing pressure on water and other natural resources - more people need more water. Although drought is a natural hazard, society can reduce its vulnerability and therefore lessen the risks associated with drought episodes. The impacts of drought, like those of other natural hazards, can be reduced through mitigation and preparedness (risk management). Planning ahead to mitigate drought provides decision makers with the opportunity to relieve the most suffering at the least expense. Reacting to drought in "crisis mode" decreases self-reliance and increases dependence on government and donors.

A vulnerability assessment is undertaken through a process of identifying, quantifying, and prioritizing (or scoring) the vulnerabilities in a system. Vulnerability from the perspective of drought planning includes an assessment of the threat from potential drought hazards to various sectors across social, economic, environmental, and political fields. Vulnerability assessments are typically performed according to the following steps:

- Cataloguing assets and resources in a system and across sectors.
- Assigning quantifiable value (or at least rank order) and importance to those resources
- Identifying the vulnerabilities or potential threats to each resource
- Mitigating or eliminating the most serious vulnerabilities for the most valuable sectors/assets

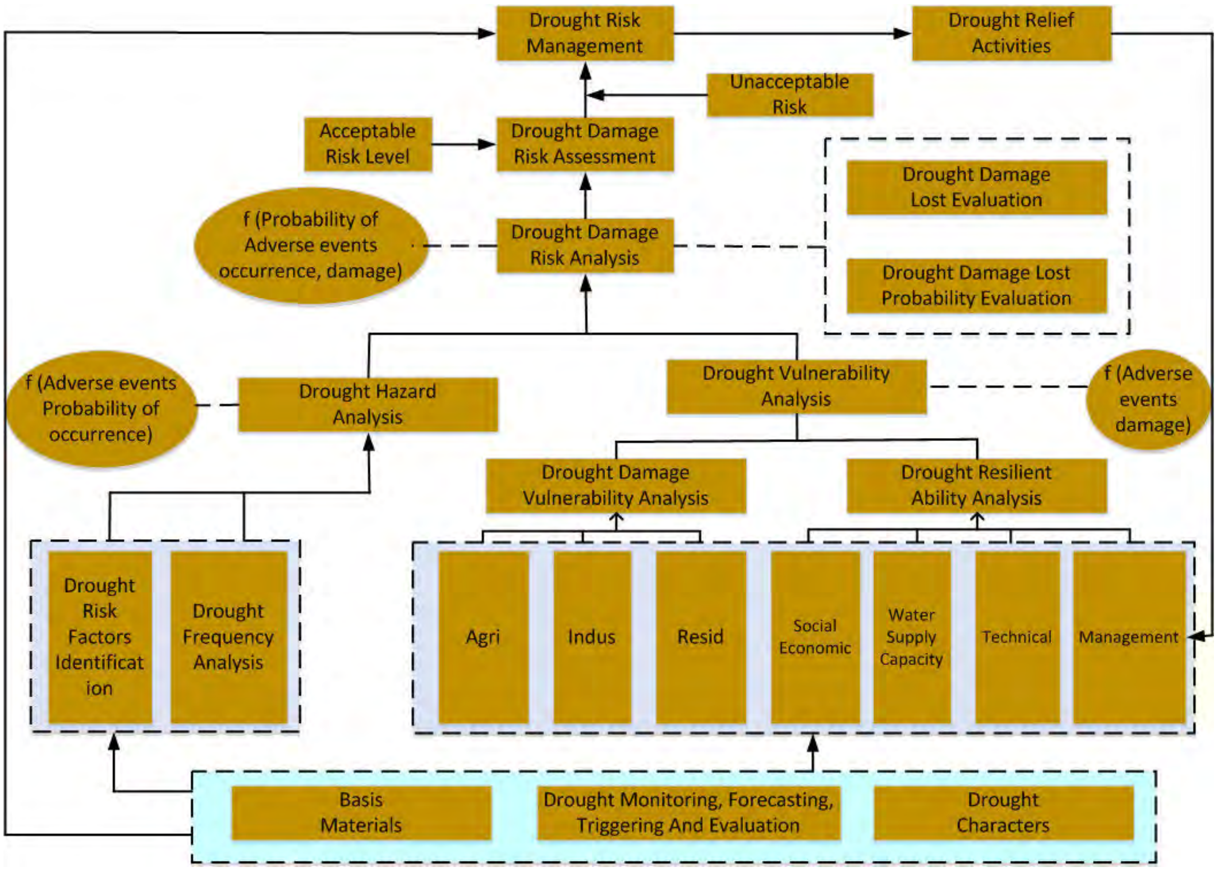
Vulnerability assessment has many things in common with risk assessment. Risk assessment for natural hazard planning is principally concerned with investigating the risks surrounding infrastructure (or some

other object) and people. Such analyses tend to focus on causes and the direct consequences for the studied object. Risk assessment thus involves determination of vulnerabilities and hazards to establish risks and risk probabilities in terms of frequency of occurrence, magnitude and severity, and consequences. At present, China is in the transition period from drought crisis management mode to risk management. Although a drought management system has been set up a national, provincial, city, district and county levels, this does not include specific drought risk mapping work, and the three pilot provinces of Liaoning, Gansu and Sichuan do not have current drought risk maps.

Nevertheless, some domestic universities and research institutions involved in drought risk management research have achieved certain results, which relate to risk theory, drought risk mapping, etc. In these studies, the theories were mainly developed from general risk management concept and there are different approaches to do the drought risk mapping in China. The Drought Relief Research Centre in the China Institute of Water Resources and Hydropower Research (IWHR) has also carried out extensive research work and developed some comprehensive methodologies. Other different risk mapping methods and different case studies exist in China. For example, the Shaanxi Province Drought Disaster Risk Atlas has been jointly prepared by the Shaanxi Provincial Meteorological Bureau, Water Resources Department and the Agriculture Department and other units (see Du Ji, et al, "Shaanxi Province Drought monitoring and early warning assessment and risk management.") This Shaanxi province case provides an example of drought risk management and risk mapping conducted systematically. It demonstrates ideas and methods which represent current thinking in many research institutions, as well as in provincial administrative departments and makes use of generally recognized and understood drought risk analysis and risk mapping methods.

The IWHR has carried out extensive research in agricultural drought risk. This is based on a crop agricultural drought risk analysis model, and represents a pilot for agricultural drought risk analysis and mapping drought risk maps in Liaoning Province. This section provides a brief introduction to the IWHR drought risk analysis and the research focus, drawing the corresponding risk maps. According to the definition of drought risk, the IWHR approach includes aspects of drought frequency analysis and damage assessment, and also hydrology, meteorology, and other economic and social data analysis. This is based on the combination of drought monitoring, forecasting, early warning, and drought eigenvalue estimates and other information to identify risk factors. The Drought Disaster Risk framework is shown in Figure 2.2.

Figure 2.2: IWHR Disaster Risk Analysis Framework



IWHR drought risk includes significant research with consolidated results, based on existing research, and made a number of innovations on drought risk point of view, including drought risk concept, the constituent elements of drought risk and drought risk assessment methods, and the following will address these aspects briefly from the IWHR research.

Drought hazard analysis is identifying the threats to society based on the hydrological, meteorological, socio-economic analysis and the drought characters, such as drought monitoring data, prediction, warning and forecast.

$R = f(\text{不利事件，不利事件发生的概率})$ (Risk as a function of adverse events and the probability of their occurrence)

Drought vulnerability analysis includes drought and drought vulnerability analysis capability analysis from agriculture, industry, residents in areas such as drought vulnerability analysis, from the economic and social level, water supply capacity, and technology and management level in areas such as drought tolerance analysis. In two ways based on the analysis of drought vulnerability analysis, function as follows:

$R = f(\text{不利事件，损失})$ (Risk as a function of adverse events and the damage caused)

Based on the hazard and vulnerability analysis, the risk formula could be described as:

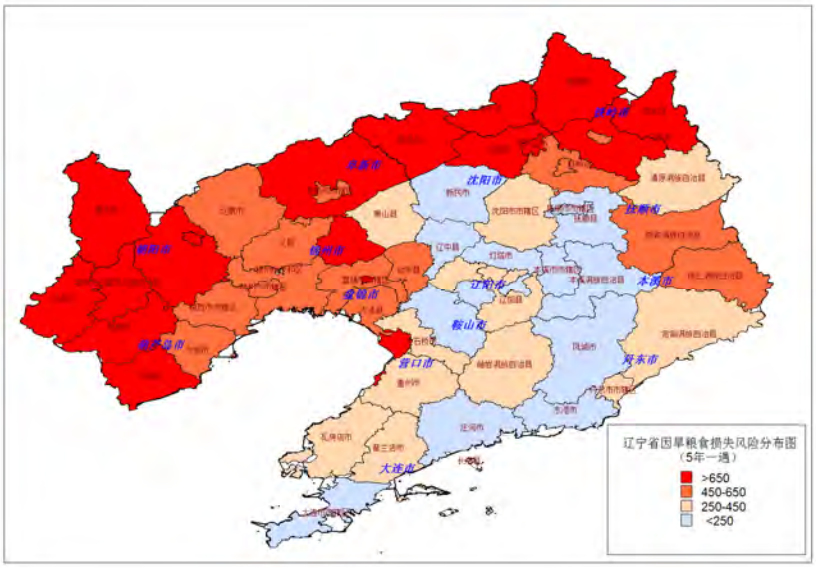
$R = f$(不利事件发生概率，损失) (relating the probability of occurrence of adverse events with damage)

Using existing domestic provincial drought risk analysis as well as international practice in drought risk mapping, combined with IWHR research in this field, the project teams in Liaoning, Gansu and Sichuan have produced three pilot provincial drought risk maps on a preliminary basis.

Because Liaoning Province has relatively good data base and technological strength, while Gansu and Sichuan data base are relatively weak in these respects, different risk analysis techniques have been adopted in this study for the three provinces. For Liaoning, it is mainly based on historical loss frequency distribution. For Gansu and Sichuan provinces, it is mainly based on the meteorological and hydrological factors which may induce a drought. Currently, the problem of drought risk in China is still at the exploratory stage, mainly concentrated in universities and research institutes, and there is no specific application above the provincial level.

The basic unit of analysis includes a comprehensive consideration of crops, weather, soil, topography, farming (including fertilization and irrigation) and other agricultural drought risk factors, relying on 30-50 year daily meteorological data. Using the calibrated DNDC model and daily meteorological data for 30-50 years period the growth and annual yields of the four types of crop could be simulated, as well as the production losses because of drought. In Liaoning, drought risk for various types of land and crops value were estimated using a combination of dynamic data (weather, food production, etc.) and environmental background data (soil, topography, etc.) The TA Team thus produced integrated crop drought risk maps with an example shown in Figure 2.3.

Figure 2.3: Risk analysis technology route of the agriculture drought disaster



2.5 Drought Forecasting System

Refer to detailed Appendix E, Proposed Drought Forecasting System

Any drought management or water supply planning methodology requires that the relationship between expected supply and demand be known to peg the risk of failure of water supply. Two terms frame this issue - risk of failure and security of water supply. Risk of failure is just what it says - the risk of running short of water - and security means the degree of insurance against failure that is provided. The information needed to assess the adequacy of water supplies is the probability that the raw water supply system will fail, that is, run out of water. This is usually presented in terms of the return period of the drought planned for or the annual probability of running short. The threshold value of an index marking the boundary between one drought condition and the next more serious state is often referred to as a ‘trigger’ because it triggers or initiates actions. Depending on the operational procedures the trigger might initiate an early warning procedure, bring in rotational cuts in supply to conserve water, or take emergency actions to alleviate the consequences of drought.

As China is currently, is in the transition from drought emergency response to drought risk management, drought management departments have not yet established a drought forecasting and triggering system. Although provincial and local drought management officers understand some risk forecasting theory, and bring up some valuable ideas, these are not implemented in practice Some regions predict drought development through drought monitoring and experience, but this is not done systematically and lacks support and consistent approaches. Although drought management departments from different administrative levels have established drought emergency relief plans, the plans are pre-planned responsive activities after drought occurs rather than a drought forecasting. Consequently, there is no provincial drought risk forecasting system strictly. This is not only the situation in the pilot provinces, but also throughout China.

The Ministry of Water Resources issued at the end of 2008 the new "Standard of Classification for Drought Severity SL424-2008", implemented in March 2009. This standard applies to most parts of the country giving criteria for agricultural drought, livestock drought, urban drought, and drinking water drought assessment, and with grading criteria and indicators corresponding to regional drought assessment.

Agricultural drought assessment indicators include relative soil moisture, precipitation anomaly percentage, number of consecutive days without rain, crop water stress ratio, and number of days without water. Livestock drought assessment indicators include precipitation anomaly percentage and the number of consecutive days without rain. Urban drought assessment indicators are water deficit rates for cities. Drinking water drought assessment indicators are basic drinking water consumption and drought duration. The classifications for each indicator are also given in the Standard. The classifications are different for some indicators in accordance with the different divisions of the North and South in China, or in accordance with the different levels of the national, provincial, municipal and county.

The implementation of the Standard has played a great role in promoting drought assessment level in the nationwide. Drought management and the relevant departments at all levels across the country, and a large number of research institutions have adopted the Standard for drought assessment. However, the Standard is based on the majority of conditions in the country and may in some areas not be very applicable. The three pilot provinces of this project, Liaoning, Gansu and Sichuan provinces, revised some

indicators and thresholds of the Standard, and have set up a series of more suitable indicators for themselves.

The three pilot provinces all have daily drought indicator monitoring currently, mainly from SL424-2008. However, the provincial administration does not take advantage of these drought prediction analysis indicators to establish an early warning system, but they are used in daily work. The TA goal has been to use these indicators for short-term drought forecasting, more or less as the beginning of a proactive drought early warning and decision support system.

Although the daily work of the provinces does not include drought prediction or a rigorous early warning system, officials use an informal process, and research in this project can serve as important reference material for their work. Thus, the provinces first need to be introduced to early warning drought prediction research, and then begin to implement provincial drought early warning system and startup programs. The most appropriate indicators are:

- **SPI index -** internationally widely recognized for drought monitoring and early warning
- **Runoff anomaly index** - which reflect whether water resources are abundant or deficient.
- **Reservoir level anomaly index** - reservoirs are generally regulating and important for water supply during drought.

Relative soil moisture will also be important in the future when the national program to improve the soil moisture monitoring network has been implemented. It is closely related with crop growth and is considered the most accurate analysis indicator, which is more applicable for short-term drought early warning.

In some cases, advanced systems can also introduce remote sensing tools and the use of remote sensing data for drought early warning. These three indicators are from the meteorological drought, hydrological drought and agricultural drought at differing angles to predict the future development trend of drought, both short-term forecast and early warning. There is also long-term forecasting and early warning. In practical applications, the provinces should be combined with practical means, considering both the prediction results of each index can also be based on one or two key indicators of drought early warning.

In the tiered DMP responsibilities proposed by this TA, the idea is for the municipal and district level drought early warning systems to receive provincial early warning of drought, coupled with the development of locally appropriate indicators to establish an enhanced local drought early warning system. Cities and district level drought early warning indicators can be selected on the basis of data availability, local conditions and ease of use. The local data base and technical strength are important to the selection and use of indicators. Local agencies should consider the local natural climatic conditions, hydrology and water resources conditions, soil and geological conditions and specific issues such as agricultural planting structure.

Many of the local indicators can be directly used or modified from the "Standard of classification for Drought Severity SL424-2008." The local drought early warning system and provincial drought early warning system will have a closely linked relationship in the long term.

Currently, there is no pre-identification of the drought stage of Pre-Drought, and actual drought levels IV to I are based on drought damages incurred. The existing drought relief plans merely quantify a drought level after it occurs based on the level of damages incurred. As proposed by this TA, daily SPI calculations are

performed at the provincial level using combined meteorological data from the MWR and Meteorology (with the integrated drought database).

In the future we recommended that these SPI levels are disseminated to the local municipalities and counties on a daily basis, along with the River Flow Anomaly and Reservoir Level Anomaly calculations. If two or three of the indicators meet the threshold, an early warning is also determined for the particular affected area to move into the Pre-Drought stage, and trigger local drought management plans and enhanced review of local indicators. As shown in the Liaoning DMP, other indicators directly extracted from SL24-2008 then determine if a particular affected area moves from Pre-Drought to various levels of actual drought. In all cases, the proposed system triggers actions including monitoring and risk reduction and mitigation measures at the beginning of the drought stage, rather than after damages have occurred.

2.6 Decision-Support System for Early Warnings

Refer to detailed Appendix F, Proposed Decision Support Framework for Early Warning

There are no current drought early warning systems in place in China to guide decision making. The current practice is to document droughts after they have occurred. Such an early warning system assumes a level of “decision support” management of potential droughts that the TA has recommended for implementation through the risk-based drought management systems being investigated in the pilot provinces.

According to a report by the US National Research Council in 2009[7], decision support consists of a “*set of processes intended to create the conditions for the production of decision-relevant information and for its appropriate use”.* Drought related *decisions are choices by individuals or organizations, the results of which can be expected to affect water resources or to be affected by drought and its interactions with ecological, economic, and social systems. Choices to mitigate or adapt to drought are obviously included, but also included are decisions about matters that may be only indirectly related to water resources (e.g., types and locations of economic development). Such issues can be captured in risk and vulnerability mapping and assessments*. (*op.cit* p34)

“Drought-related decision support involves organized efforts to produce, disseminate, and encourage the use of information that can improve drought-related decisions. It includes various kinds of activities, products, and services, including efforts to identify decision makers’ information needs; production of decision-relevant information; creation of information products based on this information; dissemination of these products; efforts to encourage the use of decision-relevant information; ongoing communication among producers and users of decision support products and services to evaluate and improve the quality of information, relationships between information producers and users, and ultimate decisions; and development of organizations, networks, and institutions to serve those purposes. Decision support cannot lower actual risks directly or immediately, but it can influence humans’ awareness of and responses to risk in ways that can, over time, mitigate threats from the natural world, as well as the vulnerability resulting from human exposure to threats”. (*op.cit* p36)

[7] Informing Decisions in a Changing Climate, Panel on Strategies and Methods for Climate-Related Decision Support, Committee on the Human Dimensions of Global Change, National Research Council (U.S.), Panel on Strategies and Methods for Climate-Related Decision Support. Division of Behavioural and Social Sciences and Education, 2009.

"*The effectiveness of decision support can be judged by the extent to which it increases the likelihood that decision-relevant information is produced and enables and empowers decision makers to use it appropriately. The many elements of effective decision support can be usefully grouped under three categories:*

- ***Increased usefulness of information**. Decision support is effective to the extent that the information provided is considered by the intended users as credible, legitimate, actionable, and salient in terms of their decision deadlines and other concerns.*
- ***Improved relationships between knowledge producers and users**. Decision support is effective when it engages scientists and decision makers in mutual learning and the co-production of knowledge that could not have emerged from either side alone and when it yields increased mutual understanding, respect, and trust.*
- ***Better decisions**. Decision support is effective when the resulting decisions have the qualities of good decisions (including productive problem definitions and clear objectives) and when the decision makers and key constituencies view the decision as having been improved by the support received".* (*op.cit* p37)

The TA has proposed a layered decision support early warning framework that uses both the MWR and the NCC meteorological drought forecasting at the provincial level FCDRH (as well as available hydrologic and agricultural monitoring) to establish triggered notices to affected local areas (basins, municipalities, counties). Once the triggered notices of potential drought are received at the lower level FCDRHs, the use of the current hydrologic indices and other hydrologic data is expanded to evaluate the probability of drought, based on the provincial warning. Depending on these combined meteorological and hydrological assessments and probability analyses, the local level DMPs are triggered for early action water reductions and water conservation measures. Depending on the severity of the potential drought, additional triggers for re-allocation of water abstractions may be considered with the Water Affairs Bureau based on the drought risk assessments and triggers outlined in the local DMPs.

2.7 Proposed Tiering of DRM and Institutional Arrangements

The TA team has proposed a tiered decision framework involving all levels of FCDRHs working in a coordinated systematic approach. Figure 2.4 provides a graphical description of the roles and responsibilities of the FCDRHs are all stages of drought risk management work, and Figure 2.5 provides a schematic overview of the processes used for the tiered DMP between provincial DMPs, local DMPs and sectorial DMPs.

The drought management plans have been developed under a presumed future "tiering" of drought management responsibilities with linked and specific roles and responsibilities at each level of the process (using existing FCDRH structures). Figure ES2 indicates the proposed institutional structure. Detailed water management decisions in IWRM are made at the lowest practical water management level. Based on this framework, the provincial DMP and local municipal and county DMPs are part of an overall hierarchy of drought planning. The lowest level would be the sectorial DMPs of the water companies, industries and agricultural interests[8]. The county and municipal level drought planning is managed and coordinated by these provincial plans, and the entire process has had guidance and oversight from the national level drought management process.

8 It is noted that agricultural interests in the PRC are in fact WABs which are (or will become) abstraction permit holders for surface irrigation of agriculture, and also regulate groundwater abstraction. As such, agriculture DMPs would probably be prepared by WABs rather than individual farmers or agriculture districts as is the case in other countries.

The proposed tiered approach to drought risk management assumes that the municipalities and counties are provided the funding and capacity building both to develop quality drought risk management plans and to manage the process. In the short term until this occurs, the provincial drought management plans may be the most practical way to manage drought risk management using the integrated drought database, drought risk mapping, and the meteorological indices. However, even these provincial DMPs require development of implementation modalities to be put into operation including development of necessary programs to access the integrated database and calculate the daily drought indicators.

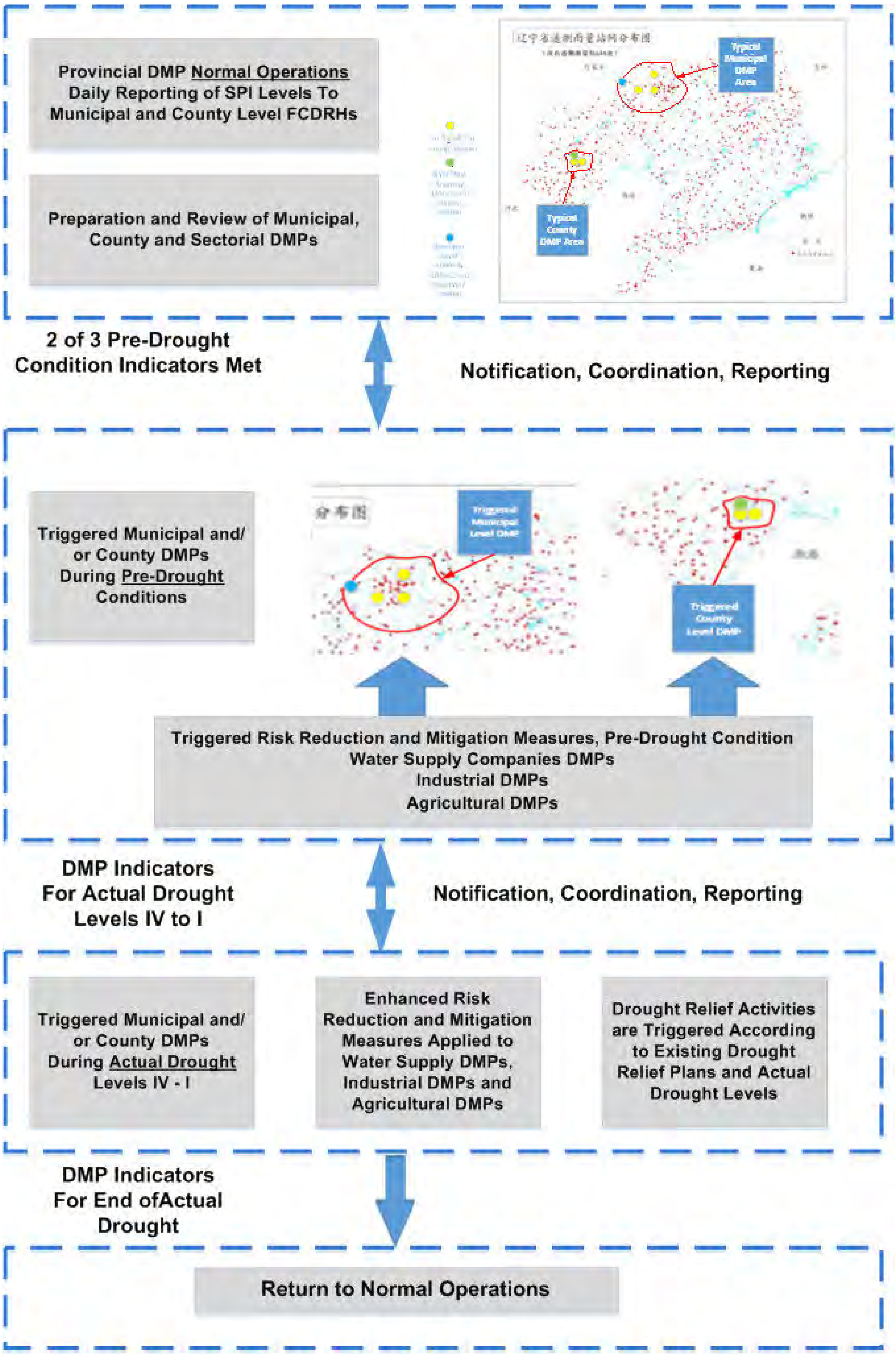
Since the practice has been to develop drought response or relief plans at various levels, there will need to be some phasing in of the concept of drought management planning at all times, even during Normal conditions. There may be an interim period where drought management and drought relief plans exist simultaneously for the local level, with the idea that the drought risk management plans should eventually supersede the need for separate drought relief plans.

Box 1 provides a summary of the drought risk reduction framework and practices as outlined by United Nations Secretariat of the International Strategy for Disaster Reduction (UNISDR) in Geneva, Switzerland, in partnership with the US National Drought Mitigation Center (NDMC), University of Nebraska-Lincoln in August 2009. It provides an overview of the emerging international best practices for drought risk management and provides some good ideas for adoption in China. This TA was structured around these emerging international best practices in the preparation of all aspects including the DMPs.

Figure 2.4: Graphical description of tiered FCDRH roles and responsibilities

Level	DRM concepts	Normal Operation	Pre-drought	Drought Levels IV-I
National	Policy Standards / regulations Budget for DRM	Implement Standards / regulations Budget for daily risk management activities	Ensure/monitor cooperation Comply with standards /regulations Large-scale drought planning coordination	Monitor compliance Large-scale drought coordination of plans and relief activities
	guidance ↓ reporting ↑			
Provincial	Data & sharing mechanisms Drought Database Provincial indicators Risk mapping Early warning Staffing and budgeting	Data collection and sharing agreed Database in use Use of daily indicators Update mapping Early warning in place Provincial DMP developed	Database in use Use of daily indicators enhanced Update mapping Early warning in place Provincial DMP triggered	Full Collaboration Review daily indicators Early warning in operation Prov. DMP continues, Prov. Relief Plan activated Coordination of regional droughts
	guidance ↓ reporting ↑			
Municipal/ County	Local data / indicators Vulnerability assessment Early warning Public involvement Drought relief planning Staffing and budgeting	Indicators and Local DMPs prepared Vulnerability assessment Enhanced early warning Public involvement Pre-planning relief supplies	Local data / indicators checked Vulnerability assessment updated Warning system in operation Public involvement DMP early actions triggered	Local data / indicators checked Triggered risk reduction measures enhanced Public involvement Local DMP continues, Local Relief Plan activated
	guidance ↓ reporting ↑			
Sectorial	Drought management plan concepts applied to urban water, industry and agricultural sectors	DMPs completed under Municipal/County DMP structure	DMPs early action triggered	DMPs further action and orchestrated and integrated into local DMPs
All Levels	Capacity Building and Training Public Information and Involvement Programs			

Figure 2.5: Schematic overview of tiered decision making process



Box 1. **Summary of the <u>drought risk reduction framework and practices</u> as outlined by United Nations Secretariat of the International Strategy for Disaster Reduction (UNISDR) in Geneva, Switzerland, in partnership with the US National Drought Mitigation Center (NDMC), University of Nebraska-Lincoln in August 2009.**

The risk associated with drought for any region or group is a product of the exposure to the natural hazard and the vulnerability of the society to the event. The UNISDR definition for "vulnerability" is "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Leaders/planners in drought-prone regions should conduct risk assessments to both better understand the drought hazard and identify the factors and processes concerning who and what is most at risk to drought, and why.

The document proposes main elements of a drought risk reduction framework in line with the priorities of the Hyogo Framework (HFA), namely i) policy and governance, ii) drought risk identification and early warning, iii) awareness and education, iv) reducing underlying factors of drought risk, and v) mitigation and preparedness, as well as cross-cutting issues. [The HFA is a 10-year plan (2005-2015) to make the world safer from natural hazards. It was endorsed by the UN General Assembly in the Resolution A/RES/60/195 following the 2005 World Disaster Reduction Conference. It is currently being updated for another five year period.]

Drought risk reduction is a long-term commitment that should complement long-term sustainable development planning efforts, such as meeting the United Nations Millennium Development Goals (MDGs) and in the Poverty Reduction Strategies. Mainstreaming drought risk reduction into these national development frameworks requires political commitment, high-level engagement, strong institutions and appropriate governance.

The process of drought risk reduction and its mainstreaming into national development frameworks should be participatory, involving a wide range of stakeholders such as national and local governments, community-based and civil society organizations, regional and sub-regional organizations, multilateral and bilateral international bodies, the scientific community, the private sector and the media.

Another important cross-cutting aspect for drought risk reduction is capacity development. Capacity development can be conceived at three different levels, namely individual and group level, institutional level and systematic level. Capacity development for drought risk reduction can be coordinated, implemented and monitored under holistic and nationally owned coordination mechanisms for disaster risk reduction such as multi-sectorial national platforms for disaster risk reduction. Other capacity building activities for drought risk reduction can build on the existing initiatives of ISDR system partners.

The five main elements in line with the priorities of the Hyogo Framework be considered for a drought risk reduction framework are as follows:

1. Policy and governance should be based on local needs, community participation and political commitment, networks and mechanisms and resource availability. In addition to national and state/provincial drought policies, increased importance has also been placed on local/community level drought policy and planning, emphasizing self-reliance and drought resilience.
2. Drought risk identification, risk monitoring and early warning, can be a starting point for promoting a culture of resilience in combination with enhancing knowledge about hazard occurrence, the potential effects of the hazard, and the related vulnerabilities of potentially affected people and activities.
3. Drought awareness, knowledge management and education, is another enabling factor for drought risk reduction. Collection, compilation, and dissemination of relevant knowledge and information on hazards, vulnerabilities, and capacities should be linked to community drought risk reduction awareness campaigns, programs, and projects.
4. Reducing underlying factors of drought risk will also contribute to reducing drought vulnerability. These risk factors can be reviewed and reduced by effective environmental and natural resource management, social and economic development practices, and land-use planning and other technical measures.
5. Enhancing mitigation measures and preparedness for drought substantially reduce drought impacts and losses if authorities, individuals, and communities are well-prepared, ready to act, and equipped with the knowledge and capacities for effective drought management.

2.8 Institutional and Capacity Development

Refer to Appendix G, Approach to Capacity Development Program as well as Separate Report on Capacity Development Program
Refer to Appendix H, Summary of Provincial Workshops
Refer to Appendix I, International Study Tour Results

2.8.1 Recommended capacity building program

2.8.1.1 Overview

The main constraints related to technical capacity in drought risk management, were identified in the surveys described in section 2.1 and concluded that:

- There is weak drought management capacity, especially at low levels; and all levels of FCDRH lack capacity in drought forecasting, monitoring and early warning capabilities. There have been considerable efforts in the past decade to improve this situation but this is mostly related to general aspects of water management, with little detailed attention to droughts.
- There are many other institutional and other constraints, but even if these are relieved, the desired impact will not be achieved until capacity is raised.
- Most training to date is general, with limited coverage of drought issues. There is not even sufficient understanding to implement current guidelines fully. Training will need to address these as well as new concepts of risk management.
- Funding for capacity-building is a key issue. The amount of technical training that is provided is currently quite low and under-resourced. Additional training is needed and yet this will have to be funded from existing budgets.
- Implementation of guidelines and DMPs will not be possible without significant capacity building.

Provincial workshops have had a significant impact on high level understanding of some key aspects of drought risk management, and the changes needed to implement it. The international study tour led to an understanding of international approaches to solving key problems: water-savings and water infrastructure can reduce the risk of drought occurring, but there is a need for drought monitoring, data sharing; drought management plans and better public understanding of risk; drought insurance and reallocation of supplies to high values uses are valuable.

The FCDRHs are the leading institutions in place to coordinate drought relief activities, and they are well situated to manage a new focus on drought risk planning and on management to mitigate drought impacts when they are emerging. However, the FCDRHs will need to ensure that their staff and those of related institutions (directly or indirectly involved in drought management) have a comprehensive understanding on drought risk management, and on the need and methods to undertake their coordination roles.

A capacity building programme, for state, provincial, city and county-level FCDRHs has been planned and designed to address the key issues identified in the capacity needs assessment. It is anticipated that a rolling programme of 10 days training for around 600 people in the three provinces will be required. In order to avoid disruption to daily work, it should be undertaken in two day blocks. This should later be extended to other provinces.

However, it is not just a question of training: in order to enhance drought risk management capacities, the workshop and other studies indicated that several other actions should be taken:

- Strengthen the training office
- Improve regulatory system related to drought mitigation
- Improve technical standards related to drought mitigation
- Establish an information sharing mechanism of drought
- Strengthen drought monitoring and forecasting warning systems

2.8.1.2 Objectives of the program

The survey and workshop identified the need to strengthen capacity in the four main topics in the strategic framework for drought risk management, including:

- Drought policies and regulations; technical standards
- Drought vulnerability and risk assessment
- Drought prediction and early action
- Proposed tiered drought management planning responsibilities
- Co-operation between agencies for managing drought risk

Capacity will also need to be built to enable preparation and implementation of the Drought Management Plans (with input from specialist research institutes). The prototype plans for the three pilot provinces provide detailed examples indicating the topics in which capacity needs to be built:

- Integrated drought database to allow for continuous monitoring of MWR and NCC data on meteorology using SPI, river flows and reservoir levels.
- Vulnerability assessments in the province, coordinated with local jurisdictions.
- Development of standard protocols and minimum requirements for municipal, county and sectorial DMPs prepared in the Province.
- Coordination of local DMP responses especially where drought affects multiple municipal areas or major sectors.
- Establishment of an organizational structure and delivery system that assures information flow between and within levels FCDRHs.
- Drought relief planning and implementation managed on provincial level according to existing regulations.
- Report on activities upward to National FCDRH and downward to local FCDRHs.

2.8.1.3 Structure of capacity development program and training methods

The capacity development program aims to:

- Further improve the management competence of drought management staff at all levels
- Enhance the drought management capacity of FCDRH at different levels
- Increase the drought **risk** management skills and knowledge of staff
- Ensure drought management staff fully understand drought monitoring and triggering, and drought management regulations, policies, and related technical standards

The main participants will be the provincial and county level drought management staff from Liaoning, Gansu and Sichuan. The greatest need is for training for these low-level staff in FCDRH, who currently have the weakest understanding of the concepts. Ultimately the program should be extended to other provinces, drawing on the experience, methods and materials from the pilot provinces.

There are 316 FCDRH at different administrative levels in three pilot provinces (detailed in Table 2.13). Assuming each FCDRH send two staff for training, the number of total staff to be trained would be 630. In order to ensure good training outcomes, the staff would be grouped and given training in batches.

Table 2.13: Number of FCDRH at each level in the Pilot Provinces

Level	Liaoning	Gansu	Sichuan	Total
Provincial	1	1	1	3
Municipal	14	14	21	49
County	44	86	134	264
Total	**59**	**101**	**156**	**316**

Source: Project studies

As set out in Appendix G, and in more detail in the capacity building programme document, the training will be undertaken at state, provincial and local levels, and is divided into three components:

- Drought management policies and regulations, and related technical standards
- Drought monitoring, forecasting and triggering
- Drought risk management

Training for provincial FCDRH staff should be organized and provided by national FCDRH, county level FCDRH by provincial FCDRH. Specialized research institutes should also be involved in developing and implementing the training. The lecturers should be organized by national FCDRH, and should be research scientists from drought research institutions, drought management staff from national FCDRH and drought researchers from universities. The Guidelines for Drought Management and the Drought Management Plans are recommended to be used as resource material.

2.8.2 Capacity-building during the Initial Provincial Workshop in Gansu

The high-level capacity-building was started with the initial provincial workshop in Gansu described in briefly in Section 2.1.4. Appendix H contains the full workshop program and summary, with the PowerPoint presentations included in an annex to Appendix H. Some of the conclusions of the workshop are shown in Table 2-14:

Table 2-14: Summary table of initial provincial workshop and field trip

Item	Feedback	Future needs / suggestions
Drought management	Current drought management practice is emergency drought relief, rather than risk-based drought management in an integrated way. Risk-based management method could supplement current drought relief practice and improve drought management in China.	International cases are more acceptable and easy to understand the risk based concept. More cases or examples could provide to inform people.
Monitoring and indicator system	Liaoning has good basis on data collection and sharing. But most places in Gansu and Sichuan have few monitoring stations, especially on soil moisture. Tiered approach can be adopted. Early warning or information sharing can start with primary meteorological data, mainly precipitation based indicators.	Data sharing could be a problem due to some institutional issues. Inter-agency cooperation needs to be strengthened. The power of FCDRH on coordination and cooperation needs to be improved. According to local situation, monitoring stations could be planned based on current station map within different organization. Overlap of stations should be avoided. Practical suggestions on local indicator selection could be given to guide local people to

Item	Feedback	Future needs / suggestions
		implement the indicators and triggers.
Institutional issues	Difficult for FCDRH to implement drought management work throughout the hundred percent time of daily work (Normal operations). Risk based drought management should be embodied into strategic documents and policies and implemented under the leadership of the government at different levels.	Suggestions can be provided to higher level and included into policies and regulations. Data sharing and inter agency cooperation needs to be strengthened. Integrated water resources management should be improved after several years implementation to include drought risk management and mitigation into the daily operation of related organizations.
Natural conditions (water shortage) vs drought management	Especially in Gansu and mountainous areas in Sichuan and Liaoning, water shortage due to natural climatic conditions. Drought caused by abnormal climatic conditions, mainly by less precipitation could be the focus of drought management by FCDRH and hence some actions in pre drought conditions need to be prepared.	Coping with water shortage problem should be included in the integrated water resources management. FCDRH should focus more on emergent drought responses and coordinate on risk reduction measures during pre-drought condition. Emergent drought responses in pre and drought conditions should be included in daily operation of different organizations, with FCDRH's role on coordination and corporation.
Infrastructure focus	Participants mentioned the engineering measures to cope with drought covering both supply and demand sides, including rainwater harvest, water storage, water transfer and water saving irrigation and cultivation. Many think strengthening the infrastructure should still be one of the future focuses.	Focusing on infrastructure and the physical construction is common in China. More training program need to be provided to expand the interests to other non-engineering measures. GDP-driven performance assessment should be switched to performance-based evaluation, as a long term goal.
Drought relief service group	According to relevant policies and documents, drought relief service groups were set up for counties. Central government provided 2 million RMB to support the development of such organization, mainly on purchase vehicles and pumps for transporting or pumping water during drought seasons.	In the light of water resources institutional reforming, drought relief service group could be part of the integrated service provider at lower level. The principle should be sharing the risks with the public and increasing the participation of the public in drought management to make it efficient and effective.
Public participation on drought management and relief	Lack of labor in rural area is a problem in terms of water transportation and caring for irrigation during drought. Small piece of land reduces the incentive of individual farmers to save their agriculture losses and paying for insurance, where available.	It's common in most rural areas in China. How to provide enough incentive for farmers to participate the drought relief and risk reduction activities?
Lack of funds	Most of the drought management budget has not been included in local financial annual plan, which makes the drought mitigation measures not fully implemented. Without financial support, drought relief actions embodied in daily operations are hardly implemented.	Strengthening IWRM and including some of the drought risk mitigation activities into daily operation of other organizations. Get support from local financial department or bureau.

2.8.3 International Study Tour

2.8.3.1 Background to Drought Management in the Study Tour Countries

Several European countries were assessed for relevance related for an international study tour on drought issues. Spain and Portugal were selected as there are a variety of topographic and hydrologic regions in Spain, so it was a good country to review how drought management is handled in diverse regions. Spain has faced significant drought problems in recent years. The study tour had been planned originally for October 2013 but was conducted in December 2013.

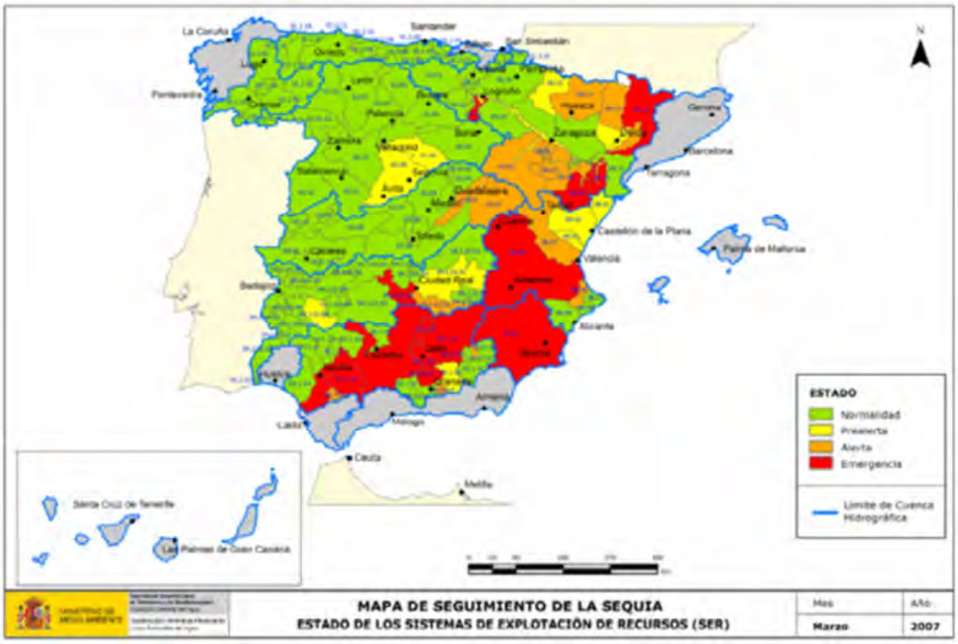
Administration of water has been performed at basin scale by Basin Agencies (Confederaciones Hidrograficas) since early in the 20th century; there have been water laws related to the design and implementation of Basin Plans (BP) since 1985, and Special Drought awareness and mitigation Plans (SDP) at basin and local scales since 2000. Since 2000, Spanish water law has required the basin agencies to develop SDPs in transform the traditional reactive crisis management approach into a proactive one. SDPs managed at the basin level are a specific requirement of the river basin management plans. They include the following components:

- Diagnosis
  - Identification and characterization of territorial and environmental elements.
  - Zonification
  - Analysis of historical droughts and drought characterization
  - Definition of indicators, thresholds and drought phases
- Program of Measures (POM)
  - Definition of general measures and specific ones for each area to be applied in each drought phase
- Management and follow-up system
  - Organization and management systems
  - Definition of indicators for the implementation follow-up and effects

The selection of indicators in Spain is based on:
- Identification of the origin areas of resources associated to specific demand units.
- Selection of indicators types according to how well they represent the resources' supply.
  - Precipitation
  - River inflows in natural regime
  - Stored volume in surface reservoirs
  - Piezometric levels in aquifers

Figure 2.6 shows a drought map for Spain as well as relevant drought classification system.

Figure 2.6: Drought Map and Classification System for Spain



TYPES OF MITIGATION MEASURES							
Indicator	1-0.5	0.5-0.4	0.4-0.3	0.3-0.2	0.2-0.15	0.15-0.1	0.1-0
Status	Normal	Pre-alert		Alert		Emergency	
Objective	Planning	Information-control		Conservation		Restrictions	
Type of measure	Strategic			Tactics		Emergency	

2.8.3.2 Main Findings of the Study Tour

(1) The national system for monitoring of drought risk

Spain and Portugal shifted some time ago from drought relief to drought risk management, with real time monitoring since 1985. A joint EU internet-based drought monitoring and prediction system for European drought has been set up and has evolved to offer timely and authoritative information. This provides real-time of monitoring and drought forecast information for each area and river basin, including drought monitoring indicators (SPI, soil moisture) and drought classification. It provides a platform and standard format for shared data, with an annual seminar for the exchange of knowledge.

(2) The introduction of water saving management is needed to avoid the risk of drought

Drought restricts agricultural development which is critical for Spain's economy, so water-saving irrigation has been highly developed and promoted by the government. Modern techniques such as drip and spray irrigation are used on 90% of the land. Water distribution systems are automated, with accurate measuring

and control equipment, and all data is compiled and managed efficiently. Farmer cooperatives are actively involved in management, thus reducing the management costs.

(3) Water conservancy construction to regulate drought risk

Water storage dams have been built for thousands of years, and are very important for mitigating droughts. In addition, water transfers from the wet north to the dry south are very important for this purpose.

(4) The development of drought management plans to address drought risks

The new Water Law in Spain in 2001 required each basin to prepare drought management plans and these have been approved at ministerial level. These ensure adequate water supply to guarantee the human life and health; minimize the ecological impact of low flows; and determine priorities for water allocation at time of drought on public water supply.

The drought management plans draw on

- Diagnosis of the drought situation – basin characteristics, historical trends, drought indicators, thresholds and standards.
- Development of drought response measures. With the development and intensification of droughts, the response gradually rises from information management to water-saving measures, and finally to restrictive measures. Drought mitigation measures include new wells, canals, desalination plants, and non-engineering measures, such as changing priorities of water, and increased abstraction of groundwater. Conjunctive management of surface and groundwater has proved to be very effective
- Public consultation, stakeholder collaboration, and integration of local knowledge and practices into different levels of water management.

(5) Through the introduction of agricultural insurance systems to divert the drought risk

Drought risk insurance is high risk, low income in comparison with other types of insurance. However, Spain and Portugal have developed a good system through collaboration between insurance companies and the Government. This followed on from a law on agricultural insurance in 1978. The government subsidises the premiums, at different levels ranging from 20-50% according to the crop (and differs between male and female farmers), and provides reinsurance to the insurance firms. This has proved to be very effective at sharing risks and has avoided the need for the government to pay out emergency relief. Farmers who do not take out this insurance will not get any relief from the government in the event of any drought.

(6) Enhanced public awareness education

Public awareness of water-saving is essential, and this starts from a very young age and is comprehensive. Full details are provided and information is available to everyone. All forms of media are used.

2.8.3.3 Lessons for drought management in China

(1) Speed up the transformation of management mode

Although emergency management through relief aid projects, to drought-affected populations with bailout funds or other forms of support is very common, this kind of passive management is seriously flawed, because it does not help beneficiaries to change their behavior or resource management practices as a condition of receiving assistance. Reliance on Government aid can reduce the enthusiasm of the affected people to get involved drought prevention and mitigation, and it is not conducive for encouraging producers to invest in enhancing the ability to cope with drought and self-reliance. It is therefore recommended that drought risk management capacity is further strengthened and the transformation of approaches accelerated.

(2) Promote institutional reform

In Spain and Portugal, all agencies associated with drought are subordinate to the Ministry of the Environment, which avoids the issues of duplication or lack of coordination of efforts. This contrasts with the situation in China, where although the FCDRHs are the drought relief authorities, there are many organizations involved in many different sectors: Ministry of Water Resources, Ministry of Agriculture, Weather Bureau, and The Ministry of Civil Affairs among others. In times of drought emergency and drought relief organizations can be coordinated efficiently and in an orderly manner at all levels, but given the slow development characteristics of drought emergencies, this linkage does not meet the economic and social demands.

Therefore, in addition to emergency drought relief functions, functions of drought resistance need to be strengthened in routine times (Normal stage), breaking through systematic obstacles from top to bottom, establishing multi-sectorial integrated coordination mechanisms.

(3) Enhancing drought risk monitoring

At present, some work on drought risk monitoring had been carried out, but it is not comprehensive so there is a need to strengthen meteorological, hydrological, agricultural, industrial, water intake and water supply monitoring systems associated with drought, and to improve dynamic (real-time) monitoring capacity for drought- related information. This should have a complete national coverage and reasonable layout, with a good network of information and resource sharing.

In addition to the establishment of drought information monitoring system, even more important is the creation of information-sharing mechanisms among the various relevant departments. At present, various inter-departmental information sharing can be done more smoothly in times of drought emergency communication, but this is difficult to achieve in ongoing drought management. Information resources are managed by the various administrative departments, with "islands of information." There are obstacles to receiving timely and relevant information from each sector to provide effective early warning for drought prediction, with objective and scientific assessment of drought risk. Therefore, the State should formulate as soon as possible and introduce drought-related information-sharing arrangements and develop data/information-sharing networks. It is essential to break the departmental segmentation of information resources as well as geographic segmentation. Establishment of interagency information-sharing mechanisms is needed to achieve the transformation from information resources to shared use.

(4) Strengthening water-saving management.

The temporal and spatial distribution of water resources in China is extremely uneven, with insufficient water resources per capita at just 30% of the world average. With global climate change and increasing demand for water, the water resources shortage situation is increasingly dire. The traditional water management model has led to increasing water demand, which cannot be met on a sustainable basis. There now needs to be a paradigm shift to water demand management, recognizing water resources capacity constraints, optimizing the industrial structure, improving water use efficiency, strengthening soil and water conservation, paying attention to water conservation and water information. In determining the scale of economic development in many regions, water constraints have not been appreciated, and its consequences have seriously affected economic and social development.

(5) Improving emergency response capabilities

In Spain the core of the management plan is to identify and develop appropriate response measures in advance, so that when droughts occur, responses can be targeted, rapid and effective. Although China has carried out similar work in the form of a drought relief preparedness system, this has exposed a lot of problems, mainly reflected in the lack of scientific reasonableness and operability of the plan. At present, China has completed the planning for drought resistance in many places, but this is often a formal content without a specific, in-depth and clear plan for response measures and it has poor operability. Different levels of emergency response, project scheduling, emergency engineering and non-engineering measures for water provision, responsibilities of related departments, must be clear and specific, highly targeted and operable.

(6) The system of drought insurance

The mode of interim relief in response to natural disasters in China has for long been to provide compensation for disaster losses to a certain extent, but this is a drop in the bucket compared with the true value of disaster losses. In Spain, and Portugal and elsewhere internationally, disaster risk insurance system is an important measure. Although agricultural insurance does cover drought risks in some provinces in China, in most cases the damage caused by drought cannot be adequately compensated by agricultural insurance. It is difficult to provide insurance to transfer the risk of drought, especially in the case of severe droughts. There is an urgent need establish a system of drought insurance, suited to the characteristics and law of drought in China. This will result in sharing of disaster risk between policyholders, insurance companies and the Government.

2.8.4 Provincial Workshops on DMPs (March 2014)

As discussed earlier, an initial provincial workshop was held in Lanzhou, Gansu Province in early September. Representatives from Liaoning and Sichuan provinces also attended. This was followed in March 2014 with further workshops to introduce drought risk management and risk-based drought management planning processes, to obtain more information and perspectives from provincial and local levels, and to gain agreement on how to introduce risk-based management methods into existing system and get it improved. Thus this was a further element of the capacity-building program during the TA implementation.

The draft provincial drought management plans for the three pilot provinces were essentially validated by the local officials as being good initial drought risk plans, with the understanding that significant additional work was necessary to put them into operational status. Many of the same issues and constraints raised during the September workshop were discussed again in these workshops. Data sharing and collaboration problems were raised as significant concerns, especially with the meteorology department. The lack of funding for full time drought management activities is a major issue and constraint. Local drought officials indicated that a national restructuring of funding for drought risk management as well as national technical direction and standards are required for them to do drought risk management seriously. They also indicated that significant additional training in drought risk management will be required to allow production of the local DMPs. Local government decision makers have difficulty assessing and investing in non-structural measures and are focused on engineering solutions.

2.9 Program for Public Education and Awareness on Water Saving

Refer to Appendix J, Approach to Water Saving Public Education and Awareness Program, Implementation Schedule as well as separate report, Water Saving Public Education and Awareness Program

2.9.1 Overview of requirements

Water saving is an essential strategy and policy to resolve drought and mitigate water deficit. A true implementation of water saving strategies calls for conscious efforts from the whole society. According to the survey results and information obtained from the workshop, either the public awareness or the water saving activities of the whole society need to be raised further. Although some meaningful work has been carried out in raising public awareness of water saving, it is generally not lasting and systematic. The past works have been more in the form of a short term campaign. Raising the public awareness of water saving in the whole society is a long term job. This project brings up methods and activities to raise public awareness of water savings from the perspectives of education objects, contents, methods and forms comprehensively and systematically.

First it is important to recognize that water saving is not the same as drought management. Water-saving should build resilience to drought, but additional and different actions needed for drought risk management. Awareness of both water-saving and drought risk management is needed. The ToR call for a water-saving awareness program, but the study indicates an even greater need for drought-risk management awareness.

Awareness of water-saving is not sufficient as there are many constraints to putting this awareness into practice. These constraints to water-saving are well recognized: lack of regulations or weak enforcement, notably of abstraction permits; limited data on actual abstractions and little auditing of the abstraction permit system; inflexible management of surface irrigation, with a need for large-scale reforms before individual actions can be effective; high initial and recurrent cost of water savings methods, with little incentive to use them; and lack of sufficient technical knowledge to implement them. Nevertheless, some individual actions can be undertaken in isolation: motivated individual households, farmers and industry leaders can be encouraged to do so by much more carefully focused awareness-raising, with more detailed information than is currently provided. However, this will not stimulate widespread action, and further general awareness-raising without addressing the other constraints will lead to frustration and boredom – ‘awareness fatigue’ - rather than action.

The distinction between water saving in general and water-saving to cope with a forecast or on-going drought is critically important. ‘Normal’ water-saving actions – improved irrigation management, additional water infrastructure, water-efficient industrial processes etc - will increase resilience in the face of a drought, but additional drought-related water-savings are needed. Awareness of the reasons for this is important, and should be the focus of any public awareness program.

There needs to be public awareness of topics such as: drought risk management; the triggers for initiating drought actions; actions when trigger levels reached (such the need to reallocate water from low to high priority uses; to reduce irrigation supplies during the crop season; to ration urban water use; to make arrangements for providing emergency water supplies; etc.); the need for abstraction permits and how they are managed; and so on.

Water education in schools will have a long term impact through ensuring a wider understanding of water issues in society as a whole. It should also have a short-term impact by influencing parents through their children. Translating this knowledge into action is equally constrained by other factors mentioned earlier.

As the concepts of drought risk are either new or subtly different from current practice for drought management, awareness raising and capacity-building amongst government personnel and technical staff at all levels is also important to ensure a common understanding and awareness of the issues and how they can be resolved. This is required not just in the FCDRH, but also in other related departments and levels of local Government. This is addressed in the capacity-building program.

2.9.2 Key issues

Target groups
There is a need to improve the awareness of water-saving of the whole society. Society consists of different people, different groups of people with different water use behaviour, and different water-saving methods. Awareness-raising on water conservation of different groups of people needs a specific approach and content for each group. Generally speaking we can distinguish the following target groups:

- **Farmers**; agriculture has the largest potential for water saving. the need for improving water-saving awareness of farmers in water activities in response to drought and water shortages is self-evident, although the constraints for implementing this knowledge must be recognised and addressed;
- **Children and students**; they are the future of the society, so enhancing students' awareness of water conservation is fundamental for raising public awareness of water savings;
- **Urban residents**. with the gradual increase in the level of urbanization, and a rapid increase in water consumption of urban residents, improved awareness of the importance of water conservation of urban residents is important;
- **Industrial enterprise managers and workers**; 23% of the country's total water consumption is for industrial water use. It is important to improve the awareness of water conservation of general managers and workers of industrial enterprises.

Contents
Raising the public awareness of water saving not only includes educating the public about water resources and drought, but also improving their capability to put their knowledge into practice and use water saving skills and techniques. Consequently, compiling different audience-oriented training and education materials for different public group is needed. However, this is materials are not yet available in the required format. Therefore, it is proposed that three pilot provinces should organize related department and research

institutions to compile audience-oriented water saving education materials based on the actual situations of water resource and drought in each province to raise public awareness of water saving.

Form and methods
World Water Day and China Water Week campaigns provide some opportunities to enhance water saving public education, but more detailed programs for different target groups are also needed:

1. **Farmers:** water conservation education through radio and television propaganda and programs, focusing on knowledge and common sense of saving tips for water- life, and for agricultural water -saving knowledge and technology, because television and radio broadcasting is the most effective medium for the majority of farmers. In addition to water saving education by television, distribution of water saving manual for agricultural water-saving by farmers is essential.
2. **Children and students**: to carry out water-saving knowledge and education through school. In primary and secondary school textbooks to include water saving knowledge and basic information. Primary and secondary water -related education is essential, from a long-term perspective, to ensure future public awareness of water conservation.
3. **Urban residents**: Water saving education and propaganda for urban residents is best through newspaper articles as most urban residents have the habit of reading newspapers daily. So proper newspapers with long term and regular water-saving columns to provide information about water saving knowledge in daily life would raise the public awareness of water saving.

Raising public awareness of water saving is a long term work, and it requires proper communications that fit the target audience in order to be effective. The method and educational contents needs to suit different target social groups. For agriculture water saving technical manual, the focus is to introduce water saving knowledge that closely related to the rural household production and domestic activities including water saving planting techniques, agriculture irrigation water saving techniques, and drought tolerant crop selection, etc. For water saving to be included in the school education, the focus is to introduce the functions of water in the biosphere, the hydrological cycle, the limited and precious nature of water, water preservation and basic water saving knowledge. For the water saving education on television and internet, the focus is domestic water saving tips and techniques. For the water saving education on the radio, the focus is to introduce international and national new industrial water saving technologies. For the water saving education on the newspaper, the target audience is urban residents; therefore the focus is water saving in urban living and water price policies. For different areas, proper water saving education contents should incorporate local natural and geographical conditions.

Funding for propaganda and educations
The program needs both regulatory and financial support. Although the benefits are long lasting from both social and environmental perspectives, this is not a profitable activity in the short term. Therefore, the government must issue related policies and develop financial support means to guarantee the implementation of water saving propaganda and educations in order to improve the public awareness of water saving gradually and better react to the drought events.

According to the institutional and water user survey results and differing water use needs and knowledge in the general public, a drought risk awareness public education and awareness plan has been proposed. The work program mainly includes suggestions on different public awareness and education organizations, groups, and education and public education and awareness methods, education and public awareness contents, as well as budgeting for education and public awareness activities.

2.9.3 Awareness Program

The overall contents and methods for the programs for the various stakeholders are listed below, although not all components will be included in each case.

Focus Group		Methods/Media	Contents
Student	Elementary school (5-12 years)	• Class • Quiz • Posters • Excursions	• Basic functions of water • Basic knowledge of water cycle • Basic knowledge of water pollution • Basic knowledge of water uses
	Middle school (12-18 years)		• Basic functions of water • Basic knowledge of water cycle • Basic knowledge of water pollution • Basic knowledge of water uses and efficient ways of managing these uses • Basic knowledge of water and soil conservation • Basic knowledge of drought
Farmers		• TV program • Agriculture water saving techniques brochures • Technical manual	• Basic knowledge of water savings • Basic knowledge of drought risk management • Understanding of drought triggers and actions • Agricultural actions to be taken when a drought is forecast or occurring • Water demand for different crops, including knowledge of water demand during key growth periods and the impact of water stress at different growth stages • Agricultural techniques for water saving and water conservation • Irrigation techniques for water saving • Basic knowledge of irrigation system management and irrigation scheduling to maximize water use efficiency
Urban residents		• TV program • Campaign • news column • internet • social media • targeted emails • bill inserts from water companies	• Basic knowledge of water cycle and the limitation of total resources • National and local water resources situation • basic knowledge of water saving in an urban context • domestic water saving knowledge and tips • water saving equipment in kitchen and washroom • basic knowledge of water pollution • water saving regulations and policies
Managers in company		• Company brief • Journals • Internet • Related documents	• water price information • knowledge of water-saving techniques • wastewater treatment techniques • greywater reuse techniques • water reuse techniques • related innovation in water saving • national and international advanced water saving techniques • national and local water saving regulations and policies

2.10 Developing a Plan for Managing Drought Risk in Each Pilot Province

Refer to Appendix K. Prototype Provincial Drought Management Plans, including Actual DMPs for Liaoning, Sichuan and Gansu Provinces which are supplied separately (Liaoning in dual languages, with Sichuan and Gansu in Chinese only)

2.10.1 Background

The previous sections in this chapter describe the work done in this TA which lead up to the final step of preparing drought management plans and managing drought risk. As also noted earlier, droughts in China are usually managed after they occur, as a response to problems. There are many reasons why proactive approaches are rarely used to predict, mitigate and manage drought potentials prior to their occurrence. Such “crisis management” can usually be characterized as follows:

- Reactive, post-impact
- Poorly coordinated
- Untimely
- Ineffective
- Poorly targeted
- Decrease self-reliance causing greater vulnerability
- Rewards the poor resource manager for the lack of planning
- Disincentive for improved resource management
- Discourages self-reliance, promotes dependence on government and donors

In contrast, some of the components of a risk based approach are as follows:

- Proactive
- Provides information and training for decision support
- Supports sustainable development principles
- Increases self-reliance for individuals, communities, sectors, and regions

2.10.2 Conceptual Framework for Drought Risk Management Planning

The TA team has developed a set of standard protocols for drought management plans (DMPs) based on China law and international best practices. The TA DMPs have been developed to provide an effective and systematic means for the pilot provinces to reduce the impacts of water shortages over the short or long term. The DMPs outline a mechanism for coordinated drought monitoring, impact assessment, response to emergency drought problems, and mitigation of long term drought impacts. There are three major components of the DMPs: mitigation, response and vulnerability assessment.

Specific goals must be developed for DMPs in China, and then tailored to the issues and needs of the specific pilot provinces. Some typical goals might include issues such as:

- Improve Water Availability Monitoring and Drought Impact Assessment
- Increase Public Awareness and Education
- Augment Water Supply Through Mechanisms to Transfer Water from Areas of Surplus to Areas of Shortage During a Drought
- Coordinate and Provide Technical Assistance for Province, Local, and Watershed Planning Efforts
- Reduce Water Demand/Encourage Conservation
- Reduce Drought Impacts to China's Economy, People, Assets, and Environment

- Develop Intergovernmental and Interagency Stakeholder Coordination
- Evaluate Potential Impacts from Climate Change

Other potential goals could include specific loss reductions in hazard mitigation such as:
- Reduce the loss of life and personal injuries from natural hazard events
- Reduce damage to province critical, essential, and necessary assets
- Reduce damage to local government assets
- Reduce province and local costs of drought response and recovery
- Minimize economic losses
- Reduce damage to personal property

The following subject areas require investigation before the drought management plan can be prepared:
- Developing locally appropriate indicator statistics in order to determine the thresholds between the four official drought classes
- Vulnerability assessments by sector
- Developing operational management options (mitigation measures) to apply when above a threshold, i.e., during a drought event
- Identifying longer term mitigation measures to make the community more resilient in the face of meteorological drought. (Such measures would fall outside the scope of the drought management plan).
- Operational planning includes prioritizing mitigation measures – a process driven by policy but adapted to the local context with stakeholder participation.

Drought Relief Regulations (DRR) at the national level were released in 2009, supported by Drought Classification Rules in 2009. However, these documents have yet to fully drive a risk management approach to drought management and response, and this project is designed to assist the FCDRH and MWR in their efforts to facilitate a more scientific and risk management approach to drought management in the provinces.

The IWHR guidance on drought relief plans (Compilation Guidelines for Drought Response Plan (SL 590-2013)) was issued by Ministry of Water Resources on 2013-01-22 and came into force in 2013-04-22. This guidance provides a blueprint for comprehensive planning and managing droughts once they are underway. Since this guidance is relatively new, the existing drought relief plans of the three pilot provinces have not yet been updated to comply with the new guidelines. The TA team recommends overlaying a drought risk planning approach on the front end of the existing drought risk planning protocols: it does not propose immediate replacement of these existing systems. As the drought risk management processes mature, some of the triggered actions in these plans should also focus on risk reduction, but this is a long term proposition. Appendix K includes a summary of the identified drought severity levels in the existing drought relief plans in the three pilot provinces.

There are also a variety of potential constraints to implementing drought risk management activities in the various institutional tiers, including:
- Drought funding and budgets are tied to drought relief activities and there is insufficient budget and staff to perform drought management activities in Normal and Pre-Drought time periods. It is noted that much of the required monitoring for drought during these periods is already being performed but not put into a drought risk management system or context.

- Collaboration and cooperation amongst water management agencies remains problematic, and will be more of a problem at times when there is not a definite drought relief crisis.
- There is some concern that staff at levels below the provincial government to adequately manage DMPs at municipal and county levels do not have sufficient capacity: additional capacity development and training will be necessary. Once their capacity is developed, this should be no further reason to keep all drought management decisions and actions at the provincial level, as IWRM demands that decisions be made at the appropriate level by those most impacted.
- It will take significant time for municipal and county level FCDRHs to develop and implement adequate DMPs so there must be a planned phasing time for the provincial drought management plan to begin to share roles and responsibilities with local jurisdictions as these plans are developed.
- Local municipal and county level officials will also require time to work with the various sector water management officials (urban water supply, industry, agriculture) on their sectorial drought management plans so that they can be connected to the municipal/county level DMPs.

As a result of these constraints the provincial DMP may be essentially a ‘command and control’ DMP for local areas, until the municipalities and counties develop adequate local DMPs and improve their technical capacity to manage drought proactively. The alternative would be for the provincial FCDRH and MWR to provide additional resources and technical assistance to the local levels in the interim period so that they able to prepare and implement local DMPs in pilot areas. The TA team is recommending both a long-term strategy of tiered drought management between the provinces and the local jurisdictions and a short-term strategy of using the new integrated drought database for overall risk based drought management at the provincial level. The short-term scenario merely involves the provincial FCDRH assuming more of the risk reduction and mitigation measure work at local levels during interim period until the municipal and county level DMPs are fully operational.

The proposed tiered provincial and local drought management plans should include consideration of the following actions:

- Collect and analyze drought-related information in a timely and systematic manner.
- Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.
- Provide an organizational structure and delivery system that assures information flow between and within levels of government.
- Define the duties and responsibilities of all agencies with respect to drought.
- Maintain a current inventory of government programs used in assessing and responding to drought emergencies.
- Identify drought-prone areas and vulnerable economic sectors, individuals, or environments.
- Identify mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.
- Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
- Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the World Wide Web).
- Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
- Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state or region.

2.10.3 Provincial DMPs

A prototype provincial drought risk management plan has been prepared using references from a US State Drought Management Plan and ideas from UK regional drought management plans while recognizing the local institutional structure. Appendix K contains an annotated outline of this prototype DMP. Appendix K also contains the provincial drought management plans prepared for the three pilot provinces of Liaoning, Sichuan and Gansu. The approaches used in the DMPs are explained in the DMPs and summarized in the draft drought risk guidelines, and thus are not repeated here.

The Liaoning DMP has been translated into English while the Sichuan and Gansu DMPs have only been completed in Chinese. These draft DMPs were reviewed with the provincial officials in workshops in March 2014 and June 2014 and there was general consensus that the approaches outlined in the DMPs were practical, but there were many constraints to full implementation in China as outlined above. In addition, it would take quite some time for the local municipal and county level DMPs to be produced work in concert with the provincial DMPs, as well as the required local sectorial DMPs (urban, agriculture, industrial). Sufficient funding and a national re-emphasis on drought risk management from drought relief is required as well as capacity building on all levels to implement the approaches fully.

2.10.4 Municipal and County Level DMPs

Refer to Appendix L, Generic Local Level Drought Management Plan

The implementation of drought risk theory in China must be performed in such a manner that is cognizant of drought management institutions and constraints. This includes recognition that water-related risk mitigation and water conservation measures are more properly managed in at the level of local water supplier drought management plans.

Provincial drought management plans should provide an overview of historical drought-related vulnerabilities throughout the province; guidance on the use of risk based proactive approaches to drought prior to the drought actually beginning; tools to assist in the production and implementation of the local water supplier DMPs; and a regional perspective and oversight when droughts extend to multiple local jurisdictions.

In the long term, however, provincial DMPs in China cannot remain “command and control” drought management plans which attempt to outline detailed risk reductions and water conservation and control programs at the local scale. Such issues are intrinsically connected to water abstraction and control programs that are part of local water management control systems. As was shown in the DFID WRDMAP program, municipal level drought management plans can contain the detailed triggers and actions necessary to manage drought proactively as it is occurring, rather than merely a response to drought after it is underway. However, this will mean a major change in the way FCDRHs view their mandates and standard operating procedures at all levels.

The IWHR guidance note on drought relief plans is a comprehensive planning tool for managing droughts once they are underway. The TA team proposes to overlay a drought risk planning approach on the front of the existing drought risk planning protocols, not propose immediate replacement of these existing systems. As the drought risk management processes mature, it is likely that some of the triggered actions in these relief plans will also focus on risk reduction, but this is a long term proposition.

The TA is recommending a long term strategy based on IWRM and drought management best practice to tier drought management decision making and allow local decision makers to implement appropriate risk reduction and mitigation measures. Given this long-term concept, the TA team reviewed some existing municipal level drought relief plans in all three pilot provinces. Appendix L provides a summary of the drought severity levels from municipalities in all three pilot provinces as examples of current municipal level drought relief plans.

As outlined in Appendix K on the provincial DMPs, the provincial drought management plan has been developed under a presumed future tiering of drought management responsibilities with linked and specific roles and responsibilities at each layer of the process. Detailed water management decisions in IWRM are made at the lowest practical water management level. Given this framework, the provincial plan and local plans are part of an overall hierarchy of drought planning. The lowest level would be water companies, industries and agricultural interests. Their drought management activities are coordinated by county level and municipal level drought planning. The county and municipality level drought planning is managed and coordinated by these provincial plans, and the entire process has had guidance and oversight from the national level drought management process.

Since the local practice has been to develop drought response or relief plans at various levels, there will need to be some phasing in of the concept of drought management planning at all times, even during Normal conditions. There may be an interim period where drought management and drought relief plans exist simultaneously for the local level, with the idea that the drought management plans should eventually supersede the need for separate drought relief plans.

The TA team assessed some examples of municipality and county level drought management plans and found them to again address only drought relief, not forecasting and drought risk reduction prior to droughts. Based on the assumed tiered approach and interconnections with the provincial DMPs, the project team has assembled a prototype local municipality or county level drought management plan using a template from the United States as well as lessons learned from the WRDMAP project, including the drought management plan produced for Chaoyang Municipality in Liaoning Province during that project.

This prototype or template form of drought management plan provides examples and ideas for the contents of such plans using approaches that are common in the USA and the UK while taking into account local institutional arrangements. Although this municipality/county level DMP was not a requirement of the project TOR, the TA team considers it a vital link in the risk-based drought management planning process proposed for China. Appendix L contains the entire prototype municipal/county level DMP. No actual municipality or county level DMPs have been produced by the TA team, as this is beyond the TOR. It is understood that county level drought planning is subordinate to municipality level drought planning but the generic features of the prototype can be applied to either level.

2.11 Guidelines for Implementing Drought Risk Management across China

Refer to separate report, Proposed Drought Risk Management Guidelines

The drought risk management guidelines are a key output of the TA program and summarize the TA findings and approaches relevant for broader application across China. Some of the other major activities of the TA are summarized in the guidelines, with lessons learned for full development of the risk-based

drought management approaches. The guidelines complement the drought management plans produced in the pilot provinces; the Liaoning DMP is attached to the guidelines as an example of drought risk management for China.

Rather than duplicating the methods used in the Liaoning DMP, the guidelines cross-reference sections to illustrate how the concepts were applied in the TA. The guidelines aim to cover drought risk management approaches with overviews of the following topics:

- Conduct of basic surveys relative to institutional capacity and water users
- Tools for Managing Drought on Proactive Versus Reactive Basis
- Comprehensive Drought Databases for drought risk assessment
- Methodologies For Analyzing Drought Hazard And Mapping Drought Risk
- Drought Risk Scenario Analyses
- Drought Forecasting Systems
- Early Warning Systems to Guide Drought Risk Planning
- Cooperation of Agencies for Proactive Drought Risk Management
- Drought risk management planning at provincial and lower levels

The pilot province DMPs first employed drought risk analysis which is the study of potential effects on the drought-threatened areas based on likely drought probabilities and drought intensity. In general, when the intensity of meteorological droughts is greater, the frequency is higher, which means the greater hazard, the risk is also greater. The provincial DMPs make hazard analysis from meteorological or hydrological aspects such as:

- Meteorological factors such as precipitation contours.
- Drought frequencies
- Dry season frequency analysis
- Water resources availability, in total and per capita by sector

Following this review, the DMPs explored drought exposure analysis. This section assessed provincial drought history and issues such as:

- Changes in cropping patterns over time.
- Drought impact distribution against various drought years, by sector including agriculture, urban water supply and rural water supply.

Based on this background the drought vulnerability assessment was conducted. Vulnerability analysis is the core content of drought risk analysis, focusing on drought-resist capacity against drought hazard from the natural environment and the socio-economic environment. The level of vulnerability to drought can "enhance" or "attenuate" the effects on the disaster, and can objectively reflect differences in drought response, mitigation and resilience. In general, when the vulnerability is larger, the risk of disaster is higher. This assessment looked at:

- Socioeconomic capacity to resist drought.
- Water Infrastructure capacity to resist drought
- Other capacity to resist drought (such as drought information collection infrastructure, inadequate station network deployment, and low degree of automation)
- Drought preparedness and mitigation systems

Based on the drought hazard analysis, exposure analysis and vulnerability analysis, the provincial DMPs then performed a drought risk assessment (DRA). The DRA included factors such as:

- Historical record of droughts
- Drought risk mapping

The Ministry of Water Resources issued at the end of 2008 the new "Standard of Classification for Drought Severity SL424-2008", implemented in March 2009. This standard applies to most parts of the country as a criterion, including assessment methods and grading criteria for agricultural drought, pasture drought, urban drought, difficulty in drinking water caused by drought, and also indicators for regional drought assessment. The proposed drought risk planning framework uses Standardized Precipitation Index (SPI) and river and reservoir anomalies for early warning of **potential drought** to initiate early action risk reduction and water conservation measures, while these SL424-2008 indices are recommended as triggers in drought management plans during various levels of **actual drought**.

Agricultural drought assessment indicators include relative soil moisture, precipitation anomaly percentage, number of consecutive days without rain, crop water stress ratio, and number of days without water. Livestock drought assessment indicators include precipitation anomaly percentage and the number of consecutive days without rain. Urban drought assessment indicators are water deficit rates for cities. Drinking water drought assessment indicators are basic drinking water consumption and drought duration. The classifications in SL24-2008 are different for some indicators in accordance with the different divisions of the North and South in China, or in accordance with the different levels of the national, provincial, municipal and county.

The three pilot provinces all have daily drought monitoring and drought indicators currently used in the daily work. The project applied the SL24-2008 indicators which were screened modifications and additions to current practices. However, provincial FCDRH or MWR does not currently take advantage of these drought prediction analysis indicators to establish an early warning system, but they are reportedly used in their daily work. The TA has recommended an interlinked system of provincial indicators at all stages including Normal, Pre-drought, and Drought (Levels IV to I) using these SL24-2008 indicators plus international best practice for short-term drought forecasting, more or less as a decision-directed drought prediction. How these indicators are used to trigger actions are discussed in the section on DMPs, as well as the related goals of provincial triggers and warnings to local level DMP triggers and actions. [*Refer to Liaoning DMP triggers as example*.]

The TA pilot province drought management plans were developed under a presumed **future tiering of drought management responsibilities** with linked and specific roles and responsibilities at each layer of the process. Detailed water management decisions in IWRM are made at the lowest practical water management level. Given the system proposed by the TA, the provincial plan and local municipal/county plans are part of an overall hierarchy of drought planning. The lowest level would be water companies, industries and agricultural interests. Their drought management activities are coordinated by county level and municipal level drought planning. The county and municipal level drought planning is managed and coordinated by these provincial plans, and the entire process has had guidance and oversight from the national level drought management process. Provincial plans need also to address the management and coordination of large scale droughts affecting multiple municipalities and/or counties. [*See figure ES-2 at beginning of report, as well as figures 2.4 and 2.5*.]

Many of the local indicators can be found and used directly from SL424-2008, and complementary triggered risk reduction and mitigation measures are required. Depending on the severity of the potential drought, additional triggers for re-allocation of water abstractions may be considered with the Water Affairs

Bureau based on the drought risk assessments and triggers outlined in the local DMPs. Although there appears to be somewhat comprehensive reporting during Normal operations, little is actually triggered or done with this information unless the drought damages begin and an actual drought level declaration is declared (slight Level IV moving up to I).

The key aspect of the approach is the pre-planning of appropriate risk reductions, mitigation measures, and potential water reallocations during Normal Operations that are ready to be employed at various Pre-Drought and Drought levels. In this way the potential or actual drought impacts can be hopefully be avoided or greatly reduced as well as the required drought response activities. Currently, the FCDRHs at various levels are doing early action drought relief planning work but little in the way of monitoring drought indices, predicting droughts and taking early action risk reduction and mitigation measures based on the predictions. Given this background, the TA is not proposing improvements to an existing decision support framework for drought relief but proposing a completely new way of doing business with drought management activities at all stages of the drought cycle (Normal, Pre-Drought, Drought, and Post-Drought).

3 Summary of TA, Achievements and Recommendations

3.1 Summary

Drought management has, in the past, concentrated on drought relief measures, with an emphasis on structural emergency water supply. Pre-drought planning is largely limited to the development of emergency water supply sources and provision of drought relief measures, but there little focus on predicting the onset of drought and taking pre-emptive risk reduction and mitigation measures which might reduce the impact of drought as it increases in scope and scale. This requires a new strategy for drought risk management, to change from passive drought relief to proactive drought risk management. This would minimize economic losses as well as social and environmental impacts.

The TA8185 project reinforces the recommendations of the ADB Phase 1 TA project that China should move toward drought risk management and away from reactive drought relief as the primary mission of the FCDRHs. Based on international best practice as well as the layered FCDRH structure, the project suggested the implementation of a tiered approach to drought risk management with interlinked responsibilities at the FCDRHs at state, provincial and local (municipality/county) levels.

Drought management activities and risk reduction activities under the drought risk management approach are best undertaken by local water sector users (urban water supply, agriculture, and industry). These should act in accordance with the requirements of municipality and county-level FCDRHs, working under the guidance of provincial and ultimately national FCDRHs. The main responsibilities of municipality and county-level FCDRHs include:

- Preparing local level DMPs, including oversight on production of sectorial DMPs.
- Receiving provincial meteorological information/indices from provincial FCDRH on potential pre-drought or actual drought conditions and implement local DMP actions including overseeing the implementation of sectorial DMPs from urban, agriculture and industrial sectors.
- Coordinating area monitoring, triggers, and risk reduction and mitigation measures found in local DMPs and detailed DMPs of major water user groups.
- Coordinating and reporting activities to province and public.

The various DMPs at the local municipality and county level will take some time to develop and implement, and thus provincial DMPs should provide a ‘command and control’ function in the interim period. Once the local planning has been completed, however, the provincial level FCDRH responsibilities would become:

- Preparing provincial DMPs (including drought risk maps and vulnerability assessments, database, early warning system, triggered actions including risk reduction and mitigation measures, etc).
- Based on provincial DMPs and management of the integrated drought database, sending provincial meteorological information/indices to potentially affected local areas to trigger pre-drought and actual drought activities.
- Reviewing and coordinating area monitoring, triggers, and risk reduction and mitigation measures from the DMPs of subsidiary municipalities and counties.
- Coordinating and reporting activities to province and public, as well as SFCDRH, especially for widespread droughts affecting multiple local jurisdictions.

The major roles at national level should then include:

- Determining resource needs with State Council (to allow training and capacity building as well as drought risk management activities at all stages of drought cycle instead of only during drought relief).
- Developing research, regulations and guidelines or drought risk reduction and management.

- Coordinating planning and response levels on major multi-province or widespread concerns.

Many of the local DMP indicators can be found and used directly from SL424-2008 (Standard of Classification for Drought Severity), and complementary triggered risk reduction and mitigation measures are required. Depending on the severity of the potential drought, additional triggers for re-allocation of water abstractions may be considered with the Water Affairs Bureau based on the drought risk assessments and triggers outlined in the local DMPs. Although there appears to be comprehensive reporting during Normal operations, little is actually done with this information until drought damage begins and an actual drought level declaration is declared (slight Level IV moving up to severe Level I). Current Drought Relief Regulations (2009) call for both provincial and local level drought relief plans, but there has been uneven performance up to now on the production of such plans. The proposed drought risk management planning does not replace the current drought relief protocols but merely adds an early action prediction and mitigation strategy to attempt to reduce potential impacts that will hopefully reduce the need for relief activities.

The key aspect of the approach is the **pre-planning** of appropriate risk reduction, mitigation measures, and potential water reallocations during Normal Operations so that they are ready to be used at various Pre-Drought and Drought levels. In this way the potential or actual drought impacts can be greatly reduced as well as the drought response activities required. Both supply-side and demand-side approaches are important for risk reduction and mitigation strategies, with incremental stepped approaches applied at Pre-drought stage and increasing with actual drought stages.

The three pilot provinces are now ready to implement the program but will need funding and support to further expand the detailed requirements of the provincial DMPs, to develop the municipal and county level DMPs, and to encourage the production of the sectorial DMPs. The pilot province DMPs provide a good starting point for the recommended process, and the model local DMPs produced by the TA project provide a good template for the development of the municipal and county level DMPs. However, this will take budgeting, time and capacity building. As noted previously, the provincial DMPs may need to serve a ‘command and control’ function until the local DMPs are implemented.

Implementing DRM the three pilot provinces and extending it beyond them will depend on addressing many issues and potential constraints to the full implementation of drought risk management. It is hoped that this project provides some impetus to move other provinces in this direction. The project deliverables can serve as important tools for raising awareness of the concepts and implementation needs of drought risk management anywhere in China. The next section provides some recommendations to address some of the identified constraints to moving toward full drought risk management.

3.2 Achievements

3.2.1 TA Activities

The TA project successfully developed and organized the necessary tools and “building blocks” necessary to move forward with DRM in China, but there are structural issues related to funding and management direction that are likely to delay any move toward full implementation of the concepts. The use of the TA products can go a long way to raise awareness of national and provincial officials on the need to move into this direction under follow-up training programs.

The following activities have been completed on the project:
- Institutional and water saving surveys have been completed in all three pilot provinces and the information has been analysed relative to impacts on other project activities, especially capacity building and public involvement programs.
- Prototype drought database for Liaoning Province has been developed. Socio-economic data may be added to assist with risk mapping and vulnerability assessment. Recommendations have been made for how to improve databases in other two pilot provinces.
- A combined provincial level workshop was held in Gansu province on 5 September. There were approximately 30 people in attendance including representatives from Sichuan and Liaoning provinces.
- Workshops were held in Sichuan and Liaoning Provinces in March 2014 to present the draft drought management plans for the provinces. There were approximately 30 people in attendance including representatives from Sichuan and Liaoning provinces.
- A 'tiering' of drought management planning levels and responsibilities was developed. A prototype municipal or county level drought management plan has been prepared and the model provincial DMP has been prepared for use in the pilot drought management plans with clear links to municipal and county level DMPs developed, as well as links to sectorial DMPs.
- A linked set of drought information indices at provincial level and drought warning systems at lower levels has been developed and tested.
- Proposed drought risk mapping systems for the three provinces have been developed.
- Drought risk management plans have been prepared for the three provinces.
- Capacity building and public involvement programs have been developed.
- Draft Drought Risk Management Guidelines have been prepared.

3.2.2 TA Design and Monitoring Framework

The TA 8185 was designed to take forward the recommendations of an earlier TA, and implement a pilot drought management strategy. The key recommendation was to shift from reactive emergency response to proactive risk management, with the FCDRHs taking a leading role in proactive drought risk management, for which they would need to institutional and organizational reform and capacity development. The project design was summarized in the Design and Monitoring Framework, which specified the following objectives:
- Output: strengthened capacity in drought risk management
- Outcome: change in drought management to risk management demonstrated in pilot province
- Impact: Improved and sustained drought management in the PRC

By the end of the TA project, the outputs should have been achieved and, provided that the assumptions in the DMF are also valid, the outcome should then be realized. The impact is a longer term target. Progress against each of these targets is reviewed in this section, together with the validity of the assumptions made in the project design. As a result some additional risks and assumptions are proposed in an expanded DMF, which is presented in a simplified form below.

The output '*strengthened capacity*' is relatively straightforward, and the assumptions stated in the DMF for achieving them could be met during the TA:
- The MWR and the governments of the three pilot provinces maintain sufficient numbers of dedicated staff with the required qualifications for the TA
- Necessary information is available on time
- All geographic sites are accessible without any government restrictions

The pilot provinces all provided good staff support for the TA project and for the workshops. Data and information was provided without a problem and all sites were accessible, although the TA work was high level, largely based on province-level information, without field investigations. However, '*strengthened capacity'* is a subjective target and although a great deal was achieved there is little doubt that more is needed – for which the TA designed a program - and there are many constraints to both strengthening capacity, and putting the strengthened capacity to effective use – which is necessary to achieve the project outcome. The proposed capacity building programme is described in a separate report and summarised in section 2.8.1. Briefly, the objectives are to promote understanding, knowledge and the ability to use this knowledge by FCDRH staff covering:

- Drought policies and regulations; technical standards
- Drought vulnerability and risk assessment
- Drought prediction and early action
- Proposed tiered drought management planning responsibilities
- Co-operation between agencies for managing drought risk

It is anticipated that a rolling program of 10 days training for around 600 people in the three provinces will be required. In order to avoid disruption to daily work, it should be undertaken in two day blocks and linked to other existing training programmes. However, there are financial constraints to implementing this program and before the outcome can be fully achieved it will also be necessary to address other key constraints to DRM, which include

- Improved coordination between agencies
- Local political commitment to DRM
- Funding for pre-drought actions

The outcome assumptions listed in the DMF are, as a result, more problematic: "*The outputs of the TA are well supported by FCDRHs, the MWR, the three pilot provinces, and other agencies*". There are also other important assumptions which were implicitly made in the project design and expressed as risks: "*Provision for staff inputs to the pilot activities is not included in the annual budgets or planned programs of the three pilot provinces*", and this in turn is dependent on assumptions about high level willingness or resources to implement DRM. The TA could prepare DMPs and guidelines, and build capacity and awareness but it was less able to influence national or provincial policy or assure the required human and financial resources. It was also limited its ability to get FCDRH staff at either provincial or local level to make use of their new capacity by implementing DRM. This was limited even in the short term by their budgetary constraints

The TA team working with participants from the pilot provinces have increased awareness and capacity in some FCDRHs and related organisations, but as indicated above there will need to be significant additional training and hands-on experience as well as other resources before this knowledge can be put to full use and contribute to the project outcome.

Thus the project made some additional implicit assumptions:

- Political commitment to DRM, with policy support at provincial and local levels
- Sustained staff capacity development and public awareness raising
- Budget support for pre-drought actions
- Implementation of an abstraction permit system
- Development of municipality and county level DMPs
- Local level drought plans (within WSCs, industries, irrigation systems etc)

The various constraints are discussed in more detail below. Although there is little doubt that DRM is more cost-effective and sustainable than Drought Relief, it requires new thinking and more resources at an early stage. Actual implementation, as opposed to just understanding and capacity to implement, also depends on other more detailed assumptions – the existence of a fully-functional WAP system, the ability to manage the politically sensitive task of planning reallocations, and to orchestrate and manage the sectorial drought management activities of water companies, agriculture and major industries. This all needs to be managed in the context of an overarching shortage of water even in normal years, and an under-resourced service even for drought relief management. Thus the project outcome is unlikely to be achieved in full in accordance with the current schedule.

Furthermore, DRM (like IWRM) requires actions to be taken at the lowest practical level. There is relatively good capacity in provincial FCDRHs, but much less at county level, and it will take longer to build sufficient capacity, address other institutional constraints, prepare local DMPs, and implement DRM at county level. The provincial FCDRHs may need to implement DRM on a ‘command and control basis’ until it can be fully implemented by local organisations.

Given the constraints to achieving the outcomes, the impact (by 2020) will only be achieved when these issues are addressed: changing the funding formula from the State Council which dictates that FCDRH work and budgets is tied to drought relief; and providing direction, guidelines and methods from higher level FCDRHs. There is a willingness to learn and apply the DRM concepts, but they can only be put into practice once the funding and direction is in place.

Table 3.1: Key Elements of an Updated Design and Monitoring Framework

Design Summary	Performance Targets	Assumptions and Risks
Impact		
Improved and sustained drought management in the PRC	Drought risk management strategy implemented in at least 15 drought-prone provinces by 2020 The number of people threatened by water shortage decreased by 30% by 2020 as compared with 2012 Grain production reduction due to drought decreased by 30% by 2020 as compared with 2012 FCDRH and MWR	The process of changing drought management is well supported by FCDRHs, the MWR, and related agencies with continuous basic research and necessary funding. The outcome of the pilots is incorporated as lessons into the ongoing process of changing drought management. ***Additional assumptions*** *Wider understanding of the benefits and methods for drought risk management, to ensure political commitment at all levels and across government as a whole*
Outcome		**Assumption**
Changes in drought management from reactive emergency response to proactive risk management demonstrated in the three pilot provinces	Tools for managing drought risk used in the three pilot provinces by 2014 A plan for managing drought risk approved and implemented in each of the three pilot provinces by 2014.	The outputs of the TA are well supported by FCDRHs, the MWR, the three pilot provinces, and other agencies. ***Additional assumptions*** *Political commitment to DRM, with policy support at provincial and local levels*

Design Summary	Performance Targets	Assumptions and Risks
		Sustained staff capacity development and public awareness raising *Budget support for pre-drought actions* *Implementation of an abstraction permit system* *Development and implementation of municipality and county level DMPs* *Local level drought plans prepared and applied (within WSCs, industries, irrigation systems etc)*
Output Strengthened capacity in FCDRHs in three pilot provinces to manage drought risk	Tools for managing drought risk developed and adopted by 2013 A program for agencies on institutional and capacity development for managing drought risk and saving water prepared and adopted by 2013 An educational and public awareness program for water users on saving water prepared and adopted by 2013 A plan for managing drought risk prepared for and adopted by each of the three pilot provinces by 2014	**Assumptions** The MWR and the governments of the three pilot provinces maintain sufficient numbers of dedicated staff with the required qualifications for the TA. Necessary information is available on time. All geographic sites are accessible without any government restrictions. ***Additional assumptions*** *Political and financial commitment to DRM, so that the newly-trained FCDRH staff can further build their capacity and put it to use* **Risk** Provision for staff inputs to the pilot activities is not included in the annual budgets or planned programs of the three pilot provinces. ***Additional Risks*** *Increased capacity is not translated into increased activity due to financing and other constraints*

This TA report outlines many of the constraints to implementation, with particular focus on the fact that funding for the drought activities is tied to relief activities which militates against proactive drought forecasting and pre-drought mitigation activities. There is a remaining question on the type and numbers of staff required in the pilot provinces to implement the TA recommendations, especially in the lower level FCDRHs and WABs. The expansion of the TA into municipal and county level drought management planning under DRM requires full-time FCDRH management staff capable of monitoring, reporting, developing and implementing risk reduction and mitigation measures under DRM protocols. It requires a comprehensive and rigorous water abstraction permitting process and an ability to orchestrate and manage sectorial drought management activities of water companies, agriculture and major industries. All of this implies not only a capacity building program of many factors, but probably an increase of staff and/or reallocation of staff from other aspects. The responsibilities and relationships of the WABs and the

FCDRHs for collecting and reporting monitoring data must be better defined and integrated so that these comprehensive tasks are properly located in staffs of both agencies.

Budgeting for FCDRHs is problematic as it tied to the quantity of drought relief work that is performed. The pilot provinces will only change this funding arrangement if there is a national restructuring of drought management budgeting. This issue was discussed at length with officials of the State FCDRH who attended TA workshops, but there was no commitment to revising the funding formula. This is likely to be dependent on higher level decisions and policy, and subject to overall financial constraints.

In summary, the TA project successfully developed and organized the necessary tools and building blocks necessary to move forward with DRM in China, but there are structural issues related to funding and management direction that will likely delay any move toward full implementation of the concepts. The use of the TA products can go a long way to raise awareness of national and provincial officials on the need to move into this direction under follow-up training programs of the IWHR and others. It is not known how quickly this raised awareness could be translated into action to resolve these constraints, but additional technical assistance could potentially help with the details of DRM implementation, especially at lower municipal and county level FCDRHs. The TA pilot provinces are keen to be involved with such additional work if funding becomes available.

The TA outlined a process of additional work including capacity development, public awareness, and production of municipal, county and sectorial DMPs that is required for the pilot provinces to implement DRM. The TA workshops indicated a high degree of willingness and support for such continued efforts, but there is little evidence that it could happen quickly. This TA confirmed the IWRM principles that such DRM decisions on risk reduction, mitigation and water reallocations during droughts must be made at lower levels.

3.3 Recommendations

3.3.1 Moving Chinese Practice from Drought Relief to Drought Risk Management

Although the concept and importance of drought risk management is understood to some degree at the national level in China, it has not been fully implemented because of constraints embedded in current institutional structures and operational mechanisms, as well as because of limited human and financial resources. A greater appreciation of the concept of drought risk management at National and Provincial levels is necessary. Drought risk management is also an essential component of the move toward Integrated Water Resources Management (IWRM) and it requires a complete re-assessment of the current reactive drought relief protocols and operations.

Implementation of drought risk management should be promoted from the central and provincial level, down to municipality and county levels. Drought risk management work involves many sectors and departments and calls for cooperation and coordination and should not solely rely on drought management departments. Therefore, the administration must truly accept the concept of drought risk management and re-evaluate current institutional structures. There is a need for greater awareness of the benefits of a risk management approach, at administrative levels of government, so that DRM is given sufficient priority and hence funds allocated. State FCDRH and MWR will need to recommend to the State Council that DRM is formally adopted as national policy, so that the State Council can issue a corresponding policy and

instructions to all relevant departments that they should allocate funds and cooperate in pre-drought stages as well as during an emergency.

Drought risk management implies a managed sharing of risk and risk management activities at various levels with water use sectors, other stakeholders and the general public. Unlike drought relief which is viewed as a top-down state government activity, drought risk management involves everyone in the assessment of the problem and the implementation of potential solutions.

In the short term, DRM is likely to be driven at a provincial level on a ‘command and control’ basis, but this should be an interim arrangement as DRM should activities should be undertaken at the lowest practical level. Local-level (municipality and county) DMPs should be prepared on a risk management basis as soon as possible, in parallel with building local capacity, so that DRM can be implemented locally under the guidance of provincial FCDRHs

3.3.1.1 Institutional Structure and Operational Mechanisms

In the past, the mission of the Flood Control and Drought Relief Headquarters (FCDRH) at all levels has been primarily involved in emergency drought relief activities and they have efficiently coordinated with related departments during actual drought emergencies. However, there is a lack of regular coordination mechanisms during normal periods (Normal and Pre-Drought stages). With insufficient sharing of data, the monitoring and early identification of droughts has not progressed sufficiently. Proactive and coordinated drought risk management has not been achieved, and the various relevant drought-related departments (including meteorology, hydrology, agriculture and civil affairs) manage on their own without coordination. This includes the establishment of different types of drought monitoring stations, strategies, plans, policies and regulations. Technical standards may duplicate or contradict each other. The drought risk management institutional structure should be strengthened to enable effective implementation of regular drought management functions at all phases of drought cycle, Normal to pre-drought, various actual drought levels (IV to I), recovery and back to Normal. Multi-departmental coordination mechanisms must be established to allow for the early prediction of potential droughts and the triggering of drought risk reduction and mitigation measures which can reduce the social and economic impacts of the potential drought. It is usually more cost effective to minimize or prevent impacts than to provide drought relief. Greater awareness by local government at each level is important to ensure that importance of these actions and the need for cooperation is recognised

According to the Drought Relief Regulation, the drought relief activities are led and organized by the state FCDRH for the whole country. The ‘drought relief’ in theory covers the whole cycle from pre-drought to actual drought and post drought phases, which can be seen from the Regulation document. The long history of FCDRHs in the drought relief activities after the drought impacts have started and reach certain level of drought warning has meant that most their attention has been on the phases of the actual drought. Activities before a drought starts have been somehow neglected. It proposed the FCDRHs at all levels restructure to suit the requirements of expanding the responsibilities to broader drought management stages. In the meantime, a mechanism used for trans-agency cooperation and coordination needs to be established at all levels to allow for the data sharing and regular consultation during the Normal conditions.

3.3.1.2 Financial and Human and Resources

The workshops held on drought risk management during the TA project indicated a high degree of appreciation and willingness to embrace drought risk management in FCDRH staff at all levels. However, there was a consistent theme that current budgets and funding streams for drought work are tied to drought relief work during emergencies, with little funding for drought prediction or risk reduction activities prior to drought declarations. The knowledge and appreciation of drought risk management and the cost effectiveness of risk reduction and mitigation measures over relief is not well understood in higher level authorities. As a result insufficient funding is allocated for drought risk management which in turn means an inefficient use of resources.

In addition to these financial constraints to drought risk reduction, there is a critical need for additional capacity building and training of FCDRH and water management staff in the tools and methods of drought risk management. This is needed in order to develop and manage comprehensive drought management plans fully at provincial, municipal and county levels. Drought risk management implies early recognition and steering of scientific and comprehensive plans with triggered actions. All of this implies a high degree of technical knowledge and insight into water planning, drought planning and management decisions and allocations during all stages of the drought cycle, for which a sustained programme of capacity-building will be needed at all levels.

3.3.2 Improving data sharing and collaboration on drought

The Meteorological department has very comprehensive meteorological data and similarly the water resources, agriculture, civil affairs and urban construction departments have good data on their respective areas. However, each sector and department works independently on its own in its own areas of responsibility, and there is lack of willingness to promote actual and effective real-time data sharing. As they are each one of the member units of FCDRH, they are obliged to provide data, but they are only willing to provide information in drought relief meetings during actual drought emergencies.

This approach for drought relief meetings is functional for drought relief work, but cooperation only happens after drought occurs and not throughout the whole process of drought. In recent years, some data sharing mechanisms and platforms have been improved and completed, such as the NCC meteorological data sharing platform and the ongoing MWR flood control and drought relief command system project phase II where the integrated drought database and the decision making supporting system for drought management are being developed. Thus, data sharing between some sectors and areas, such as the water resources and meteorological departments, has been established. However, this does not meet the full requirements of drought monitoring and early warning for the full drought cycle, since data is still not always available in real-time.

Institutional reforming and restructuring would complement the efforts in trans-agency cooperation in promoting data sharing. However, the incentive for stimulating data sharing needs to be created in FCDRHs and water resources departments. The role of FCDRH is managing and providing guidance on drought management activities without the direct access or control of the data which is held by the hydrological department.

The DFID Water Resources Demand Management Assistance Project (WRDMAP, 2005-2010) case studies included the issue of sometimes reluctant inter-sectorial cooperation. The project experimented

with various approaches to improve this cooperation in terms of several different elements of water management. This was primarily in the areas of water quality management and groundwater management but the concepts relate to all aspects of water resource management. Specifically, the project investigated the potential application of Memorandum of Understanding (MoU) and Memorandum of Agreement (MoA) to water resource issues and shared responsibilities between institutions. It is recommended that collaborative agreements using MOUs and MOAs relative to data sharing and outlining the respective roles and responsibilities for drought risk management planning at various levels. This includes sector level interactions with local municipal and county level DMP plans.

Proactive drought risk management including drought monitoring and prediction, and early action on risk reduction and mitigation measures all require a much more aggressive and regular program of data sharing prior to actual emergency situations. There are two areas of cooperation urgently needed to facilitate drought risk management.

3.3.2.1 Provincial Level Integrated Drought Database

Based on the TA project, the first critical need for data sharing is in relation to the new provincial integrated drought databases. The databases are essential for the recognition of potential droughts and triggering early action notices to potentially affected municipalities and counties within the province. For the meteorological drought index, the Meteorological department should be providing real time precipitation data (daily if not instantaneously) to the database, to be combined with the MWR meteorological stations in order to ensure complete coverage within the provinces. The water resources department controls the integrated database, but the FCDRH needs the data to manage the provincial DMP and provide the early warnings.

A clear data sharing arrangement is necessary and agreement on how the provincial DMP drought warnings will be issued. The integrated drought database will be co-managed by the provincial FCDRH and hydrology bureau, where the hydrology bureau takes on the daily operation and maintenance roles (such as calculating the drought indices, drought assessment, drought risk mapping, etc) and the provincial FCDRH publishes the early warnings to potential affected areas and coordinates the drought risk reduction and mitigation measures.

3.3.2.2 Managing Municipal and County Level DMPs

The second critical need for data sharing and cooperation is at the level of municipalities and counties managing the local DMPs. The water resources and/or local FCDRHs need to have cooperation and data from the various water use sectors in order to evaluate local drought indicators and take the necessary risk reduction and mitigation measures outlined in the local DMPs. This also involves managing and overseeing the production of sectorial DMPs for urban, agriculture and industrial sectors.

3.3.3 Improving technical aspects of drought management planning

Monitoring and forecasting plays an important role in all areas of potential drought management assessments including drought risk management. Drought can be a complicated disaster situation and is influenced by every element of the water cycle. Drought formation mechanisms are intricate, so accurate and timely prediction of droughts has been a key barrier against proactive drought management. Therefore, it is recommended that the national government promote research on drought forecasting and early

warning, and then systematically emphasize methods and techniques that are found to be both scientifically sound and practical.

The production of drought risk maps and vulnerability assessments should be undertaken in all locations using readily available data, and expanded with more scientific systems (such as IWHR Liaoning research protocols) as time allows. The undergoing state FCDRH project to expand soil moisture monitoring systems is a good start for a more comprehensive drought monitoring program that includes real-time data sharing between agencies. Remote sensing will likely play a much more critical role in drought risk management in the future, especially as drought prediction becomes more mature.

Drought risk mapping and vulnerability assessments have not progressed beyond the research level up to now. There are somewhat overlapping attempts at such assessments being performed within water resources and meteorological department but no agreed systems or protocols in place. The IWHR has been doing research work on drought risk mapping which has been used in the development of the pilot province drought risk maps and DMPs. This work is comprehensive but may take significant time and data collection to allow widespread application in all areas. In the meantime, international best practices and practical examples should be evaluated to organize simpler drought risk maps based on both historical aspects (e.g., drought history of occurrences, damages, etc) as well as future projections (e.g., high growth areas versus limited water resource availability).

A more long-term suggestion is to make more use of remote sensing and GIS methods. Remote sensing techniques have many applications for drought monitoring, for example, the weekly drought map drawn by the US National Drought Mitigation Centre. In China, the Institute of Remote Sensing Applications of Chinese Academy of Sciences and Development and Application Centre of Remote Sensing Techniques of MWR have been studying methods for drought monitoring using remote sensing. However, constraints include the high cost of data collection and difficulties with building up the technical competence. With the efforts from several organizations, the remote sensing drought monitoring sub-system has been included in the flood control and drought relief command system phase II project, which will be launched soon. The system would be applicable to the whole country, and the initial focus would be made in the Northeast and the Yellow River-Huai-Hai River area to calibrate and validate the drought assessment results. The development of the system would be led by the MWR and the outputs would be shared with drought management organizations at river basin and provincial levels, as well as lower levels. In addition, related remote sensing drought indices and technical standards will also be prepared.

3.3.4 New Policies and Regulatory Needs for Drought Risk Management

China has promulgated drought relief regulations to legislate for drought disaster management. But a complete system of laws, regulations and standards were not established, which are needed to meet the requirements of drought risk management. The following legal aspects need further development to move toward drought risk management.

First, the implementation of existing drought relief regulations needs to be strengthened. As the only regulation that regulates drought management work, the drought relief regulation has been in place for more than four years. But since many provinces and municipalities have not compiled implementation plans and rules, it has not been fully implemented. For example, the drought relief regulation requires "*administration above county level should include drought relief work into the national economic and social development plan; the budget needed could be included in the financial budgeting, to ensure the regular*

drought relief work." In fact, only few provinces and municipalities have reserved drought relief funds. Most provinces have funds only after the drought disaster occurs. If there is no drought disaster, then there is no source for drought relief funds. However, with the need to be proactive for drought risk management, the corresponding drought relief regulations at local levels have to be promulgated.

Second, drought relief regulations should be upgraded to drought management law, as the problem of water shortage is becoming more and more severe. For flood management, the flood control regulation was promulgated in 1991, and the flood control law was promulgated in 1997. This is a similar situation to drought management, and so a drought management law should be developed.

Third, the development of related additional technical standards should be initiated. Due to the complexity of identifying features affecting drought and the government pays less attention on the unstructured drought impacts, few studies have been funded in the past. The investment in theory studies and related codes and standards preparing are not sufficient. Currently, there are few technical standards, mainly

- Meteorological drought classification GB/T20481-2006;
- Drought disaster classification for wheat QX/T 81-2007;
- Classification standard for drought severity SL424-2008;
- Compilation guidelines for drought response plan SL590-2013; and
- Drought disaster classification standard [SL663-2014].

As the drought is increasing from 21 century, the outcomes in drought related studies and researches are increasing. In the future, more detailed drought-related technical standards will be required. The technical standards that need to be developed now are:

- Compilation guidelines for drought risk mapping,
- Evaluation guideline for drought management benefits,
- Compilation guideline for hydrological drought indices,
- Compilation procedures for drought management materials reserve allowance,
- Drought emergency contingency water resources management plan,
- Drought service group management plans.

3.3.5 Increasing public involvement in drought risk management activities

The drought risk management approach involves all levels of society in the development and implementation of the DMPs and related risk reduction and mitigation measures. As such, awareness of drought issues is critical in all stakeholders and the general public. It is commonly recognized internationally and nationally that a drought mitigation social system is an important component in drought risk management. Risk mitigation socialization is the foundation of raising drought risk management capacity and important measure to raise the public awareness of drought risk.

Through developing a drought mitigation culture, emphasizing drought mitigation training, strengthening drought mitigation risk education, integrating different media channels, educating the general public about drought risk management, the drought risk management idea would be conveyed to different groups of general public. Drought management implies the involvement of all stakeholders in the process in a completely different manner than top-down drought relief activities.

3.3.5.1 Increasing public involvement in drought risk management activities

The first step is to build a stronger culture of drought management. This should be an important part of social culture building, and drought management and drought mitigation should be included in the national education system. Drought management and mitigation knowledge should be improved in all levels of education from elementary school through advanced education.

Beyond classroom education, develop drought management and mitigation knowledge and propaganda activities. With the nationwide Disaster Prevention and Mitigation Day, International Disaster Mitigation Day, World Water Day, China Water Week, organize and develop drought management and drought mitigation education activities, establish a socially-involved disaster prevention and mitigation culture and develop drought management and disaster mitigation serial scientific textbooks, posters and media products. This propaganda on related policies and regulations, daily water saving techniques and disaster prevention and mitigation measure, will strengthen the adaptability of the society against drought and increase coping capacity in the face of disasters.

Drought risk management implies the full involvement of all water use sectors in the development and implementation of the drought management plans at all levels. This would include items such as:

- Goals and objectives of the DMPs
- Setting of water use priorities
- Evaluation of drought risk mapping and vulnerability assessments
- Development and assessment of potential risk reduction and mitigation measures
- Agreement on drought indicators for all pre-drought and drought stages as well as triggered actions required for all sectors

It can be seen that drought risk management, like all aspects of IWRM, is a much more bottom-up and inclusive decision making process for water resources, especially drought aspects. The raising of awareness and knowledge of these processes and techniques as outlined earlier are critical to getting full participation of the public and stakeholders in the drought management processes.

3.3.5.2 Establishing enabling environment for drought service groups

One local organization has historically had a great involvement in drought relief activities. Drought service groups (DSGs) have been the emergency drought relief teams established by local water resources management departments to provide equipment maintenance and technical guidance, etc. for local people in the area affected by drought. DSGs have had a major role to strengthen capacity for drought resilience with advantages of flexibility and quick response. There are four levels of DSGs including provincial, municipal, county, and township. They are led by the water resources administration at the same level and guided by the higher level DSG.

The main tasks for the DSGs have been:

- Deliver water for the residents in the drought-affected area;
- Emergency irrigation for drought relief
- Maintenance and renting of drought relief and materials;
- Drill and flush wells, clean cannels, dig ponds and repair, build dams on the river etc. or other drought relief emergency water supply engineering projects, take part in operation, maintenance, and management of engineering projects.

- Provide technical training for drought relief, organize and promote application of new drought relief water saving techniques, equipment and processes.

Due to the lack of policy and funding support, there is a big gap between current development of DSGs and requirements of drought relief and drought mitigation. It is not easy for the DSGs to survive and develop since they do not have enough staff and stable operational funding sources. Another implication is lack of participation by the public. It could be a good idea to integrate these DSGs into the new paradigm of drought risk management and determine how they can participate more fully in other aspects of drought management beyond drought relief. Involving private funding in establishing DSGs could be one alternative, hence related policy and initiatives need to be issued to enable this. It is important to keep as many of the public involved in drought management as possible, so it may be important to re-structure DSGs and keep them involved as China moves from drought relief to integrated drought risk management. The types of activities outlined above could easily become drought risk reduction and mitigation as well as relief in many cases.

3.3.6 Use of drought insurance and potential drought banking by urban users

The TA project has identified the potential of drought insurance and drought banking as having important roles in the future of drought management.

3.3.6.1 Drought insurance

The mode of temporary emergency support during natural disasters has for many years provided some compensation for disaster losses but it has not been sufficient. The related practices from both national and international experience show that for a natural disaster occurring randomly, a complete insurance system is an effective measure to mitigate drought risk. For example, in US, Canada, Japan etc., insurance against flood, earthquake and drought natural disasters has significantly supported the efforts for disaster prevention, resistance, and mitigation. From the international study tour under this TA, it was found that Spain is very successful in sharing drought risks by using drought insurance. In Spain, the Agriculture Insurance Law was issued in 1978. Farmers take part of the agriculture insurance in a voluntary way. Meantime, the government will provide re-insurance to the insurance firms and subsidise for farmer's payment. For farmers who don't take part in and not covered by the insurance, they will also not subject to any post disaster subsidy from the government.

Agricultural insurance has been initiated in some provinces, and there are options to add drought coverage to the policies. However, the policies only pay compensation when the loss due to drought is more than 70%. Thus in practice compensation is almost never paid. An improved system of drought insurance is urgently, as the risk of droughts is increasing due to climate change and other factors. There is an urgent need to develop a drought insurance system according to the characteristics of drought risk and based on insurance theory to support drought prevention and mitigation, to share the risk of drought loss by the insured person, insurance company and the government.

3.3.6.2 Drought banking (reallocation of water to higher value uses with compensation)

In theory, the principle that higher [value] water use sectors (urban and industrial) [should] pay into a fund to compensate lower [value] use agriculture to reallocate water as a risk reduction measure is very reasonable and could be applied in China. In addition, the drought management departments on different

levels could accept this, but it is not effectively implemented. Currently, the central and local government would afford some cost for the water transfer, and this is not called compensation cost but the work cost during the water transfer. Meanwhile, the fund is not from the water users and the water users sacrificed on lower level would not be compensated by this funds. The issues listed above are common. However, in one case, a severe water shortage in Zhejiang Zhoushan occurred in 2003. The agriculture water supply was cut to guarantee urban water supply and the agriculture water users were compensated by municipal government according to the reduced irrigation area of paddy field or reduced water uses (please refer to the urban drought relief plan in Zhoushan).

Such a water reallocation compensation plan could be implemented, but for now, it may be only feasible in economically well-developed and the water use sectors to be protected are high enough (urban or industrial). Such a water allocation system during droughts also implies a high degree of technical and management competency in the water permitting system and the issuance and management of water abstraction permits. In some cases, the water abstraction permitting system will need significant strengthening in order to apply such approaches. The policy and procedures for abstraction permits have been established through State Council Decree 460 and local level policies, but implementation is still incomplete as it is relatively complex and difficult to manage.

3.3.7 Additional technical assistance

The TA project successfully developed and organized the necessary tools and building blocks necessary to move forward with DRM. However, there are constraints to be addressed before this can be fully implemented. The TA pilot provinces are keen to be involved with additional work to resolve these problems, if funding becomes available.

The next steps should therefore be two-fold:
- to address structural issues related to funding and management direction, by additional awareness-raising for national and provincial officials on the need to move into this direction under follow-up training programs of the IWHR and others.
- to help with the details of DRM implementation, especially at municipality and county level FCDRHs.

The structural issues are not easy to resolve, and need attention at national and provincial level. The primary requirements are to
- Assure adequate finance at all times, not just after disasters emerge
- Facilitate communications and cooperation between departments
- Draft new policies and regulations, as required for the above
- Test innovative approaches to drought insurance, drawing on international best practice

DRM implementation at a local level will require a range of actions:
- Preparation of DMPs for selected municipality/counties in pilot provinces on a consultative basis
- Awareness-raising for the general public, to ensure greater engagement and understanding
- Capacity-building for officials, both within the water sector and more generally in government
- Strengthening abstraction permit system to provide the basis for reallocation before or during droughts
- Awareness-raising for local government to build appreciation of benefits of risk management approach.

4 Lessons Learned

4.1 Drought Risk Management and IWRM

The concepts of DRM are reasonably well understood by FCDRHs, particularly at higher levels (national and provincial), but the ability to put them into practice is constrained by well-known institutional factors – notably funding for pre-drought actions, coordination between agencies (particularly before the onset of a disaster), and the limited ability at lower levels (municipality, county and end-users) to prepare and implement local DMPs.

Drought risk management is a complex undertaking and it involves most aspects of integrated water resources management (IWRM). There have been many projects promoting the implementation of IWRM in China over the past 10-15 years, but there have been significant institutional constraints to IWRM as well as to drought risk management. Both require actions to be taken at the lowest possible level (water user, county, municipality, river basin, depending on the scale of the drought or problem). In practice, resources and capacity are often limited at this level and there is a need for higher level organisations to take on a greater role initially. This has been found to be the case with DRM, but greater effort will need to be put into developing capacity at local levels and into developing local DMPs.

Management of abstractions is a key aspect of IWRM which is essential for DRM. Although there has been considerable effort put into the management and pricing of water abstractions, there has still not been sufficient progress to make drought banking and water reallocation a widely applicable approach.

The FCDRHs, IWHR and MWR all seemed appreciative and willing to learn about DRM from the TA activities, but without a full structural move toward more scientific and transparent water resource management decision-making it will difficult for them to take the concepts forward. In other words, DRM management cannot be achieved without the water management components of IWRM.

4.2 The Impact of Capacity-Building without Additional Funding

The TA budget and activities were strategic in nature and aimed to introduce new concepts, ideas and practices to water and drought management officials. The work necessary to implement drought risk management fully even at pilot province level was well beyond the resource levels of the TA project. There will be significant work required for the development and management of the municipality, county and sectorial level DMPs.

The three pilot provinces are better able, as a result the TA work, to undertake the additional work required for DRM implementation than other provinces. The TA workshop participants all hoped for additional funding to assist them in moving forward with DRM, perhaps as tied to other basin water resources or environmental projects. With the current constraints of only funding drought relief, the officials intimated that only a larger, externally funded project which included resources to develop and apply DRM concepts more fully would allow them to make progress on proactive drought risk approaches.

4.3 TA Design and Implementation

Whilst the activities and outputs of the TA project were well-designed and achievable, moving to the next stage to achieve the planned outcomes in full depended on a number of assumptions outside the control of

the project. Any future TA should seek to address these assumptions explicitly: this will require work at national level to influence the funding and policy-level direction of FCDRHs, as well as at local level to ensure that any proposed actions are realistic in the context of current water uses and risks

TA projects are constrained by their limited scope and resources, and by the fact that they operate in parallel with normal government systems, yet aim to influence those systems. Pure technical assistance, without financial assistance, can affect the willingness of counterparts to participate actively. More formal arrangements, through memoranda of understanding, for counterpart staff at provincial and local level would help ensure greater and more effective involvement.

The TA design assumed drought risk could be managed at provincial level. This differs from normal practice which requires drought to be managed at the lowest appropriate level (i.e., municipality or county). Introducing drought management even on pilot basis at county level across three provinces with a combined population of over 250m would require far greater resources and skills than are available to any TA. There would need to be a focus on a small number of counties, and these should be selected on the basis of their capacity in wider issues of IWRM.

These practical issues, together with the higher level constraints to DRM, meant that the TA developed the concepts further from Phase 1 and set up a pilot ready for implementation but actual implementation will need considerable further action to address the issues addressed in Section 3.3. As indicated in Section 3.2, the TA made a number of implicit assumptions in the DMF which limited the ability to achieve the desired outcome, even though the outputs could be realised in full. To the extent possible, actions should be included in the TA which address these assumptions, through a focus on

- building a commitment outside the FCDRHs to get policy-level support for DRM and hence recognition of the need for additional funding
- developing cooperation arrangements at appropriate levels between drought-related organisations
- preparation of DMPs at local levels.

5 Next Steps

5.1 Planned Local Activities that can Utilize TA Work

There are a range of ongoing activities related to drought management. Significant among these are three planned capacity development programs on drought management, which can benefit directly from the TA outputs and deliverables. These are already planned and should be initiated imminently.

5.1.1 Training on Drought Relief Guidelines

The SL 590-2013 (Guidelines for Preparing Drought Relief Plan) went into effect in April 2013. The dissemination and training program for this 'Guideline' was approved by MWR in early 2014. MWR plans to complete preparation of the training materials by August 2014 and will organize the training by bringing the management professionals together from drought management organizations at all levels, including river basin, provincial, municipal and county level. The number of trainees would be around 80. The national TA consultant team (IWHR) is providing technical support to this training. The main recommendations of this TA, as set out in the guidelines, provincial DMP, capacity building program and public awareness program, have been incorporated into the training materials, and some of the TA documents can be converted directly into training materials in order to facilitate the promotion of the risk-based drought management concept and practices.

The main purpose of the guideline is to help people at different levels of FCDRH draft their drought management plans, according to existing drought response regulations and guidelines. The main contents of the guideline include:

- The category of drought response plan, of which there are two kinds:
  - overall drought response plan; and
  - specialized drought response plan (urban plan, ecological plan, industrial plan, important project plan and emergency water transfer plan).
- The main components of drought response plan - it should contain:
  - basic information (geology, economy, water resources, drought conditions, and drought fighting capacity),
  - commanding system and responsibilities,
  - drought monitoring and prevention,
  - drought early warning,
  - emergency response action,
  - actions after drought disaster,
  - guarantee measures, and
  - public dissemination and training.
- Method to draft a drought response plan.

Although the primary focus of SL590-2013 is on drought response, the training program for this guideline can still promote drought risk management in addition to meeting existing drought response goals. First, although the guideline is mainly about response plan, it also includes important elements of drought risk management, for example, drought monitoring and early-warning. Second, emergency response during drought conditions is one of important parts of drought risk management.

5.1.2 Training on Drought Classification Standards

The SL663-2014 (Standard of Classification for Drought Disaster) was enacted and put into effect in April 2014. It has also been included into the dissemination and training program plan organized by MWR. The outputs from this TA could be included into the training materials during the preparation. The actual time for organizing this training has not yet been determined.

The main purpose of this standard is to standardize the evaluation of drought disaster losses at different levels in China. The main contents of this standard include indicators and rating criteria for:
- agricultural drought disaster, with method to calculate indicator (Grain loss rate caused by drought)
- pasture drought disaster, with method to calculate indicator (forage grass rate caused by drought)
- urban drought disaster with method to calculate indicator (GDP loss rate caused by drought)
- drinking water difficulty, with method to calculate indicator (drinking water difficulty rate)
- regional drought disaster.

This standard is for drought disaster classification only. As noted previously, this is relevant for DRM since emergency response during drought is an important parts of drought management, as is management after drought, including evaluation of drought disaster losses. The training on drought disaster classification can also be expanded by providing more information about drought management before the onset of drought.

5.1.3 State Flood Control and Drought Relief Commanding System Phase II Project

The State Flood Control and Drought Relief Commanding System Phase II Project, was launched in October 2013. The integrated drought database built under this TA for Liaoning Province will provide a good basis for the one to be established under the Phase II project. In addition, the TA recommendations on early warning and decision support could be useful tools. The main components related to drought management include establishment of:
- Drought-related data collection system,
- Integrated database for flood control and drought relief, and
- Decision making supporting system for drought management.

The State Flood Control and Drought Relief Commanding System Phase II Project is the extension and continuation of Phase I completed in 2011. The feasibility study report for Phase II Project came out in 2008 but implementation has not yet started as there have been many times of consultation and revision processes to ensure a good project design.

The Phase II Project involves improved measures for both flooding and drought. Basically, the goal regarding drought includes：
- set up hydrological information acquisition system covering all the national stations, and set up construction information acquisition system covering the important construction projects;
- preliminary set up drought information acquisition system covering all counties nationwide;
- promoting the ability of processing drought data;
- establishment of a specific drought information acquisition subsystem, flood-drought database, drought relief application subsystem.

After the Phase II Project completed, the drought relief ability of China will be improved significantly in drought data management, drought forecasting, monitoring and risk analysis, etc.

The estimated investment for the Phase II Project is 800 RMB million over 15 years. In general, the budget will come from national level, provincial level and local level.

5.2 Other Recommended Activities

Some of the recommendations of the TA, as summarised in Chapter 3 should be implemented in the short term. These should be adapted and incorporated into FCDRH plans at various levels, although support from an additional TA may be considered. If this is taken up, then the constraints to implementing TAs noted in section 4.3 should be addressed in the design.

5.2.1 Activities which can be undertaken in the short term

The following activities have been identified as actions that can be undertaken in the short term:

- Capacity building in DRM should be mainstreamed into general water management training programs, including online programs;
- Capacity will require additional dedicated programs, by MWR or others, to build technical capacity at operational levels as well as awareness and understanding in higher echelons;
- The capacity-building and public awareness programs should be linked with draft Drought Management Plans, all prepared by the TA, and used as resource materials for this training. They should coordinated with other ongoing related programs;
- The Water Education Centre of MWR should review and develop the public awareness program so that it can be applied widely as part of their wider activities as well as forming the basis for a dedicated awareness program for DRM;
- Ongoing involvement by IWHR will ensure continuity and development of appropriate tools, including improvements to the monitoring systems. In addition there will need to detailed involvement at lower levels to address the practical constraints to putting the knowledge into use at municipality and county levels.

5.2.2 Longer term actions

DRM will require a long term commitment, involving:

- Linking the findings of the TA with planned local actions (see section 5.1 for the initial plans)
- Additional TA, or other methods to develop implementable local DMPs
- Awareness raising for local government to ensure greater appreciation of the value and need for DRM, and hence encourage resolution of problems related to funding and inter-agency cooperation
- High level actions to minimize the constraints to DRM which have been identified in this report
- Improve implementation and monitoring of abstraction permit system
- More training to ensure that there is sufficient capacity to put the DMPs into practice
- Mainstreaming DRM in water resource management

6 Work Plan and Staffing for the TA

6.1 Work Plan

The work plan was developed from the TOR and DMF. Some of the key aspects of the work plan included the following:

- Data collection, strategy development and planning during Inception stage ending 3 May 13.
- Basic surveys including institutional and water saving conducted by July 2013 (*revised to August*).
- Development of the prototype integrated drought management database for Liaoning Province by August 2013 (*revised to September*).
- Training and capacity building programs developed and implemented by December 2013.(*Revised to May 2014)* This includes provincial workshop in September 2013 on general drought risk management concepts and DMP workshops in provinces in March 2014.
- Early warning systems developed between July and December 2013.
- Provincial drought management plans prepared by March 2014 and provincial workshops held to discuss DMP implementation.
- Guidelines for drought risk management prepared from October 2013 (outline) to final in June 2014.
- Final national level workshop on findings in June 2014 along with draft Final Report.

The only change since Inception Report was a delay in the international study tour from October 2013 to December 2013.

The attached work program was planned to meet these requirements as well as the reporting and deliverable schedule outlined and is unchanged since Inception Report except for delay in the international study tour until December. Figure 6.1provides original work program.

6.2 Staffing

Staffing is closely related to the activities shown in the work program and was planned to match the responsibilities shown on the program, as described in the Inception Report. The resulting schedule is shown in Figure 6.2 which is unchanged, except that Simon Howarth undertook the last mission of the Water Saving Specialist instead of Marieke Nieuwaal, as previously discussed. As approved by ADB, the international team leader has had 5.25MM of field time in five missions, with 0.75 MM of home time to coordinate work of TA team between missions as well as to review and edit the Final Report based on comments of ADB and others. The international water saving specialist continued to have 4MM of field input, but this was in five missions instead of the three originally envisaged. This more closely aligned with the project schedule and allowed for more collaboration with the international team leader and the national team on the major deliverables.

In addition, the TA team recommended that the international water saving specialists be allowed to use two weeks of their existing input time as home time to allow for assistance on the capacity development and public awareness programs as well as the final deliverables. This was approved in a contract variation.

One trip was held in September 2013 to Gansu Province for a combined workshop with all three pilot provinces attending for general introduction on drought risk management. In March 2014 workshops were held in Sichuan and Liaoning provinces on the implementation of the drought management plans produced by the TA. The additional trips to the pilot provinces does not have any budgetary implications.

6.3 Equipment Procurement

According to TA design, some equipment procurement was anticipated, and the TA team has procured this as outlined below:

Table 6.1: Equipment Procurement

Type	Quantity	Cost ($)
Office computers with wireless broadband internet access	5	9,500
Printer (1), facsimile machine (1), digital cameras (2), and other small peripherals (1)	5	2,500

Relative to this equipment procurement, the following has been accomplished:

1. According to the procurement list shown on RRP, MM invited quotations for price for the equipment and received three quotes in the end of May 2013. The quotes were reported to ADB.
2. Mott MacDonald received the ‘ADB’s No-Objection to the Procurement of Equipment’ on 2 July 2013.
3. Contract signed with supplier. All equipment had been set up and operated properly by the end of August 2013. Paid supplier according to contract between Mott MacDonald and suppliers.

6.4 Deliverable schedule

The reporting requirements and schedule are clearly stated in the TOR, together with the requirements for various other deliverables. These were delivered in accordance with the reporting and deliverable schedule in the original work program (Figure 6.1).

Figure 6.1: Original Project Program

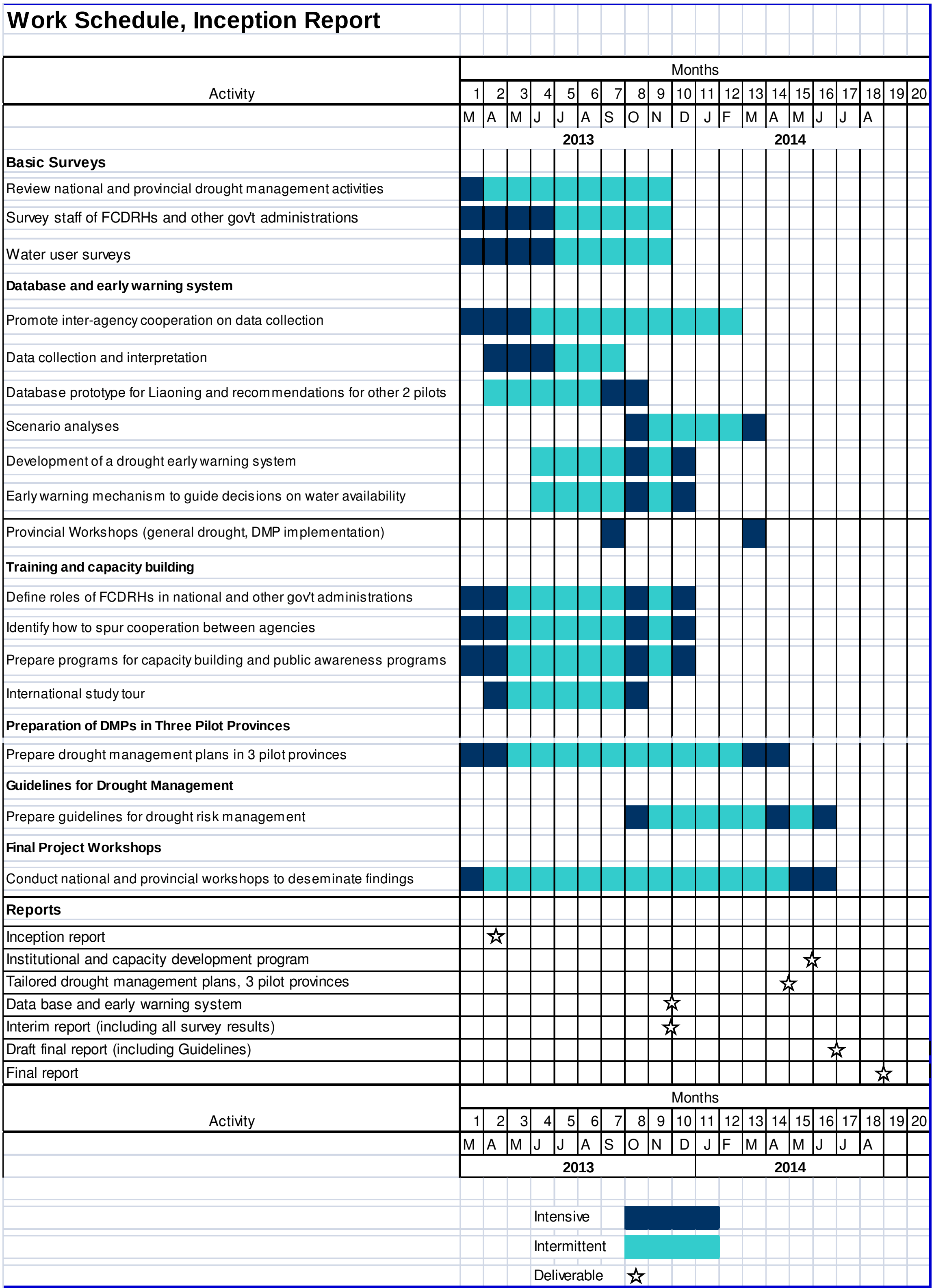


Figure 6.2: Work and Personnel Schedule

Revised Personnel Schedule - Interim Report

Home, Full Time
Home, Intermittent
Field, Full Time

Months 1–18: March, April, May, June, July, Aug, Sept, Oct, Nov, Dec (2013); Jan, Feb, March, April, May, June, July, Aug (2014)

Name/Citizenship/Position	Months of Input: Home	Field	Total	Air Travel: Int'l	Domestic
International:					
Lawrence Quinn (USA) Drought Risk Management Specialist and Team Leader	0.75	5.25	6.00	5.00	2
Marieke Nieuwaal (NL), Water Saving Specialist	0.00	4.00	4.00	5.00	2
Subtotal	0.75	9.25	10.00	10.00	4
National:					
Juan Lv (PRC) Drought Risk Management Specialist and DTL	8.00	1.50	9.00	0.00	2
Yan Sun (PRC) Capacity Development Specialist	3.50	1.00	4.50	0.00	2
Yanyan Wang (PRC) Economic and Finance Specialist	1.00	0.00	1.50	0.00	1
Yucheng Wu (PRC) Water Saving Specialist	4.00	1.50	6.00	0.00	3
Zhicheng Su (PRC) Software Specialist	3.00	1.00	3.50	0.00	1
Subtotal	19.50	5.00	24.50	0.00	9
Total	20.25	14.25	34.50	10.00	13

Reports	
Inception report	☆
Institutional and capacity development program	☆
Tailored drought management plans, 3 pilot provinces	☆
Data base and early warning system	☆
Interim report (including all survey results)	☆ 27 15
Draft final report (including Guidelines)	☆ ☆
Final report	

Activity — Months 1–18: March, April, May, June, July, Aug, Sept, Oct, Nov, Dec (2013); Jan, Feb, March, April, May, June, July, Aug (2014)

Home, Full Time
Home, Intermittent
Field, Full Time

Note: Simon Howarth replaced Marieke Nieuwaal as International Water Saving Specialist on last mission, as approved by ADB.

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TA8185: Pilot Implementation of the Drought Management Strategy

June 2014

Asian Development Bank

ADB

Mott MacDonald

Final Report - Appendices A-J

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Manila, Philippines

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A	2014/06/26	Larry Quinn Marieke Nieuwaal Simon Howarth Lv Juan Mia Yu Su Zhicheng Wu Yucheng Qu Yanping Sun Yan Wang Yanyan Sun Hongquan	Zhang Yi	Fang Songchuan	First draft for ADB Review	

Contents

Appendix A. Institutional Survey

A.1 Review of past and ongoing provincial drought risk management activities

Drought mitigation laws and regulations are mainly divided into two layers, the national level regulations, and provincial-level regulations. Until now, drought mitigation associated with country-level regulations include the "PRC Tax Law", "PRC Drought Regulations" and the "PRC Water Pollution Prevention Law." At the provincial level, regulations are generally based on the national level or related to local regulations, such as in the Liaoning Province "Groundwater Protection Ordinance", "Regulations Prohibiting Groundwater Extraction", "Water Metering Management Approach" and "Water Permits and Water Resources in Liaoning Province Fee Collection And Management Implementation Method, "and so on.

Since 2003, drought contingency planning system has been established, especially in emergency drought implementation. The system defines the extent of drought when different levels of drought response start and how to take appropriate action during drought. Currently, local governments at all levels have developed drought contingency plans basically completing the initial formation of the national, provincial, prefectural (city) and county level drought plans. The main contents include drought contingency plan monitoring and basic forecasting of drought, establishment of drought level indicators and drought classification, different levels of drought contingency actions, drought emergency action and drought early warning release mechanism.

Since 2008, comprehensive "national drought planning" work was approved by the State Council and this entered the implementation stage in 2011. Drought planning in their respective provinces covers drought engineering and non- engineering measures, specifically including four aspects:

- The drought emergency water project construction plan,
- Drought monitoring and early warning system construction planning,
- Drought dispatching system planning,
- Drought mitigation management system planning.

The three project pilot provinces Liaoning, Gansu and Sichuan provinces drought rely on both engineering and non-engineering facilities in their comprehensive plans: the total budget for the three pilot provinces was 7.935 billion RMB, 18.899 billion RMB and 18.204 billion, with a planned time for construction completion of 2020.

Since 2000 and in response to the increasingly serious drought disaster situation, the Ministry of Water Resources strategically put forward agricultural drought relief to the comprehensive drought resistance plan. In 2008, Ministry of Water Resources published the first drought related industry Standard of Classification for Drought Severity, which was then enacted in 2009 as regulations on the drought resistance of the People's Republic of China. "National drought planning" was approved in 2011 by the state council of the PRC. By 2020, the work content of the "national drought planning" will be completed so that at that time all over the country and drought engineering and non-engineering facilities will be greatly improved, and drought disaster reduction ability will be enhanced.

Long-term drought relief management work, including in the project pilot provinces at city and county levels, and drought disaster reduction management system has played an important role for emergency drought relief management. In the Pilot provinces in recent years, the major drought risk management operations have included three aspects:

- Basic formation of the drought relief plan system, in which province, city and county all have their respective plans to fight the drought, especially to decrease the passive impact before the drought fighting work begins;
- Comprehensive planning to develop a plan to fight the drought and for drought resistance through engineering and non-engineering measures;
- Great importance should be attached to drought monitoring and early warning, and began the drought monitoring and early warning system construction work.

The current coordination between national level and provincial level, provincial and municipal level, municipal and county level lies in three aspects: (1) commanding and dispatching, meaning the commanding system during drought period. (2) relations and differences between drought emergency plans on different administrative levels. (3) relations and differences between drought management plans on different administrative levels.

A.2 Institutional survey results

The TA Team designed a questionnaire related to drought disaster risk management in this project in order to identify the drought management and associated personnel that are engaged in drought risk management awareness and administrative drought risk management. Three pilot provinces were surveyed through this questionnaire survey. Meanwhile, the strong support and help of the national office and help from Civil Air Defense Office of Gansu Province enabled drought management personnel of the pilot provinces to participate in the discussion exchange meetings regarding drought risk management philosophy and understanding of drought risk management status.

A.2.1 Survey questionnaire design

A questionnaire with 30 questions (see accompanying drought risk management survey questionnaire) was designed for the drought management personnel.

The survey questionnaire was distributed to the drought management staff at all levels including provincial agriculture and meteorology departments and research institutions and the main office of the county administration.

A.2.2 Survey questionnaire response

74 responses from the three pilot provinces were received in September 2013: 16 from province, 23 from municipality and 35 from the county levels, see Table A.1.

Table A.1: Survey Responses

Pilot province	Number of responses	Administrative level		
		Province-level	City-level	County-level
Liaoning	19	2	9	8
Gansu	21	6	7	8
Sichuan	34	8	7	19
Total	74	16	23	35

A.2.3 Conclusions from the questionnaire analysis

On the basis of drought disaster risk management survey questionnaire returned by the three pilot provinces, the answers to all the questionnaire results are collated (see Table A-2). As certain problems exist in the survey questionnaire's multiple-choice answers, combined with the individual questionnaire, Table A.2 shows the results of the questionnaire and collect some the answer to the question number and the total number of the returned questionnaire which may not be consistent, like the first question in the questionnaire, 74 questionnaires returned, four questionnaires did not answer for the problem, so the Table A.2 summary data shows that only 70 questionnaires.

According to Table A.2 and combined with the results of drought disaster risk management problems in the questionnaire analysis, we form the following main conclusions.

- Those who engaged in drought management personnel have insufficient understanding of drought disaster risk management. Of the personnel engaged in drought management 30% of the staff still do not know anything about drought disaster risk management, the other 70% of the people have some knowledge about the drought disaster risk management, but it is not enough.
- Those who are in relatively poor-water district have a higher consciousness in drought management than those in relatively wet areas. In the three pilot provinces, Gansu province is relatively dry and suffers a water shortage problem, but Liaoning and Sichuan provinces have a relatively abundant water resource. Questionnaire survey results show that 90% of the total Gansu province drought management related personnel know about drought disaster risk management, whereas in Liaoning province and Sichuan province the figures were 63% and 62% respectively.
- The provincial personnel who are engaged in drought disaster risk management have a higher consciousness than equivalent city and county personnel.
- In most cases the drought management level is not high, and the drought disaster risk management is in a transition period.
- Most areas have few relevant laws and regulations to follow for drought relief management work. Relevant technical standards are also not perfect.

Some additional conclusions can be found in the Table A.2.

Table A.2: **Summary analysis of the survey questionnaire of the drought disaster risk management**

Question	A	B	C	D	E	F	G	Conclusions
1. Have you ever heard about drought risk management? A Yes B No	52	18						
2.Identify the existing management model for drought hazards management in your area A. Emergency response B. Transition period from reactive emergency response to proactive risk management C. Risk management	28	29	15	-	-	-	-	The drought management is in emergency response or transition period.
3. In your opinion, the level of drought management work in your local area is A. High B. Moderately high C. Poor D. Very poor	4	34	26	5	-	-	-	Most area are in the levels of moderately high and poor, a few areas are on the level of very poor
4. What departments actually were involved in drought management? A. Water resources department B. Meteorology department C. Agriculture department D. Administrative department E. Financial management department F. Other Department	73	64	68	50	35	19	-	Most of the areas has a complete drought management department, mainly water resources management department
5. What policy, regulation, and law in relation to drought management? A. PRC Water Act B. PRC Drought Management Regulations C. Requirements of Improving Drought Management from National Council D. Local Drought Management Regulations or Implementation Guidelines E. National flood control and drought management plan F. Local Drought Management Plan G. Other	58	68	43	30	52	44	2	Incomplete regulations exists in the most regions, some individual regions have no relevant regulations to comply with
6. Are there any standards, guidelines or handbooks in relation to drought management? A. Meteorological Drought Classification B. Drought Events Classification C. Handbooks of Developing Drought Management Plans	55	61	57	56	10	-	-	Related standards are lacking in most of the areas

Question	A	B	C	D	E	F	G	Conclusions
D. Standards for Drought Damage Classification E. Other								
7. What current drought management plans are in place for your area? A. Provincial Drought Management Plan B. Municipal Level Drought Management Plan C. County Level Drought Management Plan D. Drought Management Plan for Urban Area E. Other Drought Management Plan	39	47	58	27	7	-	-	Most regions have drought emergency plans, but they are not very practical.
8. Have the pre-planned actions in the DMPs in your area been triggered? How practical? And how does those actions relief the drought risk or damage A. triggered, very practical and prevented damage B. triggered, moderately practical and prevented some damage C. triggered, not so practical and prevented a little damage D. triggered, not practical and limited effects on preventing damage E. never triggered before	11	37	12	3	16	-	-	
9. What is the weakness you experience when you work in drought management? A. Manpower B. Interdepartmental Cooperation C. Funds D. Water Manager's Competence level E. Public Awareness F. Technical Support G. Other	61	59	71	50	52	55	1	The drought management in most areas need to be improved, including staffing and equipment, investment, management capacity, and technical support, etc.
10. What do you think moving toward drought risk management would require and achieve? A. Nothing, could achieve risk-based management very soon B. basic capacity is available, could achieve risk-based management with some efforts C. only limited capacity is available, still needs time and effort for risk-based management D. lack of capacity building, need to start from the beginning, very little chance to achieve risk-based management	2	30	22	7	-	-	-	Most areas have limited capacity or no capacity to implement drought risk management.
11. What parameters or indicators are used to monitor the drought impact to agriculture? How many drought monitoring stations for agricultural use? Operated by what departments? A. Precipitation: No. of Stations, Affiliation B. Evaporation: No. of Stations, Affiliation C. River Water Level: No. of Stations, Affiliation	62	48	55	53	46	27	2	

Question	A	B	C	D	E	F	G	Conclusions
D. Reservoir Water Level: No. of Stations, Affiliation E. Soil Moisture: No. of Stations, Affiliation F. Agriculture Conditions: No. of Stations, Affiliation G. Other : ______ : No. of Stations, Affiliation								
12. What is the data sharing frequency? A. real-time data sharing on all available data B. real-time data sharing on part of data C. no real-time data sharing, only share data at drought management planning meeting during drought events D. no data sharing at all	10	30	29	3	-	-	-	The drought management data is not shared between departments in most of the areas
13. Is there a database designated for drought management use? What is the condition of that database? A. Yes, data generated from thorough monitoring B. Yes, data is complete C. Yes, but data is not complete D. No, dependent on other database E. No database at all	3	8	37	14	10	-	-	Most areas has no specific drought management database or it is not yet complete
14. What indicators are used trigger the agriculture drought conditions? A. Continuous Rainless Day B. Precipitation Anomalies C. Soil Moisture D. Crop Water Stress Index E. Percentage of crops that under drought impact F. Other	63	31	59	44	44	14	-	Most of the areas rely mainly on consecutive rainless days, precipitation anomalies, and the soil moisture agricultural drought
15. When the drought event is coming, is there a pre-drought condition triggering and prediction system in your area? A. Yes, and they are B. No	42	30	-	-	-	-	-	50% of the areas have the systems and 50% of areas do not have
16. How does the drought management system operate in your area? A. has drought information management system B. has drought monitoring system C. has triggering system for drought events D. has dispatching command system for drought events E. Other systems, please specify	31	27	16	32	2	14	-	The vast majority of regions has an incomplete drought relief management system

Question	A	B	C	D	E	F	G	Conclusions
F. No related systems								
17. When the emergency response was triggered by drought events, how is the institutional capacity and inter departmental coordination? A. the institutions are competent on their job, departments coordinated well B. the institutions are capable of doing their job, departments coordinated moderately well C. the institutions are not capable of fulfil their responsibility, departments coordinated poorly	14	56	5	-	-	-	-	Most parts of area have strong drought emergency response capacity, the cooperation among the various departments is also well
18. During drought period, the drought relief actions for drinking water supply shortage in your area are? A. Deliver water by administrator B. Deliver water by administrator-organized and funded organizations. C. Haul water by local people D. Other, please specify	61	54	63	18	-	-	-	The solution for the drinking water deficit mainly depends on the government or the residents.
19. What is the current condition of organizations responsible for drought relief? A. County and community level drought relief organizations are both well established B. County level drought relief organizations are well established, while community level drought relief organizations are not C. community level drought relief organizations are well established, while county level drought relief organizations are not D. neither county nor community level organizations well established	10	34	12	8	-	-	-	Most of areas at the county-level has a relative complete drought service organizations, but the villages and towns are less complete.
20. What is the condition for the drought relief materials reserve in your area A. has a warehouse to reserve drought relief materials, sufficient types and amount of drought relief materials B. has a warehouse to reserve drought relief materials, insufficient types and amount of drought relief materials C. no drought relief materials reserve warehouse	11	54	7	-	-	-	-	most of area has already built the drought relief materials reservation system, but with little variety and quantity
21. What is the current agriculture insurance coverage in your area? A. has agriculture insurance, successfully protected farmers from drought damage B. has agriculture insurance, did not protect farmers from drought damage C. no agriculture insurance	14	41	18	-	-	-	-	Most of areas are suffered from the weak agricultural insurance work, the it is not very effective
22. What indicators are used for monitoring urban drought level? A. water shortage in urban area (%) B. reservoir water reserve C. river water level D. precipitation E. other, please specify	45	44	57	56	3	-	-	Most areas have focus on urban drought monitoring

Question	A	B	C	D	E	F	G	Conclusions
23. Is there a monitoring or triggering system to predict drought event A. Yes, and they are__ B. No	34	36	-	-	-	-	-	Most areas do not have drought monitoring and triggering methods and system
24. Is there drought management plans in your area? A. there is a drought management plan for each city B. some critical cities have drought management plan C. no drought management plan whatsoever	40	24	7					The urban drought emergency plans in different areas are still not complete
25. Has the drought management plan been triggered in your area? Does it prevent the drought damage? A. they are triggered in some cities (please specify), prevented drought damages B. they are triggered in some cities (please specify), prevented major drought damages C. have not been triggered	21	14	32					Most of the areas have no experience of triggering the drought emergency plan. Few has triggered it up, but it if not very effective.
26. Is there contingency water sources for your area? A. contingency water sources for each cities B. contingency water sources for some cities C. contingency water sources for a few cities D. no contingency water sources	13	39	8	12				Few cities have the contingency water sources for drought relief
27. What are the responses when drought event is happening A. emergency water transfer B. start to supply water from contingency water sources C. water restriction D. water reallocation from one sector, eg. agriculture) to another (eg urban supply E. other responses, please specify	57	53	60	50	14			Urban emergency drought relief measures mainly include emergency water delivery, switch to contingency water sources, water saving, or cuts, and reducing agricultural water consumption, etc
28. Has there been ecological drought in your area? A. Yes B. No	46	25						Ecological drought has occurred in many areas
29. Is there an ecological drought management plan? A. No B. Yes	55	17						Most areas have no ecological drought emergency plans
30. What are the drought relief actions for ecological drought? A. emergency water supplementation B. other, please specify	57	9						Most areas rely on emergency water delivery to solve ecological drought

A.3 The drought disaster risk management discussion communication research

With support and help of national FCDRH and pilot provincial FCDRH, the TA team held drought management discussion with participation of the three related pilot provinces management personnel in Lanzhou city, for the identification of the status of the pilot province drought disaster risk management response to drought related measures and methods and the combination with the drought disaster risk theory knowledge training.

Staff of nearly 50 people attended the forum, including 1 director from national FCDRH, 2 personnel from the Liaoning province FCDRH, 1 personnel from FCDRH of Sichuan province, and more than 30 people from province and country (city) level of the Gansu's FCDRH and the other related department of the Gansu province, 3 from foreign affairs office of the MWR project management institutions and the TA consultants and other 7 Chinese and international experts of the project team.

The team leader Lawrence Quinn, project team deputy team leader Lv Juan and water-saving expert Marieke Nieuwaal respectively launched the workshop around the subject of the drought disaster risk management, China's response to drought disasters and management, and water saving and water protection The competent personnel from three pilot province FCDRH also presented the approach for drought management in their provinces. More than 20 district representatives from Gansu province county FCDRH introduced their situation and problems about the drought management. On this basis, the delegates had a thorough discussion and the exchange of knowledge on relevant aspects of drought disaster management.

Through the exchange of information in the drought disaster risk management discussion meeting, it is evident that there are many aspects which need to be strengthened in order to meet the needs of drought disaster risk management. The main conclusions from the meeting are as follows.

- Although the lower level FCDRHs have been set up, the number of staff working in drought management is still insufficient.
- Three pilot provinces generally lack sufficient drought monitoring and early warning means and methods.
- Drought management personnel at all levels suffer from limited drought disaster risk management knowledge and the relevant policies, regulations and the technical standards of drought are still incomplete.

A.4 Drought disaster risk management capacity building and training programs

Research and seminars show that drought management capacity weakness is mainly reflected in three aspects. First, the governing body is not perfect; second the drought monitoring and early warning capacity is limited; and third is the need to improve drought risk management knowledge. Therefore, in order to improve drought risk management capabilities, we must first resolve these three aspects.

A.4.1 Improve FCDRH at each administrative level

Regulatory agencies at municipal levels should be improved in two respects: municipal drought management offices require a minimum of two staff dedicated to drought management work; and cooperation mechanism should be established between the municipal office of institutions in the non-

drought period including the agricultural and meteorological sector. Even during the drought period cooperation should be improved in order to ensure more comprehensive information related to droughts.

A.4.2 Capacity building to strengthen drought monitoring and early warning

Currently, the three pilot provinces widespread lack drought monitoring and early warning measures, and only in Liaoning Province has drought monitoring and early warning system construction begun to take shape. Given the actual conditions of drought management in the pilot provinces, it is proposed to build first the provincial drought monitoring and early warning systems, and give guidance to (city) and county drought mitigation and management

A.4.3 Drought risk management training

Research work indicates that related knowledge is still rather weak at all levels of drought disaster management, and there is a need for provincial, city and county in drought management personnel to undertake training to improve drought disaster risk management level and ability. This training should focus on four aspects:

- Existing drought management policies and regulations. The project questionnaire survey showed that managers in different regions have insufficient understanding and awareness of drought management policies and regulations;
- Drought technical specifications and related standards training. *Standard of Classification for Drought Severity (SL424-2008)*, *Compilation Guidelines for Drought Emergency Plan (SL590-2013)* are two water industry technical standards promulgated and implemented. In addition, "Drought Grading Standards" as a Water industry technical standard will be promulgated soon, so training of personnel is necessary at all levels around these technical standards in drought management;.
- Drought disaster monitoring and forecasting and early warning; and.
- Drought disaster risk management knowledge, including drought contingency management.

A.4.3.1 Targets and Methods of Training.

Training targets are mainly drought management staff who will be reached in batches through a centralized training program. There are 316 FCDRH at different administrative levels in three pilot provinces (detail listed in Table A.3). Assuming each FCDRH send 2 staff for training, the number of total staff to be trained would be 630. In order to ensure good training outcomes, the staff could be grouped and given training courses.

A.4.3.2 Training of Personnel

The State Flood Control and Drought Relief Headquarters will organize relevant research institutions engaged in the study of drought disaster management and technical personnel from national drought management offices to carry out training. Table A.3 shows the agency statistics office of the pilot provinces.

Table A.3: Number of FCDRH in each Pilot Province

Level of FCDRH	Liaoning	Gansu	Sichuan	Total
Provincial	1	1	1	3
Municipal	14	14	21	49
County	44	86	134	264
Total	59	101	156	316

ANNEX 1 Drought Risk Management Knowledge Questionnaire

干旱灾害风险管理调研问卷

填表人姓名：___________________________

工作单位：_____________________________

联系电话：_____________________________

备注：**干旱灾害危机管理模式**：是指当干旱灾害发生后才开始作出反应，临时制定应急对策和措施，以期减轻干旱灾害损失和影响；**干旱灾害风险管理模式**：是指通过监测、分析、预测干旱的发生、发展规律，评估干旱灾害可能造成的损失和影响，优化组合各类抗旱措施，有序、有效应对干旱灾害，并对干旱灾害进行后评价的全过程。

Note: Drought crisis management mode: Before starting to react to develop contingency measures and temporary measures to alleviate the impact of drought and disaster losses; drought risk management model is through monitoring, analysis, prediction of drought occurrence and development of the law to assess the losses caused by drought and the possible impact of the drought, and effective response to drought, drought and post-evaluation of the whole process.

[REFER TO SUMMARY TABLE 2.2]

Appendix B. Water savings and Water User Survey

B.1 Background information

B.1.1 Potential for water saving in China

According the 2030 Water Resources Group (2009), China's water demand in 2030 is expected to reach 818 billion m^3, of which just over 50 percent is from agriculture (of which almost half is for rice), 32 percent is industrial demand driven by thermal power generation, and the remaining is domestic. Current supply amounts to just over 618 billion m^3. Significant industrial and domestic wastewater pollution makes the "quality-adjusted" supply-demand gap even larger than the quantity-only gap: 21 percent of available surface water resources nationally are unfit even for agriculture. Thermal power generation is by far the largest industrial water user, despite the high penetration of water-efficient technology, and is facing increasing limitations in the rapidly urbanizing basins.

Agricultural productivity is a fundamental part of the solution but efficiency in industry and municipal systems is similarly critical. Although agriculture still makes up more than 50 percent of the total demand, industrial and urban water uses are the fastest growing (at ~3 percent per annum). According the 2030 Water Resources Group (2009), China can mitigate this rapid growth in a cost-effective way by instituting aggressive, water-conscious, "new build" programs and enacting water-saving regulatory reforms. If it does so, the cost to fill the gap is negative, implying net annual savings of approximately US$22 billion. Most of the cost-saving levers on the left of the cost curve for China are industrial efficiency measures. These have the potential to close a quarter of the gap and result in net savings of some US$24 billion. They are distributed among the thermal power, wastewater reuse, pulp and paper, textile, and steel industries. Their savings potential derives from significant savings in energy and other operational expenditures, translating into overall productivity gains. The net capital expenditure to close the remainder of the gap amounts to US$8 billion, or less than 0.06 percent of projected 2030 GDP.

The ADB report, "Drying Up: What to Do about Droughts in the People's Republic of China" explores how the country can achieve stricter demand management, mitigate risks and impacts of natural hazards and reduce economic losses through an integrated approach. The case study from Guiyang Municipality, Guizhou Province, in this report states that demand management measures such as water-saving fixtures in apartments, 30% greater industrial water efficiency, and leakage reduction could have provided Guiyang municipality with 20% more water during the 2010 Southwest drought. Investment costs of such a proposed efficiency program for Guiyang would only amount to CNY137 million (US$21.5 million), representing a fraction of the industrial losses of CNY732 million (US$115 million) incurred during the Southwest drought.

B.1.2 Water resources in pilot provinces

The pilot provinces in this project are Gansu, Liaoning and Sichuan provinces. The water resources in Sichuan are the most abundant, second most abundant in Liaoning and least abundant in Gansu. As a standard method used in China's water resources management, quantifying the total amount of water resource is adapted to evaluate the regional water resource conditions. The total amount of water resource refers to the summation of quantities of surface water and groundwater, which is determined based on the river surface flow and ground water level monitoring data. The many years average total amounts of water resources in Liaoning, Gansu and Sichuan are 34.2, 28.9 and 29.2 billion m^3 respectively (Twelfth "Five-

year" Plan for Water Saving Society Building, 2012 for Liaoning, Gansu an Sichuan). The amounts of water resources per capita in these three provinces are 820 m^3/capita, 1,100 m^3/capita, and 2,609 m^3/capita respectively. Although the amount of water resources per capita in Gansu is higher than that in Liaoning, the condition for water resources utilization is the worst.

B.1.3 Current water resources utilization in pilot provinces

Because the economic development conditions vary to a large extent, the water resources utilization situations in each provinces and different areas, and water demand in each sector are different. For example, the urbanization rate in Liaoning is as high as 70%, while the rates of urbanization in Gansu and Sichuan are only 29%. The water demand in each pilot province can be categorized based on sectors as agriculture, industrial, domestic, and ecological water demand, The detailed water demand information for each piloting province, area, and sector are listed in Table B.1

Table B.1: Water demand in three pilot provinces (2012)

Province	Administration region	water demand from variety of fields ((100 million m^3)				Total water demand
		agriculture	industry	domestic	ecology	
Liaoning	Shenyang	17.20	3.43	5.83	1.70	28.16
	Dalian	6.78	3.73	3.89	1.06	25.46
	Panjin	11.57	0.76	0.51		12.84
	Anshan	6.50	4.08	1.87	0.05	12.50
	Liaoyang	8.52	1.98	0.91	0.02	11.43
	Tieling	8.62	074	0.93	0.04	10.33
	Dandong	7.84	1.06	1.06	0.04	10.00
	Jinzhou	6.10	1.16	1.28	0.03	8.57
	Yingkou	6.08	1.10	0.98	0.02	8.18
	Fushun	3.39	2.34	1.52	0.28	7.53
	Chaoyang	3.23	0.92	1.15	0.09	5.39
	Hu Ludao	2.65	0.84	1.02	0.01	4.52
	Fuxin	2.86	0.75	0.78	0.04	4.43
	Benxi	1.49	2.13	0.71		4.33
	Whole province	92.84	25.01	22.43	3.39	143.67
		65%	17%	16%	2%	
Gansu	Whole province	98.72	13.57	7.19	4.06	123.54
		80%	11%	6%	3%	
Sichuan	Whole province	123.05	66.77	23.11	1.05	213.98

As shown in Table B.2, the agriculture water demand comprises the major part (65%) of the total water demand, especially in Gansu where it accounts for almost 80% of the total water demand. The percentages of water demand in other sectors are also summarized below.

Table B.2: Percentage of water demand in each sector for the three piloting provinces (2012)

Province	Agriculture (%)	Industrial (%)	Domestic (%)	Ecological (%)
Liaoning	65	17	16	2
Gansu	80	11	6	3
Sichuan	58	31	11	0
Average	65%	22%	11%	2%

B.1.4 Current water supply pilot provinces

According to the 2010 Hydro Year Book, the total utilized water supply in Liaoning Province was 14.37 billion m^3 (Table B.3). Compared to 2009, the total water supply increased by 88 million m^3 (i.e., an increase of less than 1%)

Table B.3: Water Supply from Different Sources

Sources	Water Amount (100 million m^3)	Percentage (%)
Total water supply amount	143.67	
Surface water	72.07	50.2
Water reservoir	35.58	49.4
Water delivery	10.37	14.4
Water hauling	26.12	36.2
Groundwater	67.59	47.0
Shallow groundwater	67.13	99.3
Deep groundwater	0.39	0.6
Saline water	0.07	0.1
Other water sources	4.01	-
Water reuse	3.98	-
Seawater	0.03	-

According to the 2010 Statistical Year Book, the total utilized water supply in Gansu Province was 12.18 billion m^3.(Table B.4)

Table B.4: Water Supply from Different Sources

Sources	Water Amount (100 million m^3)	Percentage (%)
Total water supply amount	121.8	
Surface water	96.1	79
Groundwater	24.2	20
Other water sources	1.5	1

According to the 2010 Statistical Year Book, the total utilized water supply in Sichuan Province was 23.03 billion m^3. (Table B.5)

Table B.5: Water Supply from Different Sources

Sources	Water Amount (100 million m^3)	Percentage (%)
Total water supply amount	230.3	
Surface water	210.7	91
Groundwater	16.9	7
Other water sources	2.7	1

B.1.5 Supply and demand analysis of water resources in three pilot provinces

The intensifying gap between water supply and demand is a fundamental condition in the country. In order to close this gap, especially during drought periods, the compilation of the National Drought Relief Plan was initiated in 2008. Until the end of 2011, the state council has officially finished the revision of National Drought Relief Plan and stepped into the implementation phase. After the National Drought Relief Plan was implemented, the gap between supply and demand in each province including the three pilot provinces would be largely reduced. Nevertheless, with the increase in populations of each pilot province, and the rapid social and economic development, the gap would still exist.

Table B.6, Table B.7, Table B.8 present 2020 water supply-and-demand balance analysis given different frequencies in Liaoning, Gansu and Sichuan respectively, where the frequencies refer to the probability level at which the river surface flow is greater than the designated value used for corresponding water supply-and-demand balance analysis.

Based on the development goals prescribed in the twelfth Liaoning economic and social Five-year plan (2011-2015), under current water saving conditions, the provincial total water demand would be 18.54 billion m^3 in 2015. Based on the water allocation plan for Songliao river basin and Hai river basin, assuming fully exploited, the total water supply in Liaoning would only be 16.38 billion m^3. Among these the water supply from surface water is 8.79 billion m^3, from groundwater is 6.17 billion m^3, and from non-conventional water resources is 1.42 billion m^3. The deficit at 97% reliability is 0.63 billion m^3 (about 3% of demand) in 2015, but there are significant temporal and geographical variations in the deficit across the province. The deficit is much greater in Gansu (24% per year averaged over the province), although this is for 2020 with a significant projected increase in demand. Even at 75% reliability the average deficit is 12% in Gansu, indicating a severe situation even in non-drought periods. Curiously a similar percentage deficit is projected for Sichuan, again with a large increase in demand.

Table B.6: Water Deficit in Liaoning in 2010 (10 thousand m^3)

County-level administration	Water deficit (10 thousand m^3)			
	average of several years	75%	90%～95%	≥97%
Shenyang			2,391	5,539
Dalian	5,191	7,591	18,414	20,756
Jinzhou		1,932	7,230	8,119
Yingkou			706	2,249
Fuxin		2,594	4,002	5,230
Panjin			5,784	8,522
Tieling			5,481	6,807
Chaoyang		397	4,834	5,356
Hu Ludao				214
Total	**5,191**	**12,515**	**48,841**	**62,792**

Table B.7: Water Balance for Gansu for 2020 (100 million m^3)

Freq. (%)	Water supply				Water demand						Water deficit	Water deficit (%)
	Surf. water	Ground-water	Other	Total	For life		For production		Ecology	Total		
					Urban	Rural	Agriculture	Service & industry				
75	125.41	26.65	5.64	157.70	6.76	3.45	136.39	29.66	3.88	180.15	22.45	12.46
90	120.14	26.65	5.58	152.37	6.76	3.45	149.11	29.66	3.88	192.87	40.50	21.00
97	117.79	26.65	5.54	149.98	6.76	3.45	153.87	29.66	3.88	197.63	47.65	24.11

Table B.8: Water Balance for Sichuan for 2020 (100 million m^3)

Year	frequency	water available	water demand	water deficit	Water deficit(%)
2020	75%	253.92	282.16	28.24	10.0
2020	95%	240.37	287.45	47.08	16.4
2020	97%	223.51	290.42	66.91	23.0

B.1.6 Planned investments to bridge the gap between water demand and supply

In the Drought Relief Plans, the pilot provinces have planned for comprehensive drought management from both engineering and non-engineering perspective. From 2010 to 2020, the three provinces have planned to invest RMB 7.935 billion in Liaoning, RMB 18.899 billion in Gansu, and RMB 18.204 billion in Sichuan. The investment would be used mainly on drought contingency water conservancy projects, with smaller investments on drought monitoring and triggering systems, drought response dispatching systems, and drought mitigation management system. The investments in different categories are listed in Table B.9, Table B.10 and Table B.11.

Table B.9: Summary of investments for drought planning and management Liaoning (2010-20) (10 thousand RMB)

Administrative Unit	Drought contingency water conservancy projects	Drought monitoring and triggering system		Drought response dispatching systems	Drought mitigation management system	Total
		Drought monitoring infrastructure	Monitoring &triggering system			
Shenyang	70,614	1,048			11,727	83,389
Dalian	34,431	1,222			5,992	41,645
Anshan	29,330	610			3,653	33,593
Fushun	3,675	817			2,671	7,163
Benxi	2,919	769			2,694	6,382
Dandong	7,766	1,003			3,993	12,763
Jinzhou	121,640	809			11,153	133,602
Yingkou	29,330	738			3,418	33,486
Fuxin	95,138	1,125			9,545	105,808
Liaoyang	13,555	561			2,552	16,668
Panmian	17,300	458			1,303	19,061
Tieling	77,397	1,271			9,267	87,935
Chaoyang	122,793	1,603			15,533	139,929
Hu Ludao	59,072	1,028			6,875	66,975
Provincial			500	650		
Total	684,960	13,112	500	650	94,247	793,469

Table B.10: Summary of investments for drought planning and management Gansu (2010-2020) (10 thousand RMB)

Administrative Unit	Drought contingency water conservancy projects	Drought monitoring and triggering system		Drought response dispatching systems	Drought mitigation management systems	Total
		Drought monitoring infrastructure	Monitoring & triggering system			
Lanzhou	59,623	942	0	0	15,220	75,785
Jiayuguan	40,629	226	0	0	1,860	42,715
Jinchang	12,431	480	0	0	3,995	16,906
Baiyin	75,749	849	0	0	14,695	91,293
Tianshui	141,375	838	0	0	25,920	168,133
Wuwei	90,441	1,129	0	0	9,870	101,440
Zhangye	173,278	1,268	0	0	9,890	184,436
Pingliang	242,591	1,101	0	0	24,770	268,462
Jiuquan	73,057	1,298	0	0	10,800	85,155
Qingyang	239,393	1,131	0	0	25,810	266,334
Dingxi	125,390	1,292	0	0	20,930	147,612
Longnan	180,280	1,063	0	0	29,460	210,803
Linxia	44,742	804	0	0	17,150	62,696
Gannan	138,803	872	0	0	11,975	151,650
Provincial	6,480	200	3,900	3,500	8,860	16,460
Total	1,637,780	13,493	3,900	3,500	231,205	1,889,878

Table B.11: Summary of investments for drought planning and management Sichuan (2010-20) (100 million RMB)

Drought contingency water conservancy projects	Drought monitoring & triggering system	Drought response dispatching systems	Drought mitigation management systems	Total
170.2	2.30	0.12	9.4	182.0

Of the confirmed investment amounts in the pilot provinces, about 80% came from funds at national level and 20% came from funds at provincial level, see Table B.12

Table B.12: Drought relief facilities planned investment for Pilot provinces to 2020 (100 million RMB)

Pilot province	Total investment	central government	local government
Liaoning	79.35	63.48	15.87
Gansu	188.99	151.19	37.80
Sichuan	182.04	145.63	36.41

B.2 Review of past and on-going provincial water saving activities

B.2.1 Water Saving Society

The concept of a Water Saving Society has been strongly promoted in China since 2000, when it was put forward by the Central Committee of CPC in the 10th Five-year Plan, reflecting the severe water shortage in many regions which has become a bottleneck for economic development and has resulted in serious environmental degradation. The 2002 Water Law (Article 8) requires “that the state shall carry out water saving and devote major effort to implementing water saving measures, popularizing new water–saving technologies and processes, and developing water saving industry, agriculture, and services”. Water saving means a water user consuming less water. This is done for several reasons – so that water can be transferred to other more beneficial uses, so that the environment can be protected, or so that costs can be reduced. A water-saving society (WSS) is, however, broader than this and covers the concept of society itself and relations of production - ownership and control of assets, and socio-economic dependencies. The concept was introduced in recognition of the fact that there appears to be considerable waste of water, and many opportunities for increasing the productivity of water.

MWR has promoted a program for establishing a water saving society throughout China. The water saving society implementation plans are prepared at municipality level. Goals for the program for establishing a water-saving society included that by 2010:

- all systems (preliminary) of legislation, administration, economic and technical policies, and advocacy and education for a water-saving society would be established;
- good progress will be achieved in water saving technologies and management levels;
- water-saving awareness of all the people will be significantly improved;
- wastage of water resources will be effectively controlled;
- the water use per 10,000 RMB of GDP will be reduced by 20%,
- agricultural irrigation water efficiency will be increased from 0.45 to 0.5, and there will be no increase in total agricultural irrigation water use;
- the water use per unit of added industrial water output will be reduced by 30%; and
- water use efficiency of service trades will approach the level of world best practice.

Instructions by MWR on implementation of pilot projects for water-saving society construction (circular 558 (2002) and circular 634 (2003)) led to national pilot projects at Zhangye Municipality in Gansu Province, Mianyang Municipality in Sichuan Province, Dalian Municipality in Liaoning Province, and elsewhere, and a large number of provincial level pilot projects.

The National Development and Reform Commission, Ministry of Science and Technology, Ministry of Water Resources, Ministry of Construction and Ministry of Agriculture have jointly worked out the China Water Conservation Technology Policy Outline (2005) to provide guidance to the development and application of water conservation technology, push forward the progress of water conservation technology, enhance the efficiency of water use and its benefits, and promote the sustainable utilization of water resources. This Outline provides technological policy support in order to realize water conservation goals. With the guidance of the Outline, China strived to achieve "micro-growth" in industrial water consumption, "zero-growth" in agricultural water consumption and a gradual reduction in overall per capita water consumption in urban cities between 2005 and 2010.

In order to strategically conserve water, three pilot provinces initiated a series of work. Liaoning’s water saving society building is more detailed. After finishing the compilation of Plan of Liaoning Eleventh “Five-year” Water Saving Society Building in 2008, Liaoning compiled Plan of Liaoning Twelfth “Five-year” Water Saving Society Building in 2012, which prescribed not only the provincial water saving objectives, but also sectorial objectives for major sectors including agriculture, industrial, and urban domestic.

Gansu finished the compilation of Gansu Twelfth “Five-year” Plan of Building Water Saving Society and Gansu Hexi Corridor Region National High-Efficiency Irrigation Demonstration Area Project Implementation Plan in 2011 and 2012 respectively, which not only prescribed the water saving objectives tasks, and projects in 2015 accordingly, but also launched Hexi Corridor region high-efficiency water saving demonstration area project study. Since the agriculture water use consists of close to 80% of total water consumption in Gansu, it is very meaningful for Gansu to build the water saving society.

Sichuan is one of the major provinces where water resources are abundant, relatively lagging on building the water saving society compared to the other two provinces. However, substantial amount of efforts were made on water savings. Sichuan published and implemented the Sichuan Urban Area Water Saving Directive in 1992. In 2011, the provincial government published Sichuan Provincial Government Memo about Fully Promoting Water Saving Society Building. Now, the compilation of provincial plan for building water saving society in Sichuan is ongoing.

More details about the progress and results of the Water Saving Society in the pilot provinces are described in Annex 1 to this Appendix. (This information is summarized in this appendix but is still in Chinese in Annex 1.)

Until now, each province and other municipalities or counties have established their own drought emergency plan, which added positive impacts on drought relief activities. Under normal conditions, water saving activities are prescribed in municipal-level drought emergency plans, including call for urban residents to save water during drought period, and mandatorily cut water allocation for certain sectors when drought is development into certain stage.

B.2.2 Water saving measures under normal conditions

A list of potential water saving measures is included in Annex 2. The use of water saving measures in the three pilot provinces of this project will be discussed below.

B.2.2.1 Administrative measures

One of the most important aspects of water saving is the use of administrative instruments such as water rights and water abstraction permits (WAPs). These should be based on a sound assessment of the resource availability, and a rational allocation of these resources between users and sectors. Well-defined water rights give water users the assurance that they will receive a fair and agreed share of the available water. Farmers and other water users can then plan for the best way use this water which fits in with their livelihoods, and they may even sell their right to others. Such permits will also provide the basis for reallocation before or during droughts in future. In the past abstraction permits have not been actively used for irrigation demand management. Permits are more widely used for industrial and urban water management, where they may be supported by other administrative measures such as building regulations and river quality regulations.

The WAPs must be consistently and strictly enforced, and audited. The entire system of managing permits (including the costs of monitoring the water resources as well as administering the permit process) needs to be well-financed, and this should be one of the main reasons for introducing water resource fees.

Generally speaking, China's water rights belong to the state, and are managed by the water resources management department. If any individuals or groups need to exploit water resources, they should file an application and obtain approvals from the water resources department, as well as water abstraction permits to launch the water exploitation activities.

According to the Water Abstraction Permitting Procedures approved by the state council in 1993 and piloted from Sep 1, 1993, the water abstraction for household, livestock, small amount of water abstraction for agricultural irrigation, and small amount of water abstraction with manpower, livestock, or other means of hauling do not need water abstraction permits. Water abstraction for agriculture drought relief, to guarantee mine site or underground construction safety or process safety, and to eliminate hazards to public security also do not need water abstraction permits.

In 2005, the Water Resources Department's Memo about Water Rights Transfer was published and implemented by the state. This is the first time that the concept of water rights were adopted in formal documents and the water rights transfer was defined as the transfer of rights of water resources exploitation. With this situation, several regions gradually started pilot research on water rights transfer and trade. But it has not been widely studied and implemented.

According to the 2010 Hydro Yearbook, 13.689 billion m^3 water of the total supply of 14.367 billion m^3 (95%) in Liaoning Province was covered by abstraction permits. The distribution of water abstraction permits over different sectors is presented in the table below (Table B.13). Such data were not presented for the other two pilot provinces.

Table B.13: Water abstraction permits

Sectors	Number (10 thousand)	Water Amount (100 million m^3)
Total Coverage	1.37	136.89
Surface water	-	78.38
Groundwater	-	58.51
Industrial	0.59	33.47
Domestic	0.17	15.52
Agriculture	0.61	87.90

It is relatively easy to state the water abstraction permit requirements in general terms, but there are many practical difficulties and the administrative burden of managing water abstraction permits and water rights certificates is considerable. Under the DFID Water Resources Demand Management Assistance Project (WRDMAP) a case study on Water Abstraction Permit Management in Shiyang River Basin in Gansu province was carried out. Many Issues with regard to managing water abstraction permits were identified:

- Accuracy of water resources availability assessments (through monitoring and modelling or other methods) and the impact of demand management measures (some reduce total consumption, some may simply reduce return flows without reducing consumption)
- Administrative procedures for data collection and analysis of demands
- Audit arrangements to ensure that permits/rights and resources are consistent; that demands and supply match; that irrigation norms are consistent with crop requirements; that loss calculations are correct
- Impact of demand management on livelihoods (financial compensation or resettlement, if needed to offset well closure/land area reduction).

B.2.2.2 Economic measures

Economic instruments such as water tariffs and service charges are widely seen – in China as in the rest of the world - to play a critical part in achieving water savings. They have had a useful impact in the urban and industrial sectors, but have had a much smaller impact in the irrigation sector. Economic instruments remain important in the irrigation sector, but their nature and impact is rather more complex than stimulating a reduction in demand as a direct result of an increase in price.

In China water tariffs have been rising gradually since the early 1990s. However, in general, water prices are still below the requirements for financial cost recovery and are generally too low to reflect its scarcity value and therefore do not have sufficient impact on demand for water. This has made it difficult for water utilities to maintain infrastructure adequately, to expand their service to outlying and poorer areas, or to operate their infrastructure in a manner that meets environmental standards. Thus, the first step toward setting prices right should be at least meeting the utilities' financial performance requirements.

In the pilot provinces in general, water prices in rural areas are relatively low while the urban and industrial water price is high. Rural water use includes agriculture water use and household domestic water use. Agriculture water price is generally several fen per cubic meters. The private water abstraction for household domestic water use is free of charge. The water price for household domestic water use from a centralized water supply system follows the water supply cost also.

As for industrial and domestic water use in urban area, the water price includes wastewater treatment fee and which comprises 20 to 30% of total water price. Normally, water price in the commercial sector is higher than that of the industrial sector, and industrial water price is higher than domestic water price. Table B.14 lists the water price in Shenyang (Liaoning's Capital), Chengdu (Sichuan's Capital), Lanzhou (Gansu's Capital) in different sectors in the year of 2012.

Table B.14: Water price in selected urban area of pilot provinces

Municipality	Domestic (RMB/m^3)	Industrial (RMB/m^3)	Commercial (RMB/m^3)
Shenyang	2.4	3.5	4.0
Lanzhou	1.5	2.6	3.5
Chengdu	2.8	4.0	4.0

According to the 2010 Hydro Yearbook, Liaoning province (excluding Dalian City) collected 302 million RMB (US$47.45 million) of water fees, increasing 19% compared to 2009. Among this, 19 minority counties and poor counties collected 31 million RMB (US$4.87 million), other counties collected 256 million RMB (US$40.22 million), and the Provincial level collected 15 million RMB (US$2.36 million). Such data were not presented for the other two pilot provinces.

Rising block tariffs for domestic consumption and rates for nondomestic tariff categories aimed at conserving water and promoting the sustainability of water utility companies are becoming more widely adopted and cities in China are now. The objectives of these water tariffs are:

- recovery of all costs
- achieve a reasonable profit for water utilities
- promote water conservation equity among users

Water markets are a topic of considerable interest both internationally and in China. There are many examples of water trading, but this is generally informal exchange of water between adjacent irrigators. But, as with the case of full cost pricing, there are many constraints and it will be many years before water markets are widely adopted.

Water tariffs for water supply companies

The National Guideline on Water Tariffs (NGWT), formulated by the State Developing Planning Commission (SDPC) and the Ministry of Construction (MOC), was issued as SDPC notice no. 1810 on 23 September 1998. The NGWT is a state ministry and commission administrative regulation that derives its authority from provisions for water tariffs in the Price Law (1997) and the Urban Water Supply Regulation (State Council order No.158, 1994 10 01). Objectives of the NGWT include improving the financial sustainability of water supply companies, assuring water services are affordable for the urban poor, encouraging water conservation, and protecting the consumer.

Irrigation service charges

The 2002 Water Law provides for cost recovery for water-related services under Article 55, which states that 'Water supply' fees are to be levied to recover the full costs of their provision and to allow a reasonable profit. Regulations on such charges are to be formulated by the departments of price administration (the Price Bureaus) jointly with the water supplying organizations.

The 2003 ‘Regulation on Water Price Management in Water Schemes’ provides detailed guidelines on irrigation charging. Amongst other things, it stipulates that:

1. Tariffs should be divided into two categories, agricultural and non-agricultural, with the agricultural ‘water price’ excluding profits and tax whereas the non-agricultural should include them,
2. Of the two forms of irrigation charge, the Basic ‘Water Price’ (the charge per mu) should include direct salaries and management expenses and 50% of the scheme depreciation and repair costs whereas the volumetric charge per m3 should include all other costs, including the water resource fees,
3. The charges should take account of their affordability to users and
4. For schemes funded by loans and bonds the charge should be sufficient “to reimburse the capital and interest” and obtain a reasonable profit; i.e. it provides for recovery of even the full capital costs.

SCD460 provides the framework for the water resource abstraction and the water resource fee (WRF) system, but it does not specifically cover irrigation charging. It will become more relevant to ISCs in the future if WRFs are charged for abstraction for surface water irrigation. These WRFs would then become a cost which would need to be recovered from users through the ISCs.

The ISC regulations at the Province level generally follow the national regulations. In Gansu, the ‘Provisional Regulations on Water Supply Cost Accounting for Water Projects in Gansu Province’ were published in 1998, providing detailed instructions on how to calculate the capital and O&M costs of irrigation and other water projects and are the basis used for the cost estimating work done by the Water Resources Bureaus and other water sector organizations. They do not, however, cover how irrigation charges should be calculated to recover these costs.

B.2.2.3 Legal framework for Permits and Fees

The legislative basis for water abstraction permitting and management of water resources fees is the Water Law (2002). Articles 7, 48 and 49, require promulgation of special measures to implement a water abstraction permit system (WAPS) and collection and management of water resources fees (WRFs) based on volumetric measurement. Regulations are given in State Council Decree of PRC No. 460 (2006), “Regulation for Water Drawing Permit and Collection and Management of Water Resources Fee” (referred to hereafter as SCD 460).

SCD 460 refers to droughts in Article 4 and Article 41. Article 4 stipulates exceptions to water abstraction permits including temporary emergency water abstraction that must be done to combat drought in agriculture or protect the ecology and environment. Article 41 sets out how the requirements for abstraction permits may be restricted during a drought: ’If a major drought occurs, the competent authority may implement emergency limitation to the amount of water drawing by units and individuals.’ No definition of a ‘major drought’ is given.

There are also provincial regulations. For example, in Gansu: “Detailed Rules of Gansu Province for Implementation of Water Abstraction Permit System” and “Measures of Gansu Province for Administration and Management of Water Resource Fee Collection.” The principles are the same as those of SCD 460 with the exception for one provision for water resources fees for agricultural use.

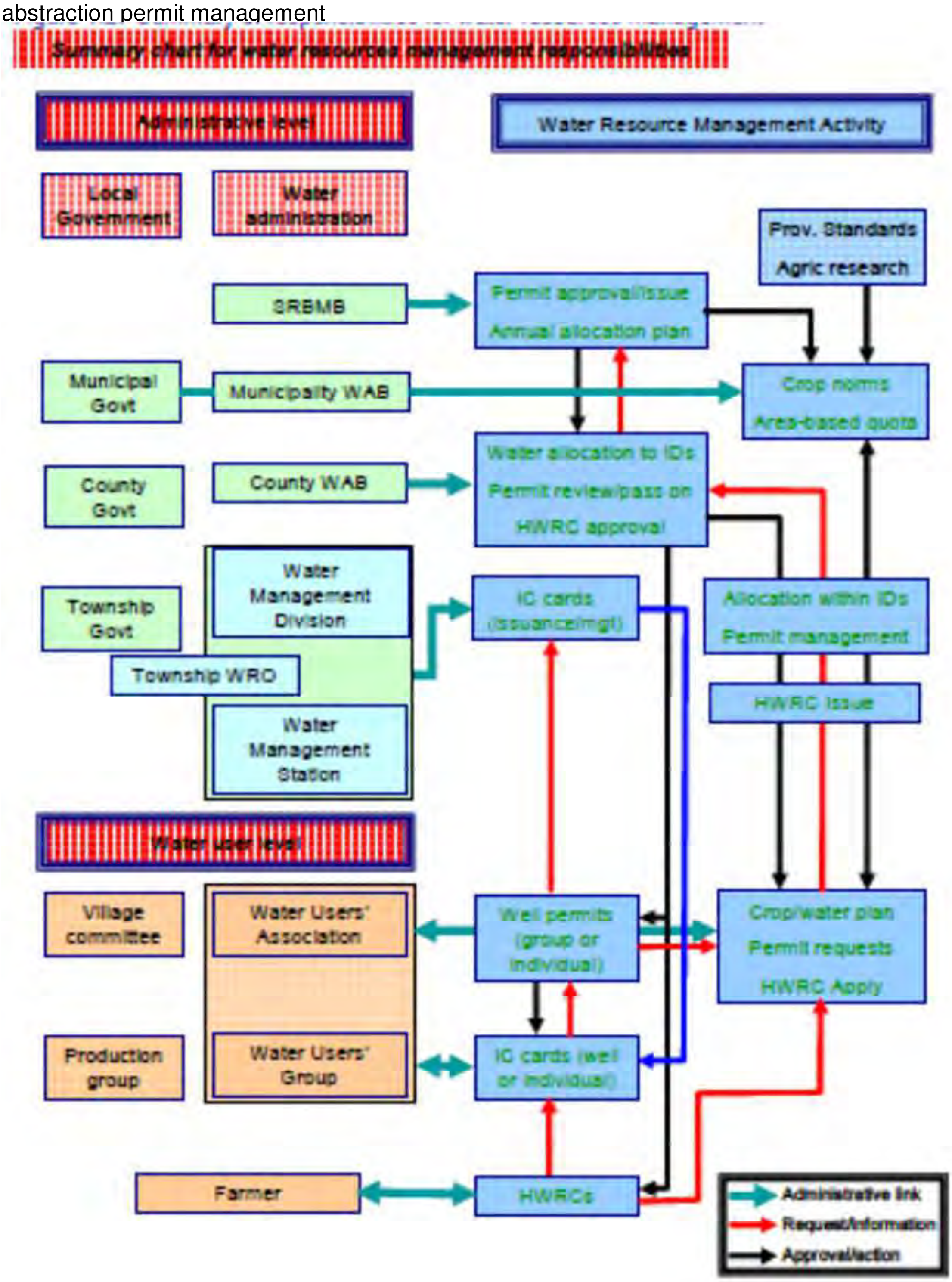
B.2.2.4 Institutional roles

The WRDMAP case study in Shiyang River Basin in Gansu shows the process and responsibilities for water abstraction permit management, as outlined in Figure B.1. These responsibilities are shared between a number of organizations, including local government and the water administration at all levels from the Shiyang River Basin Management Bureau (SRBMB), an affiliated agency of the Gansu Provincial Department of Water Resources, and municipality level down to villages and even individual users.

The, SRBMB needs to ensure that permits are only issued up to sustainable value of water resource availability. Procedures are needed for:

- Water resource assessment and annual review/allocation
- Application, review, approval, issuance, management of permits
- Verification of household rights for consistency with resource availability
- Compliance monitoring
- Permit audit process
- Verification of underlying data
- Compliance with procedures
- Impact on groundwater level

Figure B.1. The WRDMAP case study in Shiyang River Basin: Process and responsibilities for water abstraction permit management



B.2.2.5 Technical measures

Agricultural measures

Although agriculture uses more water, agricultural water demand management has a more indirect impact since many of the ‘losses’ can be reused further downstream. This does not mean that water use efficiency should not be improved, but it does mean that the water saving measures have very different impacts at local level and on water resources in the basin as a whole are not the same. The overall basin ‘efficiency’ may be quite high already, even if the individual systems are ‘inefficient’.

The concept of ET (evapotranspiration) management has been introduced in parts of China. This is a valuable approach which focuses efforts on reducing consumptive use of water, and placing less emphasis on reducing losses which are available for reuse. It requires a reduction in irrigated areas and a reduction in losses which result in seepage to saline aquifers or the sea, or in unproductive evaporation.

Agricultural water-saving technologies in the pilot provinces include spray irrigation, micro-irrigation, canal irrigation and canal lining. A few areas focus on choosing drought-tolerant crops. The "big double ridge" cultivation techniques that the TA team saw during their field visit in Gansu Province are advanced techniques that preserve soil moisture and save water. Mulching cultivation is also widely used as water-saving technology.

Urban measures

Urban uses of water are generally smaller in volume than irrigation uses, so the potential for saving is less. But it is still very important, and with rapid urbanization it is growing in importance. Savings can be achieved for example through leakage reduction, reusing water and installing water saving equipment. The value of the water saved in economic terms is normally higher, since in most situations it is treated and potable water that is being ‘saved’. Additionally, in many countries urban water saving has received more attention since it is linked to private sector investments and associated returns where finance and economics are taken into greater account in decision making.

Industrial measures

Industrial water saving includes process improvements, leakage control, recycling, treatment and reuse of wastewater ant water efficient equipment.

B.2.3 Additional / enhanced water saving measures for pre-drought and drought conditions

Water saving measures are mostly applicable under normal conditions (long term measures). For potential drought predictions additional water saving measures can be triggered, such as limits to water abstraction permits.

- Temporary reductions in water use
- Assessment (e.g. ‘Prospects for Spray Irrigation’)
- Voluntary reductions
- Restrictions of abstraction licenses (should be in place before action needs to be taken)
- Temporary water reallocation

- Reallocation to prioritized users or areas
- Water transfers to redistribute water from areas of surplus to area of local deficit

PRC State Council Decree No. 460 under Water Law (2002) sets out the requirements for abstraction permits and how these may be restricted during a drought.

In the UK uses drought orders and drought permits to manage water use and supply in drought periods.
- Drought orders
  - To restrict water use in certain areas: Examples include water use for car / vehicle washes; garden sprinklers; sprinklers for landscaping (terminated or limited to a set number of hours per day); water to clean any premises, apart for safety or hygiene reasons; 'wetting' of roads to curb dust nuisance; public fountains; swimming pools and ornamental ponds; automatically-flushing toilet cisterns at times when buildings are unoccupied, etc.
- Drought permits
  - To enable additional supplies to be provided to certain users during droughts.
  - Related to meeting human needs (e.g. water for hospitals).

The regulatory arrangement for implementing these short-term, additional water saving measures should be prepared under normal operations and triggered at various drought warning levels in the proposed DMPs). Examples include:
- Evaluating and rating reliability of existing suppliers
- Setting up water saving plans of individual suppliers to be ready to implement during pre-drought or drought conditions
- Evaluating potential water reductions and reallocations such as agricultural transfer to urban use – including leases, changes in abstraction permits, drought insurance, payments to individual farmers, etc.

B.3 Water user survey results

B.3.1 Water saving questionnaires

The water user surveys have been completed in August 2013 and the results have been analyzed in September 2013. The surveys aimed to determine the current state of knowledge and awareness of water saving methods in the three provinces. The water user survey results would be valuable input to the capacity building and public awareness programs.

A questionnaire with 25 questions was designed (see attached water-saving questionnaire). With major support of provincial FCDRH in three pilot provinces the questionnaire was distributed under relevant staff in the three pilot provinces, including FCDRH, water resources, hydrological, meteorological and agriculture departments or research institutions at provincial, municipal and county level. The provincial departments included provincial FCDRH, agriculture, and meteorological management or research departments. The municipal and county-level departments included mainly FCDRH. A total number of 74 questionnaires were returned and analyzed. The results have been summarized below.

According to the returned surveys all answers to the survey were summarized and listed in Table B.15. Because several questions were multiple-choice, and several surveys were lacking answers, there are discrepancies between numbers of total counts of returned survey and numbers of answers in Table B.15.

Table B.15: Detailed information about feedback of the survey

Pilot province	Returned	Counts by administrative level		
		Province-level	Municipal-level	County-level
Liaoning	19	2	9	8
Gansu	21	6	7	8
Sichuan	34	8	7	19
Total	74	16	23	35

B.3.2 Analysis of survey questionnaire results

A summary of the results is presented in Table B.16. These results show that the constraints of on water saving present in several aspects and vary between sectors. For all sectors, the main constraint for installing water saving equipment is that the initial investment is too high. Chinese farmers have limited arable lands, the agriculture water price is low and therefore the cost-effectiveness of water saving techniques is a major constraint. The constraints for industrial water saving is also economic, so the water saving techniques improvements have not been fully implemented. Lack of policies also presents constraints for water saving in all sectors. The industrial water saving policy is not complete. Another constraint for agricultural and urban water saving is the lack of public awareness. Currently, the major driving force for water saving techniques improvements is regarded to be progressive water price.

Table B.16: Summary of water-saving questionnaire analysis of the pilot provinces

	A	B	C	D	E	Conclusions
General						
1. How will the water demand change in next 5 years in your area? A. rapidly increase B. slowly increase C. will not change D. slowly reduce	32	34	5	0		Most participants agree that water demand will increase over the next 5 years (rapidly or slowly) in their area although some participants in Liaoning Province think it will not change.
2. Is the progressive water price implemented for urban water supply? A. a few sectors B. all sectors C. not implemented D. in planning	40	9	20	3		Progressive water price was implemented in a few sectors in urban water supply. Quite a few areas have not implemented progressive water price.
3. How public is aware of water savings? A. very well B. moderately C. poor D. no public awareness on water saving	11	49	10			Most areas have moderate public awareness of water saving.
4. What are the public educational programs in your area? A. TV programs B. Community education C. Internet educational program D. Program implemented occasionally during certain period of time	57	48	38	58		Public education program includes TV, community education, internet education, and campaigns.
5. In your opinion, the water saving education and public awareness program should be facing? A. Students B. Civilians C. Farmers D. Employees	44	53	37	35		Most people think public awareness program should be facing students and civilians.
6. In your opinion, the most efficient water saving measures are? A. increase water price B. implement progressive water price C. improve public awareness program D. water saving equipment E. optimize industrial structure	9	48	17	51	29	Most people think the most effective water saving measures are to implement progressive water price and water saving equipment.
7. What are the constraints towards water saving in your area? A. lack of techniques B. lack of management measures C. lack of public awareness D. lack of regulations and standards E. water price is not reasonable	30	34	52	28	9	Most of people think lacking public awareness is the major constraint, second is lacking management measures and lacking techniques.
8. The sectors that have the greatest potential on water saving are? A. Industrial water use B. Agriculture water use C municipal water use D. other water use	44	54	49	23		Most people think agriculture has the most potential of water saving, domestic living has the second most and industry has the third most potential.
Agriculture water saving						
9. What are the technical measures for water saving in your area? A. Sprinkler irrigation B. pipe irrigation C. drip irrigation D. micro irrigation	61	62	58	44		The water saving techniques in irrigation include sprinkler, pipe, drip, and micro irrigation.
10. What is the current condition of agriculture water saving in your area? A. almost no implementation B. less than 25% of area C. 25% to 50% D. 50% to 75% E. more than 75%	5	30	31	3	2	In general, 25%-50% of area implemented water saving irrigation. A few areas did not implement.

	A	B	C	D	E	Conclusions
11. In your opinion, what is the major reason why the water saving irrigation is implemented? A. no water shortage B. too much initial investment C. lack of techniques D. lack of public awareness	10	53	28	13		The main reason is that the initial investment is too high.
12. Have you ever done water saving training to farmers? A. occasionally B. regularly C. very often D. no	40	22	4	5		Most participants have occasionally been involved in water saving training to farmers.
13. How the agriculture water use in your area will change in next 5 years? A. rapidly increase B. slowly increase C. will not change D. slowly reduce	12	36	11	12		Most participants think that the agriculture water use in most of the areas will increase slowly in next 5 years.
Industrial Water saving						
14. When did the industrial water saving technical improvements start? A. not B. in recent 5 years C. ten years ago D.20 years ago	7	23	34	5		Most of the areas started water saving technical improvements around ten years ago, a few areas did not start.
15. What are the industrial water saving measures? A. water reuse B. reclaim grey water C. sea water use D. progressive water price	55	32	1	20		Industrial water saving measures in most areas include water reuse.
16. What percentage of industry in your area has implemented technique improvements to save water? A. more than 60% B. 40% to 60% C.20% to 40 D. less than 20% E. not clear	6	9	20	10	19	The majority of the participants estimated that 20%-40% of industry in most areas has implemented technique improvements to save water.
17. How will the industrial water use change in the next 5 years? A. rapidly increase B. slowly increase C. will not change D. will reduce	36	29	10	2		Most participants expect the industrial water use to increase (rapidly or slowly) in their area in the next 5 years.
18. In your opinion, why some industries did not implement technical improvement to save water? A. lack of water saving awareness B. lack of regulations or standards C. too much initial investment D. water price is too low	22	13	52	15		Main reason why some industries did not implement technical water saving measures is too high initial investment.
Urban domestic water saving						
19. When was the water saving equipment installed in your area? A. just started B. 2 years ago C. 5 years ago D. 10 years ago E. not clear	9	6	9	19	27	Most areas installed water saving equipment around ten years ago, a few areas just started.
20. Why the water saving equipment was adapted by urban people A. administrative forced B. administrative lead C. voluntarily adapted	4	27	19	11		In most areas urban residents switched to water saving equipment because of administrative measures or voluntarily.
21. What is the percentage of your area that the urban water saving equipment was installed A. less than 20% B. 20% to 40% C. 40% to 60% D. more than 60%	35	18	27	9		Most participants think less than 20% of the area was installed with water saving equipment
22. What are the constraints toward installing water saving equipment?	12	32	34	7		The main reason is the water saving equipment is

	A	B	C	D	E	Conclusions
A. lack of water saving equipment B. the water saving equipment are expensive C. lack of public awareness D. water price is too low						the high costs of water saving equipment. Another main constraint, especially in Liaoning, is the lack of public awareness.
23. Why the water saving equipment in some cities was more adapted? A. administrative force B. administrative lead C. voluntarily adapted by local people D. water price is high	9	40	29	8		Most people think administrative measures could promote the installation of water saving equipment.
24. What percentage of tap water lost due to leakage in your area? A. less than 5% B. 5% to 10% C. 10% to 15% D. more than 15% E. not clear	4	11	17	22	16	Some people think the leakage is between 10% and 15%, quite a few people think it is more than 15%.
25. How often do you have public awareness program in your area? A. very often B. regularly C. occasionally D. never	10	41	10	1		Public awareness programs are held regularly in most areas, several areas hold them very often (Sichuan), and several areas occasionally.

ANNEX 1: Progress and results of Water Saving Society in pilot provinces (In Chinese only)

Progress and results of WSS in Liaoning (In Chinese only)

辽宁省节水型社会建设在如下几个方面取得了进展：

(一)用水效率得到提高

“十一五”期间，辽宁省节水型社会建设取得了重要进展。2005 年至 2010 年，全省万元 GDP 用水量从 166m3 下降至 94m3，下降了 43%；万元工业增加值用水量从 62m3 下降至 35m3，下降了 44%；农田灌溉水有效利用系数从 0.53 提高到 0.558，提高了 3%。

(二)构建出节水型社会框架体系

“十一五”期间，辽宁省基本形成了节水型社会框架体系，这一框架体系主要包括四个方面：(1)以水资源总量控制与定额管理为核心的水资源管理体系。(2)与水资源承载能力相适应的经济结构体系。(3)水资源优化配置和高效利用的工程技术体系.(4)自觉节水的社会行为规范体系。

以水资源总量控制与定额管理为核心的水资源管理体系正在逐步形成。一是实行用水总量控制和用水定额管理。“十一五”期间编制完成了《辽宁省水资源综合规划》、《辽宁省节水型社会建设“十一五”规划》及《辽宁省区域经济可持续发展水资源配置规划》等水资源相关规划，14 个地级市均制定了本地区的节水型社会建设规划，确定了全省及地区用水目标和任务。完成了辽宁省大凌河流域水量分配工作，经省政府同意已批准实施。通过各项节水措施，至“十一五”末期全省用水总量控制在 143 亿立方米左右，其中农业用水总量控制在 93 亿立方米左右，工业用水总量控制在 25 亿立方米左右。修订了辽宁省地方标准《行业用水定额》，扩大了用水定额的范围和标准，进一步完善了用水定额管理。对各类取水工程发放了取水许可证，基本实现了水资源的有序开发，截止 2010 年底，全省共发放取水许可证 1.37 万套，许可水量 136.89 亿立方米，其中地表水 78.38 亿立方米，地下水 58.51 亿立方米。全面加强了建设项目水资源论证工作，新建、改建、扩建项目全部进行建设项目水资源论证，否决了一批不符合国家产业政策、高耗水、高污染的建设项目。二是加大了水资源保护力度。加强饮用水源保护，对县城以上城市饮用水水源地划定了保护区。加强地表水水功能区监督与管理，每月对 127 个重点水功能区进行检测与评价。对全省入河排污口进行了普查登记，加强了入河排污口监督管理。加大了污水处理厂的建设力度，全身已建成污水处理厂 136 座，已运行 123 座，运行率达到 75%，污水处理率达到 63%。加强了地下水的保护，划定地下水资源保护区，对在保护区开采地下水实行了加收水资源费政策。全面实施了地下水保护行动，全省依法封闭地下水井 916 眼，退还地下水 0.26 亿立方米，核减地下水取水指标 0.6 亿立方米，地下水超采和海水入侵的恶化趋势得到了控制。三是稳步推进水资源监测系统建设。加强了取水计量工作，全省安装 IC 卡智能水表 2560 块；建设了全省取水远程实时监测网络系统，对 402 个大中型取水工程实现了远程实时监测。加强了水量、水质监测工作，实施了全省地下水水位远程实时监测站网建设 ，在大凌河流域建设了市际行政界地表水监测站网。

通过经济体制改革和产业结构调整，与水资源承载能力相适应的经济结构体系正在逐步建立。“十一五”期间，省委、省政府高度重视节水型社会建设工作，始终把节水减排作为调整经济结构、转变发展方式、推动科学发展的重要抓手，根据全省水资源条件，逐步调整经济结构和产业布局，实现从“以需定供”—“以供定需”—“以水定发展”的转变，采取了一系列强有力的政策措施，逐步建立了与区域水资源和水环境承载能力相协调的经济结构体系。以是调整工业布局，推行清洁生产。大力发展节水型工业，控制高耗水和淘汰落后设施及用水工艺，提高对高耗水、高污染建设项目(产品)的准入门槛，在缺水地区严格控制高耗水、高污染项目的审批和建设。对年用水量 100 万立方米以上的重点用水单位进行跟踪指导。二是大力发展循环经济，提高用水效率和效益。把发展循环经济通全省产业结构调整结合起来，建设资源节约产业体系，以高新技术改造传统用水工艺，加大对工业用水会受重复利用设施的投入，提高工业用水重复利用率，提倡循环用水、一水多用。扩大非常规水源利用范围，新建、改建、扩建项目优先采用再生水、海水及矿井水等非常规水源。三是调整农业种植结构，发展高效节水农业和生态农业。根据区域水资源条件进行农作物布局和种植结构调整，以节水、高产、高效为核心，加强农作物品种选育工作，积极裴蕴耐旱的优质高效作物品种，控制发展水田灌溉面积，将水田种植面积控制在 950 万亩左右，大力发展设施农业、旱作节水农业，并采取生物节水、农艺节水、工程节水等相结合的综合节水措施，提高灌溉水利用效率。

水资源优化配置和高效利用的工程技术体系建设不断加快。一是建设水资源优化配置工程。 完成了引细入汤、大伙房输水工程等 4 项输陪睡工程，开工建设了三湾水利枢纽及输水、锦凌水库等 6 项应急供水工程建设，基本形成了北、中、南三线组成的“东水济西”水资源总体配置格局，水资源配置得到了进一步的优化。二是大力推进水资源高效利用工程技术体系建设。加大现有水资源利用设施的配套与节水改造，推广使用先进、实用、高效的用水设施和技术，完善水资源高效利用工程技术体系，初步建立与水资源优化配置相适应的节水工程体系。在工业用水方面，加快火电、石油化工、造纸、冶金、防治、建材等高用水工业企业的节水技术改造，采用先进的节水技术、工艺和设备，逐步淘汰落后的、耗水量高的工艺、设备和产品，提高工业用水的重复利用率；在农业用水方面，加大力度推进大中型灌区的续建配套和节水改造，推进农业节水工程建设，实施大中型灌区节水改造和渠系配套工程、节水灌溉示范工程、旱作农业节水工程，发展农业节水灌溉面积。在非常规水源利用放米娜，大力开展废污水的综合利用，建设再生水利用工程、矿井水利用工程、海水直接利用和海水淡化工程等替代淡水资源。

节水宣传教育不断强化，全民节水知识不断普及，初步形成了良好的节水社会氛围。深入开展了“世界水日”、“中国水周”和“城市节水宣传周”宣传活动，充分利用广播、电视、报刊等各种媒体深入宣传节水的重大意义，不断提高公众的缺水忧患意识和节约意识，动员全社会力量参与节水型社会建设，“十一五”期间共出动节水宣传人员 12000 余人次，宣传车 3000 多台次，张贴标语 25000 多条，投入宣传资金 1000 余万元。大力开展群众性节水宣传活动，尝到节水生活方式。在社区举办“居民如何节约用水”只是讲座，每年印发节水宣传材料 30 余万份，设立节水宣传站 1394 个，鼓励居民使用节水器具。大力开展校园节水宣传教育活动，通过举办节水知识讲座、主题班会、张贴节水警示牌、宣传板报、发放《节水宣传手册》及组织学生观看节水宣传教育电视片、写观后感等形式，向广大学生宣传普及节水知识，让广大学生了解到节水的重要性，树立节约用水的观念和意识，使学生逐渐养成节约用水的好习惯，形成了节约用水的良好校园风气。

(三)节水型社会制度建设取得进展

“十一五”期间，全省节水型社会建设法规体系进一步健全。在水资源开发利用方面，出台了《辽宁省水能资源开发利用管理条例》、《辽宁省取水许可和水资源费征收管理实施办法》、《锦州市城市供水用水管理办法》等。在水资源节约方面，颁布实施了《辽宁省节水型房屋卫生洁具使用管理暂行规定》，全省 14 个市制定了城市供水、节水管理办法，鞍山、抚顺、营口、辽阳、朝阳市制定了全市节水管理办法。在水资源保护方面，修订了《辽宁省地下水资源保护条例》、出台了《辽宁省大伙房水库输水工程保护条例》、《辽宁省污水处理厂运行监督管理规定》，《朝阳市城市应用水水源保护管理暂行办法》、《北票城区饮用水地下水源保护区环境保护管理办法》、《凌源市城市饮用水水源地保护管理办法》等；在水价政策方面，出台了《辽宁省水利工程供水价格管理办法》、《辽宁省城市污水处理费征收管理办法》。目前，全省已建立并实施了取水许可、建设项目水资源论证、水资源费征收、用水总量控制与定额管理、取水计划管理、地下水资源保护区、水功能区和入河排污口监督管理等水资源管理制度。

(四)节水工程建设取得进展

农业重点节水工程建设情况。完成了凡河、辽阳、凌海、龙潭、孤山、柴河、三道、通江子、浑北 9 处中型灌区节水配套改造工程，实施辽蒲灌区、灯塔灌区优质水稻生产节水改造等近 40 余项节水灌溉示范项目，通过建设节水工程实现了年节水量 2.9 亿立方米；推广机械化保护性耕作 3 万亩，深松保墒技术 4 万亩。新增节水灌溉面积 122 万亩，至 2010 年底全省节水灌溉面积达到了 699 万亩，占农田有效灌溉面积的 31%，较 2005 年提高 6 个百分点。

工业重点节水工程建设情况。完成了朝阳发电厂渗透水冲服利用工程、营口造纸厂造纸废水资源化工程、本钢发电厂化学车间节水设施改造工程、辽化公司节水改造工程等重点企业节水改造工程 29 项，实现年节水量 5135 万立方米。至 2010 年末全省规模以上工业用水重复利用率提高到 91%，较“十五”期末，提高了 6 个百分点。

城镇公共生活重点节水工程建设情况。完成了 2500KM 城市公共供水管网改造，推广节水器具 50 万套，实现年节水量 2.5 亿立方米。大连、鞍山等市在大型宾馆、饭店、大专院校、集中住宅小区建设再生水利用和雨水利用示范工程。

非传统水源利用工程建设情况。完成了华能营口电厂利用海水进行机组冷却和除灰渣冷却水等 4 项海水淡化及直接利用工程，年替代淡水量 5659 万立方米；完成营口市西部污水处理厂再生水利用工程、锦州市再生水利用工程、铁岭市污水处理厂再生水利用工程(一期)等城市再生水利用工程 8 项，年再生水利用量 1.57 亿立方米；完成阜新矿业(集团)有限责任公司矿井水利用工程、辽宁南票煤电有限公司矿井水利用工程等 2 项矿井水利用工程，年利用量 3270 万立方米。

水资源监测系统建设情况。完成了全省取水远程实时监测网络系统建设，建成监测站 650 个，对 402 个大中型取水工程实施了远程实时监测，建设了全省地下水监测系统，建成地下水水位在线监测站 258 处。

节水型社会建设示范项目。为推动节水型社会建设，自 2008 年起，启动了一批节水型社会建设示范工程，3 年共开展抚顺市辽宁石油化工大学节水型高校建设、鞍山市雨水收集利用示范项目、朝阳市自来水公司区域计量检测系统工程、营口市大型企业水平衡测试等示范项目。

(五)开展了节水型社会建设试点

“十一五”期间，全省开展了 8 个节水型社会建设试点，并初见成效。其中大连、鞍山、辽阳、本溪为国家级试点，朝阳市、阜新市、凌源市、建平县均为省级试点。通过节水型社会建设试点建设，探索了不同类型地区节水型社会建设模式和运行机制，积累了许多经验，为全省节水型社会建设起到了较好的示范效应。

大连市：2003 年被水利部确定为第一批国家级节水型社会建设试点，是国家继张掖市、绵阳市之后第三个试点城市。自试点确立以来，通过实施水资源优化配置，强化水资源开发利用全过程管理，调整工业产业结构和空间布局，健全市场经济调节机制、深化水务管理体制改革，建设节水示范工程等，节水型社会建设试点建设取得显著成效，全面完成试点建设目标及任务，提高了用水效率和效益。2010 年末，全市万元 GDP 用水量降至 30 立方米，万元工业增加值用水量降至 20 立方米，规模以上工业用水重复利用率 87%，农业节水灌溉面积工程比例达到 90%，农田灌溉水有效利用系数提升到 0.559 左右，用水水平在全国和全省范围内处于先进水平。

鞍山市：2005 年被辽宁省政府确定为省级节水型社会建设试点，2006 年被水利部确定为第二批国家级节水型社会建设试点。自开展试点建设以来，针对全市水资源短缺及水体污染等突出水问题，以工业企业节水减排为重点，为重工业城市和大型钢铁工业节水积累了重要的经验。2010 年末，全市万元 GDP 用水量降至 59 立方米，万元工业增加值用水量降至 47 立方米，规模以上工业用事重复利用率达到 90%，农田灌溉水有效利用系数提升到 0.541 左右，城市再生水利用率为 44%，用水水平在全国和全省范围内处于较先进水平。

辽阳市：2005 年被辽宁省政府确定为省级节水型社会建设试点，2008 年被水利部确定为第三批国家级节水型社会建设试点。辽阳市针对水资源短缺、重化工业集中、水染污严重、地下水超采等问题，确定了以重化工业节水、水生态修复等为重点的示范和建设领域。通过节水型社会建设，至 2010 年，全市万元 GDP 用水量降至 155 立方米，万元工业增加值用水量降至 55 立方米，较 2005 年分别降低 52%、53%，规模以上工业用水重复利用率 78%，农田灌溉水有效利用系数提升到 0.504 左右，通过加大水污染治理、人工回灌、压采等措施，全市水生态环境和地下水超采得到了明显改善。

本溪市：2005 年被辽宁省政府确定为省级节水型社会建设试点，2010 年被水利部确定为第四批国家级节水型社会建设试点，编制完成了试点规划和实施方案。本溪市是水资源相对丰富地区，人均水资源占有量 2070 立方米，是全省 2.5 倍，但太子和本溪城市段水污染严重，用水效率较低。“十一五”期间，本溪市主要通过加强节水减排，转变用水方式，强化用水管理等措施，节水型社会建设取得了一定成效。2010 年末，全市万元 GDP 用水量降至 50 立方米，万元工业增加值用水量降至 53 立方米，较 2005 年分别降低 64%、59%，规模以上工业用水重复利用率提高到 90%，农田灌溉水有效利用系数提升到 0.481 左右，水功能区水质达标率达到 83%。

朝阳市：2005 年被辽宁省政府确定为省级节水型社会建设试点，2009 年省政府又将朝阳市的凌源市和建平县确定为省级试点县(市)。朝阳市是严重缺水地区，地区水资源匮乏，水资源供需矛盾突出，旱灾频繁，水生态环境脆弱，严重制约着地区社会经济的发展。“十一五”期间，通过开展节水型社会建设，再用水管理和制度建设、水资源优化配置与高效利用、生态环境治理等方面进行探索与实践，节水型社会建设初见成效。2010 年末，全市万元 GDP 用水量降至 82 立方米，万元工业增加值用水量降至 39 立方米，较 2005 年分别降低 52%、66%，规模以上工业用水重复利用率提高到 80%，农田灌溉水有效利用系数提高到 0.598。

阜新市：2005 年被辽宁省政府确定为省级节水型社会建设试点。阜新市资源性缺水、工程性缺水和水质性缺水并存，特别“十一五”以来，阜新市正处于资源型城市转型时期，水资源短缺问题尤为突出。自开展试点建设以来，全市以提高水资源利用效率和效益为目标，节水与减污并行，初步建立了总量控制与定额管理相结合的水资源管理体制，通过产业结构调整、经济手段调控和推广新技术新工艺等措施，初步构建了与地区水资源承载能力协调的经济结构体系。2010 年末，全市万元 GDP 用水量降至 117 立方米，万元工业增加值用水量降至 68 立方米，较 2005 年分别降低 59%、73%，规模以上工业用水重复利用率提高到 90%，农田灌溉水有效利用系数提高到 0.612。

Progress and results of WSS in Gansu (In Chinese only)

“十一五”期间，甘肃省节水型社会建设在如下五个方面取得了显著的进展。

(一)水资源利用效率和效益明显提高

全省万元 GDP 用水量由 2005 年的 638 立方米下降到 2009 年的 351 立方米，年均下降 9.0%；万元工业增加值用水量由 2005 年的 211 立方米下降到 2009 年的 98 立方米，年均下降 10.7%；农业节水灌溉率由 2005 年的 61%提高到 65%，灌溉水有效利用系数由 2005 年的 0.47 提高到 0.51，工业用水重复利用率由 2005 年的 65%提高到 2009 年的 70%；城镇管网供水漏失率由 2005 年的 25%下降到 2009 年的 20%；节水器具普及率由 2005 年的 36%提高到 2009 年的 55%，主要目标和节水指标均已完成。主要指标完成情况见表 1-1。

表 1-1 “十一五”期间节水指标完成情况统计表

指标	单位	2005 年	2009 年
用水总量	万立方米	122.9	120.6
万元 GDP 取水量	立方米/万元	638	351
非常规水资源开发利用量	亿立方米	1.1675	1.4359
城镇污水处理回用率	%	11	16
灌溉水有效利用系数		0.47	0.51
农业节水灌溉率	%	61	65
万元工业增加值取水量	立方米/万元	211	98
工业用水重复利用率	%	65	70
城镇管网供水漏失率	%	25	20
节水器具普及率	%	36	55
城镇污水处理率	%	40	49
水功能区水质达标率	%	15	48

(二)节水型社会建设四大体系基本建立

1、初步建立了以用水总量控制与定额管理为核心的水资源管理体系

省水利厅组织各市(州)和厅属流域机构，根据《甘肃省水资源综合规划》确定的全省宏观用水控制指标和逐级分解原则，编制完成了《甘肃省黄河流域取水许可总量控制指标细化方案》、《河西内陆河主要河流初始水权分配方案》、《甘肃省长江流域取水许可总量控制指标细化方案》，初步将我省允许利用的水资源量按流域分解到市州级行政区。在此基础上,将新增用水总量分类配置，新增生活用水按区域刚性分解，张掖、武威等市已先行将区域用水总量配置到具体用水户，总量控制工作取得实质性进展。

取水许可与水资源有偿使用制度得到全面贯彻。《取水许可和水资源费征收管理条例》(国务院第 460 号令)、《甘肃省取水许可和水资源费征收管理办法》(省政府第 67 号令)等法规规章的颁布，使取水许可和水资源有偿使用制度有章可循、有据可依。同时，水资源论证制度持续深化，从源头上遏制了盲目兴建高耗水、高污染项目，促进水资源合理高效利用。

2、初步建立了与水资源承载能力相协调的经济结构体系

经济结构逐步与水资源承载能力相适应。通过提高节水经济作物种植比例，压缩高耗水作物面积，适度调整夏秋作物比例，大力发展节水高效农业，推广以全膜双垄沟播技术为重点的旱作农业集成技术等措施，大大缓解了水资源短缺的矛盾,农业用水实现负增长。各地在产业布局和城镇发展中充分考虑水资源条件, 转变用水方式，控制用水总量，建立自律式节水机制, 提高用水效率，减少废污水排放，降低了经济社会发展对水资源的过度消耗和对水环境与生态的破坏，促进了产业结构优化升级。

3、逐步建立了水资源高效利用的水利工程体系

加大对现有水资源利用设施的挖潜改造，对病险水库、水闸、提水泵站进行除险加固，大力开展大中小灌区节水改造，加大渠系、井渠等输配网改造、更新、建设力度，实施农村人饮安全工程，建立完善的高标准的供配水网络体系，提高用水效率。加大对城市自来水管网改造力度，减少输水管网的跑、冒、滴、漏，降低管网漏失率。实施引大入秦、引洮供水一期、盐环定扬黄续建甘肃专用工程、南阳渠、疏勒河农业综合开发等水资源配置工程建设和黑河、石羊河流域综合治理。基本构筑集调、蓄、供、节、排于一体的全省水利工程体系，为实现全省水资源的联合调度、优化配置和高效利用提供了基础保障。

4、初步建立了全社会自觉节水的行为规范体系

全省各级水行政主管部门以宣传节水型社会建设为重点，充分利用“3.22 世界水日”、“中国水周”等集中宣传时段，切实开展形式多样的科技培训和节水宣传活动，通过印发宣传册、张贴标语、散发宣传手袋等方式，提高全社会的节水意识。结合节水增收入户工程，水权水价改革，创新宣传方法，扩大宣传范围，营造宣传氛围，创建全国节水模范县，使宣传工作做到了家喻户晓，形成了全民总动员、全社会参与的节水新局面。 “十一五”期间，全省累计编印各类宣传材料 1200 余万份，举办大规模培训班 235 期，举办乡村培

训班 10000 多场次，扩大宣传覆盖面，干部培训率达到 100%，农民培训率 40%以上，为科技惠农、科学致富搭建了良好的平台。

各级水行政主管部门积极探索节水型社会建设参与式管理，充分发挥公众在节约用水中的“主人翁”作用，积极组建农民用水者协会、节水灌溉协会、节水股份制公司、水利合作社、节水灌溉公司等社会化节水服务组织。目前全省已成立农民用水者协会 2500 多个，涉及行政村 2100 多个，农户 100 万户，协会不仅参与水权和水价的确定、水量水质的监督、公民用水权的保护，而且参与水市场的监管、水利工程的管理、维修和水费收取，使协会成为连接政府与公众、沟通管理部门与社会的桥梁和纽带，有效推动了我省城乡节约用水工作的开展，逐步形成了用水户自主管理与水管单位专业化服务相结合的管理模式。

各地积极探索节水型企业、节水型社区、节水型学校等节水试点的创建活动开展。农业节水试点突出了水资源管理、用水户参与、工程配套、结构调整、低耗高效、综合节水、新农村配套措施和整村推进的方法与模式；工业节水试点突出了再生水利用、循环用水设施的建设、雨污分流技术的应用等内容；城区节水试点突出了分户计量、器具改造、水价改革等内容。节水示范点的创建，为节水型社会建设探索了不同模式，积累了丰富经验。

(三)法规制度建设

1、水利立法取得重大进展

“十一五”期间，全省各级水利部门依托水利中心工作，积极配合省人大、省政府推进水利立法工作，先后制定出台了《甘肃省石羊河流域水资源管理条例》、《甘肃省取水许可和水资源费征收管理办法》等涉及水资源费征收、取水许可、水量分配、水资源保护的法规、规章。2007 年 7 月，《甘肃省石羊河流域水资源管理条例》经省人大颁布施行，该《条例》是我省首次为一条河流的水资源管理单独立法，条例的颁布标志着石羊河流域管理工作迈上了依法管理的新阶段，对推动流域治理工作的健康发展，促进流域水资源的统一调配和合理利用，有效遏制民勤绿洲生态恶化具有重要意义。2009 年，根据省人大和省政府的立法计划，在总结石羊河流域立法经验的基础上，我省又开始对疏勒河水资源管理进行立法，在广泛调研论证的基础上，起草了《甘肃省疏勒河流域水资源管理条例》，于 2010 年 5 月向省政府上报了送审稿。《甘肃省讨赖河流域水资源管理条例》的起草工作也已启动。

2、水务管理稳步推进

“十一五”期间，全省各地充分利用政府机构改革之机，以地级城市为重点，推进和深化城乡一体的水务管理体制，创新运行机制，研究加强水务市场化的政府监管手段和措施。在水利部的大力支持下，2009 年 1 月，省编办发文要求将酒泉等 12 个市水利(务)机构名称统一规范为水务局，甘南、临夏 2 个自治州水利(务)机构名称统一规范为水务水电局，县(市、区)参照市(州)水务(水电)机构形式设置，职能逐步调整到位。各级水利部门进一步规范，加强了对水务管理工作的政策引导、督促检查和规范管理，积极推进城乡水务一体化管理。目前，全省所有市(州)、县(市、区)都统称为水务(水电)局，职能的调整和明确在不断推进，水资

源供、用、耗、排、回用的统一管理得到加强，保障了城乡供水安全，优化了用水结构，改善了城市生态环境，水资源的综合社会效益显著提高。

3、节约用水制度进一步完善

“十一五”期间，全省各地围绕国家和省级节水型社会建设试点，因地制宜深入推进节水型社会建设，大力开展行业节水，制度建设方面成效显著。各地先后出台了节约用水、水资源配置、以水定电、以电控水、农民用水户协会等管理制度和办法，从总量控制、定额管理、取水许可、明晰水权、水价机制等多方面规范和促进节约用水，为节水型社会建设稳步有序推进提供了制度保证。

4、取水许可和水资源费征收制度建设得到加强

“十一五”期间，全省各级水利部门以贯彻落实《水法》、《取水许可和水资源费征收管理条例》为基础，大力开展水资源监督管理体系建设，尤其是在取水许可和水资源费征收方面制定出台了大量的规章制度。2010 年 5 月，省政府颁布了《甘肃省取水许可和水资源费征收管理办法》(省政府令第 67 号)，自 2010 年 7 月 1 日起实施。《办法》是在省委、省政府提出新的区域发展战略，加快发展循环经济，实现经济社会跨越式发展的关键时刻发布实施的，也是我省贯彻落实国务院办公厅《关于进一步支持甘肃经济社会发展的若干意见》，实行最严格的水资源管理制度的重大举措，对于进一步规范取水许可和水资源费征收管理，促进水资源的优化配置和节约保护，推进节水型社会建设，为全省经济社会发展提供水利支撑和保障具有重要意义。另外，市县政府及水利部门也相继出台了规范取水许可和水资源费征收的相关规定，酒泉市政府将全市地下水的取水许可审批权统一收归市级水利部门，同时提高了水资源费征收标准。武威市民勤县出台了《实施甘肃省水资源费征收管理办法细则》，加强了取水许可和水资源费征收的监督管理。

5、水资源保护制度全面推行

2007 年《甘肃省水功能区划》经省政府批准实施后，全省以饮用水水源地保护为重点，2008 年核准公布了全省第一批重要饮用水水源地名录，加强重要水源地水质监测和监督检查，落实了水源地水质监测和信息通报制度。完成了第三次入河排污口调查以及近年来实施的农村人饮安全工程供水水源和入河(湖、库)排污口管理保护专项检查，加强了对全省主要河流界断面水质监测和入河排污总量监测，及时向各级政府和部门通报监测信息。同时，强化地下水管理，初步明确了全省的地下水超采区范围，制定了维护地下水的采补平衡、生态平衡和保护地下水资源的相应措施。按照维持全省水生态、水环境良性循环和节能减排的要求，大力推行清洁生产，加大废污水的循环利用，初步构建了从末端治理向源头治理控制转变,从单纯的点污染源治理向点源、面源及其流域综合治理转变模式。“十一五”期间制度建设情况见表 1-2。

表 1-2 “十一五”期间节水型社会制度建设统计表

序号	项目名称	主要内容
1	流域管理制度	

1.1 流域管理条例 制定石羊河流域管理条例，启动疏勒河流域管理条例立法工作。

1.2 流域管理委员会的职能 成立流域管理委员会，建立协调管理制度，确定流域管理委员会的职能

1.3 流域管理协商会议制度 制定完善流域管理协商会议制度，对水资源管理采取统一调度管理和民主协商相统一

1.4 流域管理局的能力建设 加强流域管理局的能力建设，提高流域管理的能力和效率

1.5 地下水管理办法 定期编制地下水超采区报告，对地下水开采实行统一管理

1.6 取水许可和水资源费征收管理办法 严格执行国家取水许可和水资源费征收管理办法，并制定本地区的管理办法

1.7 流域水资源管理信息共享制度 制定流域水资源管理信息共享制度，为水资源统一调度提供平台

1.8 流域水资源管理咨询专家委员会制度 实行专家咨询制度，提高水资源管理水平

2 水量分配和调度管理制度

2.1 水量分配方案 按照黄河、黑河水量调度条例开展工作

2.2 水量调度管理办法 制定总量控制和水量调度管理办法

2.3 水权转让与交易管理办法 建立健全水权转让与交易管理办法，完善水权交易市场规则

2.4 流域的水资源监控与计量

管理办法 对流域水资源实行监控与计量，并制定相应的管理办法

2.5 水资源管理预警制度 建立水资源管理预警制度，提高对重大水事件的处理能力和效率

3 水资源保护制度

3.1 水功能区管理办法 依据《甘肃省水功能区划》，制定水功能区管理办法，在水功能一级区中的缓冲区及二级功能区中的重要饮用水源区建立监测断面

3.2 入河排污口管理办法 制定入河排污口管理办法，严格控制污染物排放标准

4 节约用水制度

4.1　　节约用水管理办法　　制定节约用水、计划用水及行业用水管理办法

4.2　　用水定额管理制度　　编制各地区行业用水定额标准

4.3　　水价管理办法　规范供水价格，制定水价管理办法

5　　公众参与制度

5.1　　用水户协会管理办法　　制定用水户协会管理办法，规范用水户协会职能

5.2　　水事纠纷处理管理办法　加强涉水纠纷处理能力，制定相应管理办法

5.3　　水资源管理听证制度　　采取多种形式广泛征求社会各界意见，规范听证制度

(四)农业节水成效显著

到“十一五”末，全省节水灌溉面积发展到1230.92万亩，其中高效节水灌溉面积已发展到600多万亩。建设了43个国家及省级节水增效重点县，10个高标准节水增效示范项目区。全省累计实施了13处大型、5处中型、52处小型灌区续建配套与节水改造、4处大型泵站更新改造、21个小型农田水利重点县和21个专项工程项目、45个农牧区节水灌溉示范项目，极大的改善了项目区农牧业生产条件。全省万亩以上灌区渠道衬砌总长度达1.37万公里。通过节水工程建设，全省农田灌溉用水量逐年下降，由2005年的96亿立方米下降到2009年的91亿立方米，农业灌溉水利用系数由0.47提高到0.51。

全省各地高度重视节水新技术、新工艺的引进应用工作，走出了一条有地方特色的节水技术推广路子。先后开展了30多项节水灌溉重大课题研究，全省有20多个大型灌区推广了计算机自动化管理系统， IC卡控制机井数已覆盖河西地区的90%以上。引进10多个国家的节水产品进行试验和推广，以全膜双垄沟播技术为重点的旱作农业集成技术、大田深耕保墒、秸杆覆盖，耐旱品种等农艺节水措施得到广泛应用。

(五)节水型社会建设试点扎实推进

“十一五”期间，全省各地以建设资源节约型和环境友好型社会为目标，紧紧抓住国家将甘肃省列为全国第一批循环经济试点省份的契机，深入推进节水型社会试点建设。截止目前，张掖、敦煌、武威、庆阳市被列为全国节水型社会建设试点，其中张掖试点在水利部通过验收的基础上，将建设主体逐渐由农业向工业和生活领域拓展，并加强示范区建设，着力巩固和保持全国第一面节水型社会建设旗帜。敦煌试点以党河水资源综合利用和保护月牙泉景观为重点，强化水资源可持续利用和生态环境保护，试点建设已通过水利部中期评估。武威市按照试点实施方案，通过调整经济结构，转变用水观念和经济增长方式，建立总量控制，定额管理的水资源管理制度，尤其是在当地政府推动下，合理安排城镇生活及工业用水、减少农业用水、有效增加生态用水，统筹安排地下水，在提高地表水利用效率和效益方面取得了积极进展。

在全面总结张掖节水经验的基础上，全省 43 个省级节水型社会建设试点因地制宜开展了试点建设工作，努力实现从单纯的试点探索向全面推进的跨越。2010 年 10 月，省水利厅组织对第一批 9 个省级节水型社会建设试点进行了检查验收。试点工作注重发挥典型示范和引导作用，在初始水权分配、水权转换、水票制、水价改革、组建农民用水者协会等方面做了大量工作。部分试点地区在源头节水(取水许可)、结构节水、工程节水、高新技术节水、管理节水等方面已取得初步成效和可借鉴的经验。全省节水型社会试点建设情况见表 1-3。

Progress and results of WSS in Sichuan (In Chinese only)

与辽宁省和甘肃省相比，四川省节水型社会建设工作相对滞后。目前，四川省出台的两个规定将会有利于节水型社会建设的推进，这两个规定分别是 2011 年 11 月发布的“四川省人民政府关于全面推进节水型社会建设的意见”和 1997 年 1 月发布的“四川省城市节约用水管理办法”。

《四川省人民政府关于全面推进节水型社会建设的意见》

川府发〔2011〕39 号

各市(州)、县(市、区)人民政府，省政府有关部门、有关直属机构：

为深入贯彻落实《中共中央国务院关于加快水利改革发展的决定》(中发〔2011〕1 号)、《中共四川省委四川省人民政府关于贯彻〈中共中央国务院关于加快水利改革发展的决定〉的实施意见》(川委发〔2011〕1 号)以及中央水利工作会议精神，省政府决定从 2011 年起，全面推进节水型社会建设，从根本上改变全省水资源开发利用粗放的现状，提高全社会节约和保护水资源的意识和能力，为实现“两个加快”提供水资源保障。

一、全面推进节水型社会建设的重要意义

建设节水型社会是中央立足我国的基本国情水情，从促进水资源的可持续利用、保障经济社会可持续发展的战略高度出发做出的重大决策。全省各级人民政府要深刻领会严格水资源管理、建设节水型社会在我省经济社会发展大局中的重要性。四川是“千河之省”，多年平均水资源总量 2616 亿立方米，人均水资源量 2900 立方米，略高于全国平均水平。随着经济社会的发展，水资源供需矛盾日益突出。一是水资源空间分布不均，呈现区域性缺水。人口耕地集中、生产总值占全省 85%的盆地腹部区水资源量仅占全省的 22%，水资源的地域分布与工农业生产布局不适应。二是水资源时间分布不均，呈现季节性缺水。每年的 4—6 月是农业用水高峰期，而全省降雨主要集中在 7—9 月，干旱缺水是农业和农村经济发展的重要制约因素。三是骨干水源工程偏少，呈现工程性缺水。全省蓄引提水能力仅占水资源总量的 10%左右，农业灌溉水有效利用系数仅 0.41，尚未摆脱“靠天吃饭”的局面。四是水污染日益加重，呈现水质性缺水。盆地腹部地区多数河流受到不同程度的污染，城市附近水体污染更为严重。五是水资源的使用效率不高，浪费水的现象时有发生。工业和城市生活用水跑、冒、滴、漏现象普遍存在。

建设节水型社会是一场深刻的社会变革和制度创新，是解决我省水问题、保障经济社会发展的战略性和根本性措施。全面推进节水型社会建设，必须集中资金投入，集中人力、物力，以县(市、区)为单位整体推进，逐步实现“四个转变”，即将节水型社会建设由一般号召向全面建设转变，由分散投入向集中投入转变，由单项突破向整体推进转变，由重建轻管向管建并重转变。全省各级人民政府和有关部门必须站在推动科学发展和推进“两个加快”的高度，充分认识建设节水型社会的重要性和紧迫性，把严格水资源管理作为加快转变经济发展方式的战略举措，把建设节水型社会作为建设资源节约型、环境友好型社会的重要内容，全面强化水资源节约保护工作，形成有利于水资源节约保护的经济结构、生产方式、消费模式，推动全社会走上生产发展、生活富裕、生态良好的文明发展道路。

二、全面推进节水型社会建设的总体要求和基本原则

(一)总体要求。

以提高水资源利用效率和效益为核心，以全面实行最严格的水资源管理制度为重点，政府主导，动员社会力量，整合各类资金、集中投入、整体推进，构建节水型农业、工业、生活服务业和良好的水生态环境，形成节约用水的生产方式和消费模式，为促进经济社会可持续发展和全面建设小康社会提供水资源保障。

到 2015 年，基本建立起最严格的水资源管理制度、水资源管理行政首长负责制和水资源管理考核制度，实行用水总量、用水效率和水功能区限制纳污“三条红线”控制管理；基本完成万人以上水源地达标建设，建设一批河流水资源保护工程；基本建成省、市、县三级水资源管理系统。全省用水总量控制在 377 亿立方米以内(以国家下达指标为准)，万元工业增加值用水量下降 30%，农业灌溉水有效利用系数提高到 0.45 以上，重点水功能区水质达标率提高到 75%以上，县级以上城市供水管网漏损率降低到 15%；设市城市污水处理率提高到 85%，县城污水处理率提高到 70%；地下水基本实现采补平衡。

到 2020 年，水资源的管理、节约和保护工作得到全面加强，各项节水指标达到全国先进水平。

(二)基本原则。

1. 全面推进。以县为单位，工程措施和非工程措施并举，在农业、工业、生活服务业节水和水生态环境保护等方面同时推进。

2. 因地制宜。根据当地水资源状况、经济社会发展状况及其用水需求，科学制定五年规划，分年度组织实施。

3. 政府主导。发挥政府在节水型社会建设中的主导作用，加大财政投入，整合各类资金，加强部门协作，建立“政府主导、多元投资、群众参与”的多层次、多渠道长效投入机制。

4. 突出重点。用三年时间分批启动建设 100 个节水型社会建设重点县(市、区)，实行重点扶持，集中投入，通过 5—8 年努力，基本建成节水型社会。

5. 严格管理。把实施最严格水资源管理制度作为主要任务，落实水资源管理工作行政首长负责制，严格水资源管理考核，用严格的制度管理好、保护好水资源。

6. 以供定需。因水制宜，量水发展，优化调整工农业生产结构，合理确定城市规模，使经济社会发展有可靠的水资源支撑和保障。

三、全面推进节水型社会建设的工作重点

(一)突出抓好节水型社会重点县建设。在双流等县(市、区)成功试点的基础上，从 2011 年起分批启动建设 100 个节水型社会重点县(市、区)。各地申报后，按照公开、公平、公正的原则，确定重点县(市、区)

名单(中央小型农田水利重点县与全域灌溉试点县申报节水型社会重点县的优先确定)，经公示后报省人民政府审定。第一批、第二批和第三批重点县(市、区)分别确定 30 个、30 个和 40 个县(市、区)，分别从 2011 年、2012 年和 2013 年开始建设，每一批建设时间为五年。

(二)加快推进农业节水。大力推进农业节水示范区项目建设，全面推广渠道防渗、管道输水、坡耕地改造、田间集雨设施等工程节水技术。发展高效节水农业，选育和推广耐旱作物品种，调整种植结构，优化种植制度，规范旱地改制，因地制宜发展旱粮作物。加强灌溉用水管理，发展、巩固和完善农民用水协会，推广农耕农艺节水措施，建设节水高效农业和生态农业。

(三)着力推进工业节水。禁止扩建、新建不符合本地区水资源条件的高耗水、高污染项目。结合技术改造和产品更新换代，提高节水能力。加强定额管理，强化用水计量器具的监督和检测，加大节水计量检测能力投入，推广中水回用，提高工业用水重复利用率。

(四)深入推进城镇节水。大力发展城镇、城乡集中供水，加强节水器具和节水产品的推广普及工作，建设节水型社区。开展雨水收集回用和中水回用系统建设。

(五)加强水资源保护。在水功能区的保护区和保留区修建水电站等水工程，应严格水资源论证，加大下泄流量，维护江河健康生态。开采矿泉水、地热水的,凭取水许可证办理采矿许可证,并按照水行政主管部门确定的开采限量开采。矿井日常疏干排水的，应经水行政主管部门同意并办理取水许可证。新建、改建、扩建项目的节水、治污设施必须与主体工程同时设计、同时施工、同时投入运行。“十二五”期间基本完成万人以上水源地达标建设，实施水功能区、水库、饮用水水源区以及水利工程渠系水资源保护工程，开展以河流或流域为单元的水资源保护工程建设，实现清水入江河湖库。

(六)优化配置水资源。做好用水总量配置工作，促进水从低效益用途配置到高效益领域。加快建设一批大中型骨干水利工程，围绕“再造一个都江堰灌区”核心目标，积极推进“全域灌溉”和水利现代化灌区建设，用 5 年时间，基本完成已成灌区渠系配套，完成 30 个在建大中型工程，开工一批大中型工程。确保在 2015 年和 2020 年分别新增 1000 万亩有效灌溉面积。确保城市用水。

(七)严格管理水资源。严格实行水资源论证及取水许可制度。加强相关规划和项目建设布局水资源论证工作，国民经济和社会发展规划以及城市总体规划的编制、重大建设项目的布局，要与当地水资源条件和防洪要求相适应，并进行科学论证，实行水资源论证一票否决。严格实行入河排污口设置同意制度。确立水功能区限制纳污红线，从严核定水域纳污能力。在江河、湖泊新建、改建或者扩大排污口，应当经过有管辖权的水行政主管部门或者流域管理机构同意，由环境保护行政主管部门负责对该建设项目的环境影响报告书进行审批。

四、全面推进节水型社会建设的保障措施

(一)加强组织领导。建立政府负总责、相关部门齐抓共管的节水型社会建设工作机制。严格实行水资源管理工作行政首长负责制，县级以上地方政府主要负责人对本行政区域水资源管理工作负总责。市(州)、县(市、区)政府今年内要制定严格水资源管理、全面推进节水型社会建设的意见。严格实行水资源管理考核制度，考核结果作为对市(州)、县(市、区)政府及其主要领导干部综合考核评价的重要依据。

(二)深化体制改革。继续深化水务体制改革，打破城乡之间、地区之间的水管理界限，进一步理顺职能，完善制度，建立权威、高效、协调的水资源统一管理体制。

(三)明确责任主体。全省各级人民政府是节水型社会建设的责任主体，政府各相关部门要根据工作职责做好节水型社会建设的组织宣传、资金筹措和工作推动等工作，采取有效措施提升各类用水单位和个人节水的自觉性。

(四)加大投入力度。全省各级人民政府要积极整合中央和地方、各部门的相关资金、技术等资源，加强部门协作，努力增加投入渠道，形成齐抓共管、共同推进节水型社会建设的良好局面。

(五)完善价格机制。完善水资源有偿使用制度，合理调整水资源费征收标准，对高污染行业取水征收高额水资源费。加大水资源费征收力度，严格水资源费使用管理；制订合理的水利工程供水和城市供水价格，利用价格杠杆促进节约用水。

(六)加强法制建设。修订《四川省取水许可和水资源费征收管理暂行办法》、制定《四川省节约用水条例》、《四川省地下水保护管理条例》等涉水法规。深入开展水行政执法，抓好重大水事违法案件查处。

(七)广泛宣传发动。利用各种媒体广泛宣传国家有关节水的政策措施、各地节约保护水资源的先进典型，弘扬“节约水、保护水、爱护水”的社会风尚，让节水意识深入人心，真正成为全社会的自觉行动，促进节水型社会建设深入开展。[1]

四川省人民政府

二〇一一年十一月二十二日

《四川省城市节约用水管理办法》

(1992 年 1 月 13 日四川省人民政府批准 1992 年 1 月 30 日四川省建设委员会发布 根据 1997 年 12 月 29 日四川省人民政府令第 103 号修正 自发布之日起施行)

第一条 为了加强城市节约用水管理，保护和合理利用水资源，促进国民经济和社会发展，根据国务院批准的《城市节约用水管理规定》，结合四川实际，制定本办法。

第二条 本办法适用于城市(包括设市城市、建制镇，下同)规划区内节约用水管理工作。

在城市规划区使用公共供水和自建设施供水的单位和个人，必须遵守《城市节约用水管理规定》和本办法。

第三条 城市实行计划用水和节约用水。

第四条 省人民政府城市建设行政主管部门主管全省城市节约用水工作，业务上受省人民政府水行政主管部门指导。其它有关部门按照省人民政府规定的职责，负责本行业节约用水管理工作。

县级以上城市人民政府城市建设行政主管部门和其它有关行业行政主管部门，按照同级人民政府规定的职责，负责城市节约用水管理工作。

第五条 城市人民政府制定城市供水发展规划和节约用水年度计划。

各有关行业行政主管部门制定本行业的节约用水规划和年度计划，报同级人民政府城市建设行政主管部门备案。

第六条 城市的新建、扩建和改建工程，节约用水设施应与主体工程同时设计、同时施工、同时投产使用。节水设施不得采用国家已经淘汰的用水设备、器具。城市建设行政主管部门应当参加节水设施的竣工验收。

第七条 城市建设行政主管部门会同有关行业行政主管部门制定行业综合用水定额和单项用水定额。

第八条 城市用水计划管理对象和用水计划指标由城市建设行政主管部门根据水资源统筹规定和水长期供求计划制定。

第九条 超计划用水的必须向城市建设行政主管部门缴纳超计划用水加价水费。超计划用水加价水费从税后留利或者预算包干经费中支出，不得纳入成本或者从当年预算中支超计划用水加价水费标准：

(一)超计划用水 10%(不含 10%)以下的，超计划部分用水水费加价一倍；

(二)超计划用水 10—30%(不含 30%)的，超计划部分用水水费加价二倍；

(三)超计划用水 30%以上的，超计划部分用水水费加价三倍。

超计划用水加价水费，由城市建设行政主管部门会同财政部门安排，专项用于节水科研、城市节水设施建设、节水奖励基金。

第十条 用水单位必须把生产用水和生活用水分开，分别装表计量考核。

生活用水按户安装计量水表，按户计量收费，取消“包费制”。

第十一条 生产企业在车间和用水设备上分别安装计量水表，进行用水单耗考核，以降低单位产品耗水量：冷却、洗涤、工艺用水应采取循环用水、废水处理综合利用等措施，提高水的重复利用率。

第十二条 用水单位不得在城市公共供水输配水干管、支管及进户管上直接装泵抽水和转供水。确需转供水的，须经城市建设行政主管部门批准。

第十三条 园林、环卫和基建工用水应当充分利用城市废水。

凡有水冷却设施和清洗设施的单位，均应采取循环用水措施，一水多用。

第十四条 节约用水设施应保持正常运行，不得擅自拆除或闲置。确需拆除或停用的，必须征得所在地城市建设行政主管部门同意。

第十五条 城市供水企业和自建设施供水的单位，应当加强供水设施的维护管理，减少水的漏损量，增加有效供水里。

第十六条 用水单位必须加强用水管理，并在城市建设行政主管部门的规划和指导下定期开展水量平衡测试工作，发现用水浪费的，应及时采取措施改进。

第十七条 在城市节约用水工作中做出显著成绩的单位和个人给予表彰和奖励。

第十八条 违反本办法规定有下列行为之一的，城市建设行政主管部门应责令限期改正，逾期不改的由城市行政主管部门限制其用水量，可并处五千元以下的罚款：

(一)城市的新建、扩建和改建工程项目未按规定配套建设节约用水设施的；

(二)节约用水设施检验不合格的；

(三)生活用水实行“包费制”的。

第十九条 违反本办法规定有下列行为之一的，城市建设行政主管部门应责令限期改正，逾期不改正的，由城市建设行政主管部门限制其用水量，对从事非经营活动的个人可并处 200 元以下的罚款，对从事非经营活动的单位可并处 1000 元以下的罚款，对从事经营活动的个人和单位可并处 5000 元以下的罚款：

(一)用水设备和管道严重跑、冒、漏水的；

(二)在城市公共供水输配水干管、支管及进户管直接装泵抽水的：

(三)未经批准擅自转供水的；

(四)经水量平衡测试发现用水浪费不整治改进的。

第二十条 逾期不缴纳超计划用水加价水费的，由城市建设行政主管部门通知限期缴纳，并按日加收超计划用水加价水费 5%的滞纳金，拒不缴纳加价水费和滞纳金的，由城市建设行政主管部门通知城市供水企业停供计划外用水量。

第二十一条 当事人对行政处罚决定不服的，可以在接到处罚通知次日起十五日内，向作出处罚决定机关的上一级机关申请复议；对复议决定不服的，可以在接到复议决定次日起十五日内向人民法院起诉。逾期不申请复议或者不向人民法院起诉又不履行处罚决定的，由作出处罚决定的机关申请人民法院强制执行。

第二十二条 城市建设行政主管部门的工作人员玩忽职守、滥用职权、徇私舞弊的，由其所在单位或者上级主管部门给予行政处分；构成犯罪的，由司法机关依法追究刑事责任。

第二十三条 本办法具体应用中的问题由省建设委员会负责解释。

第二十四条 本办法自发布之日起施行。

ANNEX 2: Water saving measures

Potential water saving measures are listed below.

Administrative measures
- Norms for water use
- Water quotas and rights
- Water abstraction permits and allocation measures
- Rationing

Economic measures
- Water pricing
- Service charges

Institutional measures
- Adjust legal and institutional framework to accompany the implementation measures

Technical measures
- Agricultural measures
  - Agricultural structure (crop choice)
  - Agricultural practices and field irrigation techniques
  - Water saving irrigation systems (drip irrigation, etc.)
  - Irrigation system management
  - Irrigation infrastructure (canal lining and control structures, and canal conveyance efficiency)
  - O&M of canals, pumps and structures
  - Flow measurement infrastructure
  - Irrigation return flows (to rivers and aquifers)
- Urban measures
  - Actual delivery of norms to each household (considering variations between household types, and losses within households)
  - Losses within the WSC (ratio between bulk supply and deliveries to household)
  - Wastewater treatment
  - Investment in leakage control and waste water treatment, and collection of tariffs
  - Regional water saving
  - Water saving washing machines, toilets, showers, etc.
- Industrial measures
  - Process improvements
  - Leakage control
  - Treatment and reuse of wastewater
  - Water recycling
  - Water efficient equipment
- Supporting measures
  - Public education and awareness campaigns
  - School education programs

  - Awareness of water resources, savings, permits
  - Knowledge and understanding of fees – reasons for changes, uses of fees etc.
  - Trust in the water management system and use of the fees collected
  - Ensuring that all water users comply equally
  - Participation in management of canals and wells
  - Participation in water abstraction and flow monitoring
- Incentive to promote and adopt water saving
  - Administrative measures (regulatory controls)
  - Financial incentives
  - Technical skills and support
  - Understanding of the needs for and impacts of not saving water
  - Cooperation and co-ordination

Appendix C. Prototype Drought Database

C.1 Approach

This appendix explains the differences in data collection for drought monitoring in provinces across the PRC, and specifically in the pilot provinces (Sichuan no database, Liaoning an advanced database, Gansu somewhere in between). It also explains the issues associated with data sharing and why Liaoning is more advanced than other two pilot provinces.

The Consultant team has designed a prototype database and identified the steps a province would need to take to implement such a database.

C.2 Existing drought databases

C.2.1 Sichuan drought database

Sichuan Province has no regular operation of the complete database of drought currently; MWR department is mainly relying on the water situation and meteorological database and the agricultural sector data sharing for Drought analysis.

Table C.1 shows the research statistics and some counties in Sichuan Province on the number and types of monitoring sites department situation. Analysis shows that the rainfall data are taken charge by the Sichuan Provincial Meteorological Department and MWR departments, evaporation data are grasped by the meteorological department, river water levels and reservoir levels are entirely used by water sector. Soil moisture and agricultural condition data is mainly controlled by the agricultural sector.

Table C.1: Number and Types of Monitoring Sites in Sichuan Province

Region	Rainfall	Evaporation	River water levels	Reservoir levels	Soil moisture data	Agricultural condition
Gansu	1100 MWR 695 Met 405	254(MWR 11eteor 243)	167 MWR	223 MWR	103 (Agriculture 86；MWR 17)	4410(Agric 4324 ， MWR)
Huidong county	98(Met. MWR)	1 (Meteo)	2 MWR		1(Meteo)	
Anju district	26(Meteo.)	26(Meteo.)	5 MWR	88 MWR		
Chuanshan dist	11(Meteo.)	11(Meteo.)	4MWR	38MWR		
Dayin county	11(Meteo.)	11(Meteo.)	5MWR	18MWR		
Mianyang	102 MWR	3 MWR	20 MWR	15 MWR	29(MWR Ag)	9(Agriculture)
Santai county	5(Meteo.)	0(Meteo.)	4MWR	3(MWR)	0(Agriculture)	5(Agriculture)
Xintong county	32(Meteo.)	32(Meteo.)	2 MWR	169 MWR	(Agric)	(Agric)
Lu county	19(Meteo.)	Meteo.	MWR	MWR	Agriculture	Agriculture
Guangan	100+(Meteo.)	~100 Meteo+Ag	100+ MWR	314 MWR	(Agriculture)	(Agriculture)
Hua ying	30(Met, MWR)			19 MWR		
Gongjin district	9 (Water Cons)					

Region	Rainfall	Evaporation	River water levels	Reservoir levels	Soil moisture data	Agricultural condition
GuangRMB	80(Meteo.)	60(Meteo.)	20 MWR	105 MWR	55 Agriculture	
Huili county	87(MWR)		3 MWR	85 MWR		30 Agriculture
Leibo County	115 Met+MWR	1(Meteo.)	1 MWR	2 MWR	0	0
Luzhou	50(Meteo.)	50，Meteo.				
Gulin county	43(Meteo.)		1 MWR	10 MWR		
Lu county	28(MWR)	Water Bureau	9 MWR	2 MWR		
Suining	105，Meteo.	105，Meteo.	20 MWR	334 MWR		

C.2.2 Gansu drought database

Gansu Province and Sichuan all are similarly in the database of drought with no regular operation, MWR department is mainly relying on the water situation and meteorological database and the agricultural sector data sharing for Drought analysis.

Table C.2 shows some counties in Gansu Province and the number and types of monitoring sites department situation through the statistical survey. The data monitoring and management arrangements are similar for three pilot provinces. Rainfall data are taken charge by the Provincial Meteorological Department and MWR departments, evaporation data are collected by the meteorological department, river water levels and reservoir levels are entirely used by water sector. Soil moisture data is mainly controlled by the agricultural sector, and agricultural condition data is basically mastered by the agricultural sector.

However, Sichuan Province, Gansu Province, the problem is more than the data that is incomplete, as the databases lack a specific number of various sites, only an approximate number.

Table C.2: Number and Types of Monitoring Sites in Gansu Province

Region	Precipitation	Evaporation	River water levels	Reservoir level	Soil moisture data	Agricultural condition
Gansu	~1000(MWR, meteo)	~500(MWR)	~100 MWR	~ 400 MWR	86	86
Gangu county	132 (Met MWR)	1 Meteorology			3 Meteorology	1 Meteorology
Qingyang city	130					
Tianshui city	341(MWR)	7(Meteorology)	12(MWR)	12(MWR)	7 Meteorology	
Huan county	164(MWR132 Met32)	1 Meteorology)	2(MWR)	5(MWR)	2 (Meteorology)	
Zhangye city	260(Met、MWR)	40(Meteorology	25(MWR)	58(MWR)	24(Meteorology)	

C.2.3 Liaoning drought database

C.2.3.1 Basic Information

Liaoning has set up an advanced drought database, which under the control of the water resources department, mainly the hydrological data. Up to 2010, there were variously 1300 monitoring stations under the control of water resources dept., including 120 hydrological stations, 648 precipitation stations, 65 water quality stations, 528 ground water stations, 37 evaporation stations, 77 basic soil moisture stations and 91 telemetry moisture stations. One station may have multiple functions. Such as the hydrological station, it observes the water flow, water level, precipitation, evaporation, soil moisture, ground water, sediment, water quality, water temperature, and so on. That means the hydrological station and the precipitation station may located in the same place, and this situation frequently happened.

Table C.3 shows some counties in Liaoning Province and the number and types of monitoring sites department situation through the statistical survey. Analysis shows that the data in Liaoning Province and other province has similar vesting conditions. Rainfall data are taken charge by the Provincial Meteorological Department and MWR departments, evaporation data are grasped by the meteorological department, river water levels and reservoir levels are entirely used by water sector. Soil moisture data mainly controlled by the agricultural sector, agricultural condition data is basically mastered by the agricultural sector.

Table C.3: Number and Types of Monitoring Sites in Liaoning Province

Region	Precipitation	Evaporation	River water levels	Reservoir level	Soil moisture data	Agricultural condition
Liaoning Province	648（MWR 292 Met 356)	38（MWR）	94（MWR）	396（MWR）	77（MWR）	
Dalian City	238（MWR）			41（MWR）	24（MWR）	
Shenyang City	43 Met23MWR20	1（Met.）	5（MWR）	4（MWR）	1（Met.）	23（Met.）
Benxi City	（MWR）		（MWR）	（MWR）		
Chaoyang City	311（MWR）	3（MWR）	8（MWR）	39	12（MWR）	
Dandong City	157（MWR）		9（MWR）	27（MWR）	4（MWR）	
Hulu Dao	78（MWR）	1（MWR）	3（MWR）		7（MWR）	
Liaoyang City	(Met.）	(Met.）	（MWR）	MWR）	Met、MWR	Agriculture
Tielin city	155（MWR）	12（MWR）	12（MWR	56（MWR）	9（MWR）	
Tuchang county	70（MWR）	1 ((Met.）	5（MWR）	56（MWR）	1 (Met.)	
Donggang City	80 (Met.）	1 (Met.）	8（MWR）			
Henren county	73 (MWR. Met	3（MWR, Met)	7（MWR）	11（MWR）	6（MWR Met)	
Lianshan District	Met.	Met.	MWR	MWR	MWR	
Liaoyang County	32 (Met.）	2 (Met.）	2（MWR）	2（MWR）	15 Agric.	15Agric.
Pu Landian city	58MWR, Met.		30（MWR）	13（MWR）	27MWR,Met	
Su Jiatun District	23Met 20MWR	1（Met.）	5（MWR）	4（MWR）	1（Met.）	23 (Met.）
Tieling county	27（MWR）	（MWR, Met.	（MWR）	12（MWR）	6Agriculture	Agriculture

C.2.3.2 Data Details

2.3.2.1 Precipitation Stations

There are 648 precipitation stations managed by Water Resources Dept. of Liaoning Province, and each station covers 249 km^2. All these stations automatically transfer the data into the data center. Moreover, Water Resources Dept. shares data with provincial Meteorological Dept., which another 786 precipitation stations data is available. But the daily drought monitoring mainly rely on the 648 stations, because the shared data could not be provided timely.

Besides, there are some national meteorological stations managed by NCC. They provide daily temperatures and precipitations. But, according to our survey, these data could not be conveyed in real time. Usually, you need administrative power and negotiation to get the recent data (a couple of days, weeks or months ago), or you can get the historic data in a hard copy or download way from NCC or provincial Meteorological Dept.. So, as the data sharing issue, this is the point we can suggest.

2.3.2.2 Surface Water Monitoring Stations

There are many hydrological stations in Liaoning Province and most hydrological stations have multiple functions. The quantity of surface water stations is less than the total number of the hydrological stations.

There are 93 basic hydrological stations monitoring water flow in flood season, in which 7 is water level stations. But, in non-flood season, there are only 51 hydrological stations reporting water flow. Especially in the northwest of Liaoning Province, the arid regions, there are only 16 hydrological stations.

Figure C.1: The 648 automatically/telemetry precipitation stations

Figure C.2: Liaoning Water flows stations

Figure C.3: Liaoning Reservoir stations observes the levels, etc.

Figure C.4: Liaoning River level stations

2.3.2.3 Ground Water Monitoring Stations

There are 494 ground water stations, of which 258 stations are automatically remote metering. These stations are used for industry and life living.

2.3.2.4 Soil moisture monitoring stations

Up to 2011, there are 77 manually measured soil moisture stations and 97 remote metering stations. Another source tells that the number of remote metering stations is 91 up to 2010. But according to the survey result, most of the remote metering stations don’t run very well. But the manually measured result is very good.

Figure C.5: Liaoning soil moisture stations manually measured

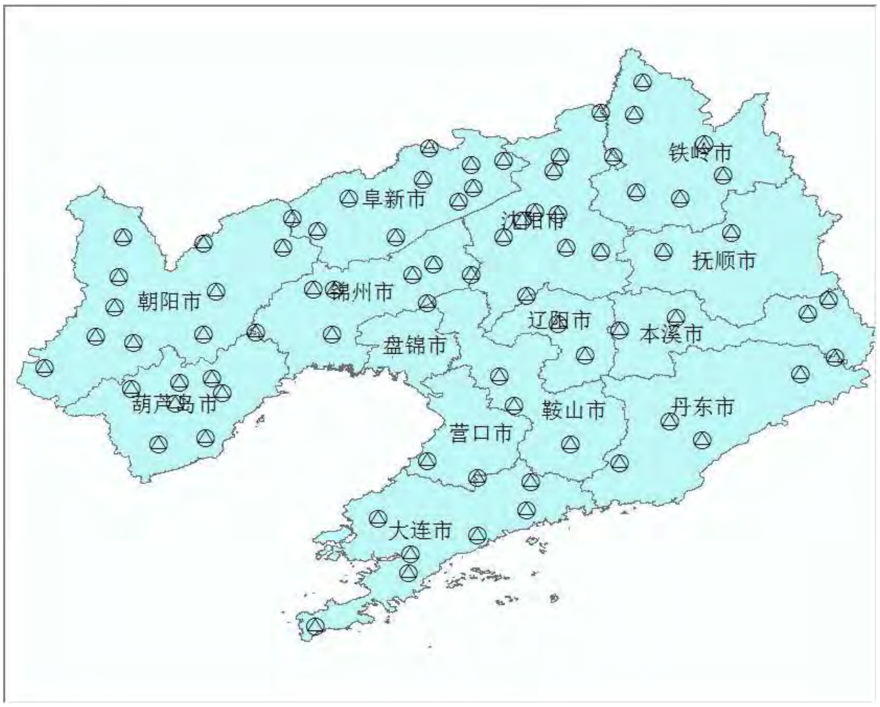
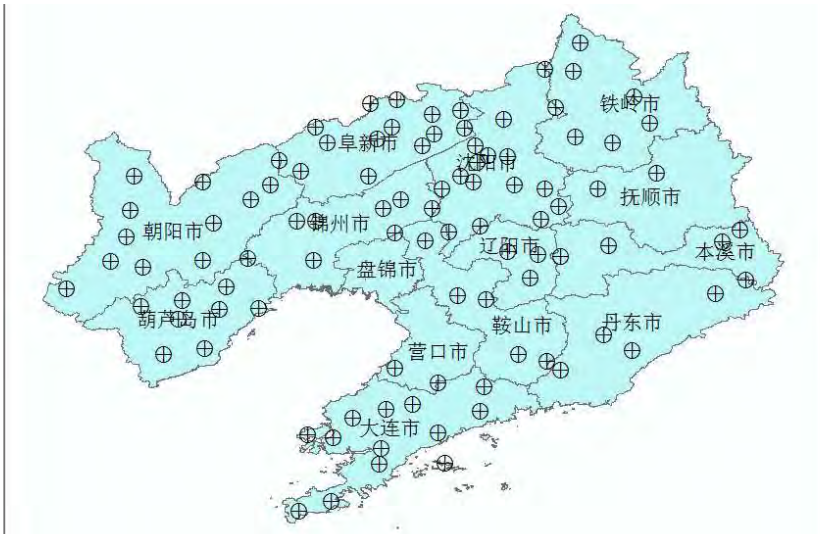


Figure C.6: Liaoning soil moisture stations remotely metered



2.3.2.5 Evaporation Station

There are 37 evaporation stations in Liaoning Province. The evaporation data are representative and has a long term. But so far, they are not remote metering, and the evaporation information does not used in drought reporting.

Figure C.7: Liaoning Evaporation Stations

2.3.2.6 Meteorological Stations (NCC controlled)

Some national meteorological stations data controlled under Meteorology Department are available from NCC. In Liaoning Province, there are about 28 stations of this kind, which specifically providing temperature data in the current database system.

Figure C.8: Liaoning NCC national weather stations, specifically providing temperature data

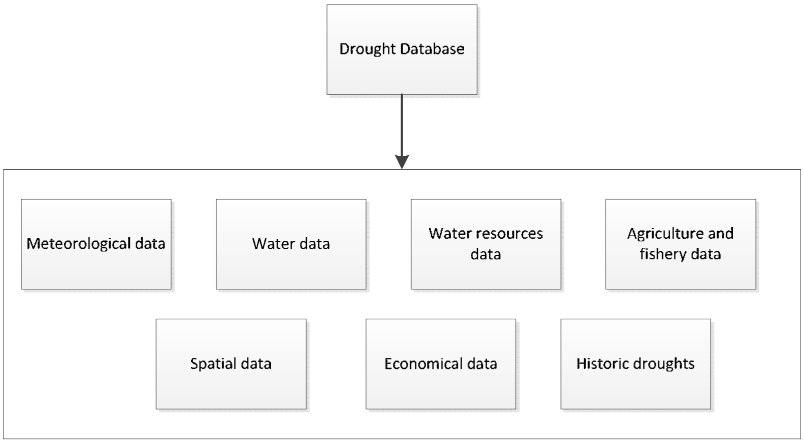
C.2.4 The Structure Of The Drought Database In Liaoning

Liaoning Province, drought database (including Gansu and Sichuan) mainly depends on the real Hydrology database, the database now rainfall in drought associated with the main data table for a brief introduction, a total of seven tables, detailed as follows:

1. Basic property sheet Station
2. Precipitation Table
3. Daily evaporation Scale
4. River Water Table
5. Table water regime
6. Soil moisture meter
7. Groundwater table

Figure C.9 shows the Structure of the current drought database in Liaoning Province.

Figure C.9: Structure of the current drought database in Liaoning Province



This is the basic structure map of the drought database in Liaoning Province.

- Meteorological data: temperature and precipitation
- Water data: water flow and level
- Water resources data: water stored in reservoirs and depth of ground water level
- Agriculture and fishery data: crop area, irrigation area, yields, crop type, etc.
- Spatial data: administrative boundaries, lines of the rivers, locations of reservoirs, monitoring stations.
- Economic data: GDP, population, etc.
- Historic drought data: description and statistic data of the past drought.

C.2.5 Conclusion and Analysis

Through the above analysis it can be determined in the three pilot provinces that Liaoning has a relatively complete database of drought, while Sichuan and Gansu have no specific drought database, and the current data management systems have the following characteristics related to drought:

- Construction of the integrated drought database. In Liaoning Province, the drought database contains hydrological, meteorological, agricultural and socio-economic aspects, but one of the primary data is still water situation database hydrological data from.
- Drought indicators. Drought analysis indicators Liaoning Province is mainly rainfall, runoff, soil moisture, etc. Therefore, the contents of its database can be constructed mainly based on those needs.
- Drought database structure. As the real-time hydrological databases have established a mature unified monitoring and reporting structure, the proposed drought database will use the hydrological reporting system database in a similar tabular structure.
- Drought database operations. For Liaoning Province, drought database construction is to provide basic support for the drought disaster management system. However, the current drought in Liaoning Province Disaster Management system is not predictive or action triggering, so the drought database

has not fully played a management role on drought. Due to the fact that the Sichuan and Gansu databases are not been established, there is no need to review their operational aspects.
- In summary, the proposed integrated drought database is combined with an existing hydrological database on the basis of the conditions and actual needs, is feasible, but there are still many aspects to be improved. Relevant recommendations are described in Section 3.

C.3 Moving Toward an Integrated Drought Database

C.3.1 Potential Improvements for Three Pilot Provinces

Through previous analysis of the drought situation data management in three pilot provinces, combined with the actual advanced experience and technology needs of the integrated drought database, the following are some suggestions for the database construction of the three provinces, taking into account the availability of data sharing. Because of previous drought issues, Liaoning Province built a database, but no drought database exists in Sichuan and Gansu provinces. Some of the issues and recommendations for integrated drought database in Liaoning Province can be integrated into future drought database in Sichuan and Gansu provinces in the future. Refer to the description of the Liaoning drought database construction.

The technical level recommendations are as follows:
- Drought database should include hydrology, meteorology, agriculture, socio-economic and other data. The existing database in Liaoning Province, the drought should be strengthened to complement other aspects of the data. For meteorological data, in particular, should complement the temperature data; data for agriculture, including crop acreage, crop farming structure, the biological characteristics of the crop, and soil conditions. For socio-economic data, include the economy, population, water supply and so on.
- Drought database should be easily interconnected and transferable with other existing databases. Liaoning Province, the existing database from drought and hydrological data is designed to achieve interconnection, but only the table structure and other aspects. There is no physical interchange to achieve real time data transfer, that is, data and other water situation and has no real-time database transfer capability to the drought database. There is a need to manually export, copy, etc., for interchanging data.
- In addition, the current from the Liaoning Province of drought monitoring and early warning indicators and data needed to consider the actual needs and the idea is worthy of improvement to the integrated drought database, and the other two pilot provinces can learn how to build similar databases from Liaoning example.

Management recommendations are as follows:
- Drought and Drought Mitigation need be guided by the information contained in the database management system. The current Liaoning drought database system does not play the role because of the main reasons. Currently drought management relies mainly on the Hydrological Bureau and other departments for data extraction and analysis processes. As such, there is no current practice to use the drought database for management purposes.

- There continue to be drought database data sharing issues that need to be addressed. This database is to promote the construction of the root causes of the drought. “Make bricks without straw," would be similar to a drought database when there is a lack of data sharing between departments, beyond hydrological data.
- Drought database construction needs institutional support and funding. The existing hydrological database system is widely used in the country in hydrological departments at all levels. The main reason is that the initial investment promotion, and ongoing financial support and income protection. Drought database should also be achieved through administrative means to promote and government investment, the establishment of a database management system for droughts.

C.3.2 Integration of Provincial DWR Data with Other Data

Currently, water sector and the meteorological department, the agricultural sector and other drought-related sector data sharing mechanism is not perfect. In the view of the three pilot provinces, Liaoning Provincial has established a data sharing mechanism between the Water Conservancy Department and the Meteorological Dept. only on the precipitation data. That means hydrological and meteorological departments have different rainfall sites, respectively. These two departments share rainfall data with each other. However, on the one hand this is limited to the rainfall data sharing, on the other hand it did not achieve real connection between databases which is more often not possible to achieve real-time sharing of data. In Gansu Province, there is no data sharing mechanism established between various departments. The data were requested after the drought occurred and the consultation meeting held. So, there is no guarantee for this sharing, which could not ensure the needs of the drought monitoring and early warning. Sichuan Province, also did not establish a sharing mechanism, either. Besides, due to the drought administrative departments in Sichuan Province is under the control of in the Ministry of Agriculture, It is much difficult to acquire the meteorological data and even the hydrological data.

In previous context, we mentioned the drought database should include hydrology, meteorology, agriculture, socio-economic data, etc. So, we suggest that sectorial cooperation can be considered for the data sharing. A recommended framework is setting the drought database in Hydrology Bureau, which take the responsibility for daily operation and maintenance. The meteorology, agriculture and other sectors provide the corresponding data in real time or short-term delayed transmission to the database. Also, each agency has permission to access all the data in the database. It is necessary to change the existing data sharing negative attitudes and raise awareness, but also need to provide a solution to this problem from the institutional mechanisms. There needs to be a distribution of benefits among the various data provided on the department and other issues, to discuss the development needs of each department in consultation, but the building needs to be the top forward.

Meteorological Department publishes reports regularly using meteorological data, which plays very important role in drought monitoring in China. It will be significant and helpful if the data or the results of the hydrological and meteorological departments can be merged. Basically, the meteorological department releases drought monitoring and early warning information overall the nationwide daily, weekly, or monthly. Although this data may not fully meet the needs of the provincial -level drought management,

but if the use of existing hydrological data combined with the meteorological released map, it will be a very effective drought management means. Therefore, we propose to consider the following aspects:

- If the data sharing mechanism can be established and the raw monitoring data are available, we suggest the hydrological department is responsible for integrating the data from all departments, and drought monitoring and early warning.
- If the data sharing mechanism can be partially established and the raw monitoring data are not available, we suggest the FCDRHs negotiate with the corresponding departments that the meteorological department provides the released map information to the hydrological department. The information is not just a monitoring map but should include the elements of the map. And the hydrology department is responsible for the information integration, processing, analysing, etc.
- If the data sharing mechanism could not be established totally, we suggest the FCDRHs use the released map directly. The map will be made as an auxiliary reference tools to combine with the analysis of hydrological data monitoring and early warning.

C.4 Prototype drought database

C.4.1 Drought monitoring

Table C.4: Prototype Liaoning Database

Potential Database Information	Availability in existing Liaoning database	Data granularity
Precipitation	Yes	Daily
Temperature	Yes	Daily
Evapotranspiration	Yes	Daily
Soil moisture	Yes [some areas]	Daily
Surface water flow rates	To be added	Daily
Groundwater levels	To be added	10days – monthly
Reservoir and lake levels (multi-purpose national)	To be added	Daily
Municipal, agricultural and industrial reservoir levels	To be added	Daily

C.4.2 Drought Analysis, Indicators and Drought Levels

Refer to appendix D

C.4.3 Recommendations for Scenario Analysis and Drought Forecasting

Refer to appendix E

Appendix D. Drought Risk Mapping Scheme

D.1 Current Provincial Drought Risk Mapping Schemes in Use

At present, China is in the drought crisis management to risk management transition period. National, provincial, city, district and county levels have been established at all levels of drought risk management mechanism, the system does not carry out specific drought risk mapping work, Liaoning, Gansu and Sichuan three pilot provinces true.

Nevertheless, some domestic universities and research institutions involved in drought risk management research have achieved certain results, which relate to risk theory, drought risk mapping, etc. In these studies, the theories were mainly developed from general risk management concept and there are different approaches to do the drought risk mapping in the PRC. The Drought Relief Research Centre in the China Institute of Water Resources and Hydropower Research (IWHR) has also carried out extensive research work and developed some comprehensive methodologies. Other different risk mapping methods and different case studies exist in the PRC. For example, the Shaanxi Province Drought Disaster Risk Atlas is by the Shaanxi Provincial Meteorological Bureau, Water Resources Department of Shaanxi Province, Shaanxi Province, jointly prepared by the Agriculture Department and other units (DU Ji, et al, "Shaanxi Province Drought monitoring and early warning assessment and risk management.") The Shaanxi province example provides drought risk management and risk mapping conducted a systematic exposition of the ideas and methods which represent the current PRC thinking in many research institutions, including provincial administration departments with generally recognized and understood drought risk analysis and risk mapping approach.

Shaanxi Province in central China's inland, the Loess Plateau hinterland, adjacent Gansu Province, mostly arid, semi-arid, climatic and geographical conditions also pilot provinces Gansu Province have a similar place. The risk of drought risk atlas includes zoning map of Shaanxi Province, Shaanxi Province, rural drinking water risk maps, Shaanxi Province, water conservancy drought maps, off the large irrigation water risk maps, Shaanxi urban water supply capacity distribution, supply risk counties in Shaanxi Province Figure six kinds of image files. Among them, Shaanxi drought risk zoning map is the most basic image files, but also the integrated image files.

Drought risk zoning map is based on the probability of occurrence of different levels of drought, over the years the minimum rainfall contour map, water conservancy, meteorology and geography departments of Shaanxi Province arid district drawn diagrams and other information as the basis for drawing. The province is divided into severe drought risk areas, risk areas and mild to moderate drought risk zone three residential districts. Severe drought risk areas are mapped for more than 50% probability of occurrence of drought, moderate drought risk zones probability 30% to 50%, mild drought risk less than 30% probability.

Rural drinking water risk map is divided into four grades. Rural people drinking water in areas with mild risk areas; proportion of people drinking water solution 95% to 100% of the region as moderate-risk areas; proportion of people drinking water solution 80% to 95% of the region as a serious risk areas; proportion of people drinking water solutions less than 80% of the area of large-risk areas.

Drought tolerance mapping for hydraulic engineering projects is not based on grading. The risk mapping is calculated based on water resources situation of separated area. Off the large irrigation water risk maps is considering irrigation water diversion methods (reservoirs, water diversion and mechanical lifting water), water runoff conditions, irrigation management needs water conditions (crop distribution, irrigation canal, field engineering, etc.), taking into account the water situation, the supply risk is divided into four levels, namely mild irrigation water, moderate irrigation water, severe and extra severe irrigation water shortage.

Urban water supply capacity and no maps were graded, as they merely drew the current situation and the main water source of water supply capacity for rendering comprehensive risk zoning map. County water risk maps of urban water supply capacity further refines the distribution division, and is divided into four levels, namely mild risk areas of water supply, water supply moderate risk areas, severe water supply risk area and king-risk areas.

Through the above cases can be seen in Shaanxi Province, the current domestic drought risk map drawn mainly by "element" draw different maps, then these maps integrated, divided into different regional drought disaster risk level and characteristics. From these elements of risk analysis theory, that is, drought vulnerability, exposure and hazard, etc., from disciplines such as ours, that is, meteorology, hydrology, agriculture, socio-economic, and even some delicate precipitation, temperature, water resources, irrigation, planting structure, population, economic development and so on.

D.2 International Examples of Drought Risk Mapping

Internationally, drought risk map is still in its infancy. Europe and other countries to carry out more research work, which began in the late 1990s. At present, the international community generally used is based on the risk factors for drought risk mapping method. Risk mapping process according to the number of features to consider elements of risk maps can be divided into single-and multi-factor risk maps. The former is to consider only a single element of risk maps, which quantify the level of risk identified by the elements. The latter is considering multiple factors risk maps, which quantify the level of risk is relatively complex, generally using normalized indicators for risk classification.

A. <u>Single factor maps</u>

1. The precipitation is based draw arid partition map. Examples such as the U.S. Drought Monitor map from time to time, mainly based on precipitation for dry partition. U.S. Drought Monitor map from time to time, the daily published online by the figure, while the maps also said two kinds of agricultural drought and hydrological drought are in arid distribution zone information.
2. The drawing is based on a percentage of precipitation deficit arid partition map. Being executed, “the EC ESPON project ", the use of 90 years of rainfall data 1905-1995, according to the percentage of rainfall deficit, rendering the whole European drought risk map which is divided into five areas of drought level.
3. The runoff modulus plotted based on hydrological drought map. In some areas of the United States, according to calculations finishing runoff modulus plotted hydrological drought maps.

B. Multi- factor maps

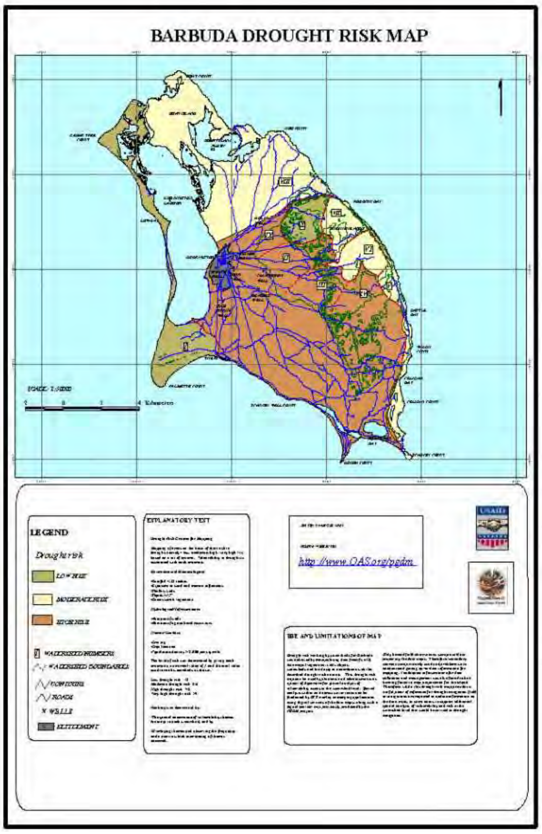
1. Using multivariate drought risk, drought risk maps drawing. Such as the U.S. and the Caribbean Disaster Emergency Response Agency, to take advantage three years, completed in 2001. The 6 elements are rainfall, vegetation, soil, ground slope, land use and watershed.

D.2.1 Barbuda Drought Risk Map

America and the Caribbean Disaster Emergency Response Agency, to take advantage three years, in 2001 completed a Caribbean Island nations (Antigua, Barbuda to, Nevis Nevis) Disaster Reduction Research. The work of the most important research is to draw the region's drought risk maps.

As shown on Figure D. 1, Barbuda region is drought risk maps, Barbuda in the Caribbean Lesser Antilles archipelago in northern area of only 160 square kilometers. Risk mapping took into account rainfall, vegetation, soil, ground slope, land use and watershed six elements, using a normalized level of risk quantification standards that will eventually Barbuda classified as low-risk areas, medium-risk areas and high-risk areas.

Figure D.1: Barbuda Drought Risk Map



D.2.2 Remote Sensing

Several international consulting engineering firms and international agencies now use remote sensing images of drought disaster risk assessment. Remote sensing images have covered a wide range of advantages of fast and efficient computing. With the rapid development of remote sensing technology in recent years, more and more areas began to monitor and evaluate the use of remote sensing images. As an example, the Danish firm COWI uses MODIS imagery, through standardization crop index (NDVI) and other indicators of drought risk classification.

D.2.3 DMCSEE

Southeastern Europe under the European Organization Drought Management Centre for disaster risk management in arid has made remarkable achievements, from nine countries from the 15 organizations cope with drought mitigation problem, not only made a number of innovative approaches, and the development of Drought monitoring and early warning and risk analysis system platform. The organization uses the SPI index of meteorological drought monitoring and early warning, use WISAREG model developed by the University of Lisbon for monitoring and risk assessment. In this model, soil, crop and climate data, soil and irrigation systems to simulate crop water requirement to obtain such results.

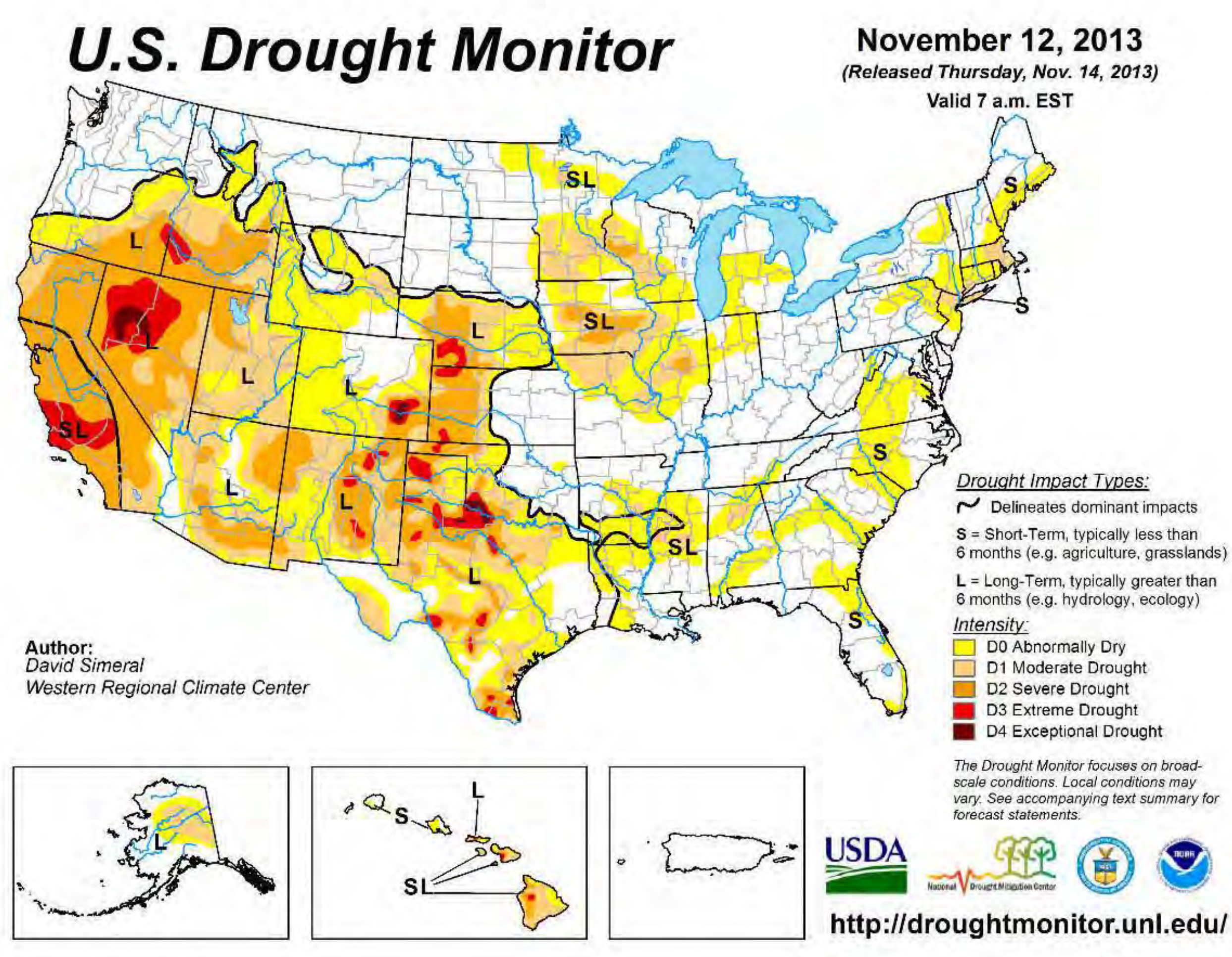
D.2.4 US National Drought Mitigation Center (NDMC)

The U.S. National Drought Mitigation Center disaster risk management in arid areas also work on international drought issues. NDMC and the Joint United Nations International Strategy for Disaster Reduction secretariat has prepared a "drought risk reduction framework and practices - aimed at promoting <Hyogo Framework for Action>" (Drought Risk Reduction Framework and Practices Contributing to the Implementation of the Hyogo Framework for Action) a book.

The book systematically expounded drought risk management connotation and denotation, constructed mitigate drought risk framework and introduced worldwide to reduce the risk of drought many good practices introduced called the current drought the most systematic and comprehensive risk a monograph.

But more noteworthy is, NDMC monitoring and early warning of drought has done better. Cooperation with the United States a number of agencies, released weekly U.S. Drought Monitor map, as shown in Figure D.2 below. While NDMC none provided risk analysis results, but the figure has been monitoring the number of users, such as insurance companies, government decision-making departments used to do risk analysis.

Figure D.2: US NDMC Drought Monitoring Map



D.3 IWHR Research on Drought Risk Mapping

IWHR drought risk in a lot of research has been carried out in the consolidated results, based on existing research, made a number of innovations on drought disaster risk point of view, including drought disaster risk connotation, the constituent elements of drought risk and drought disasters risk assessment methods, as will address these aspects briefly IWHR research.

D.3.1 Drought Risk Profile

From agriculture, industry, residents in areas such as drought vulnerability analysis, from the economic and social level, water supply capacity, technology and management level in areas such as drought tolerance analysis. In two ways based on the analysis of drought vulnerability analysis, function as follows:

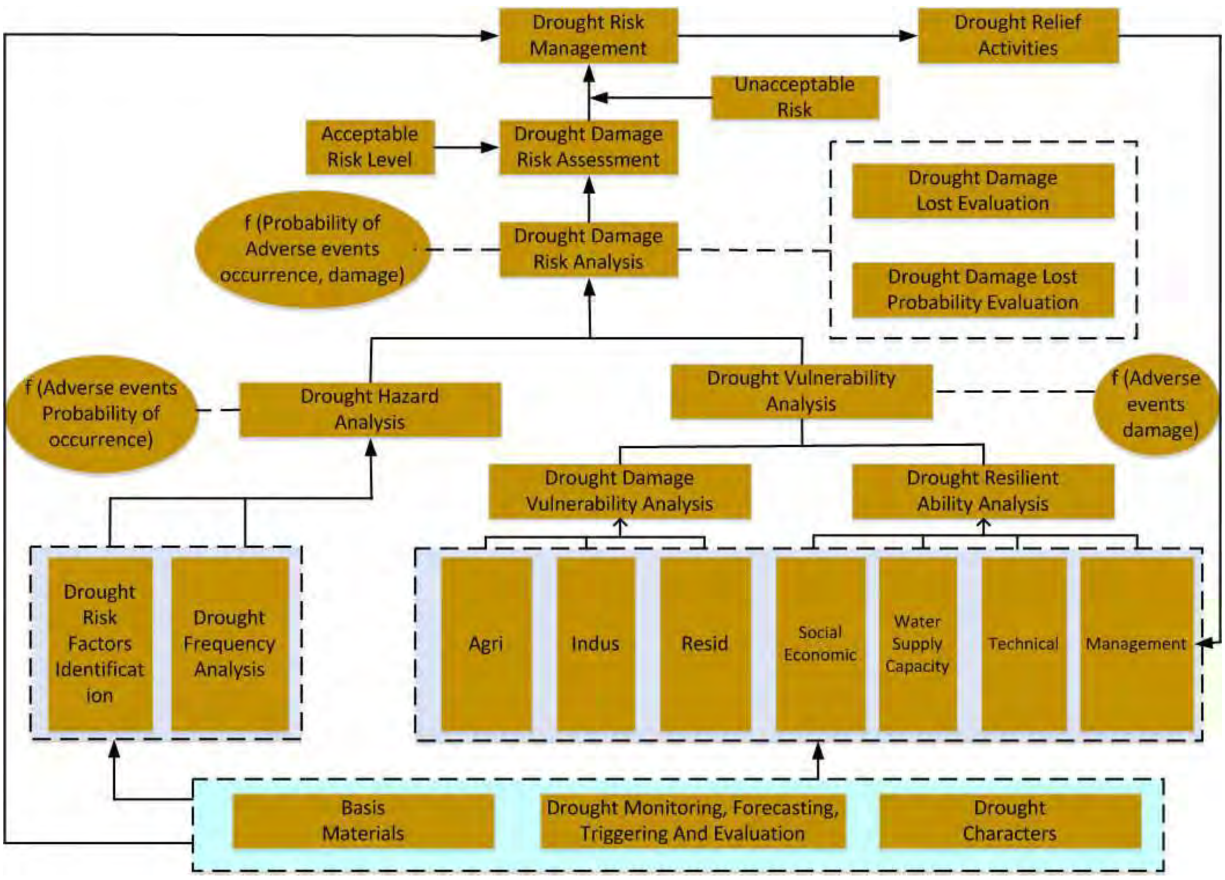
$R = f$(不利事件，不利事件发生的概率) (adverse events, the probability of the occurrence)

$R = f$(不利事件，损失) (adverse events, damage)

$R = f$(不利事件发生概率，损失) (probability of adverse events occurrence, damage)

IWHR Drought Disaster Risk analysis ideas are shown in Figure D.3.

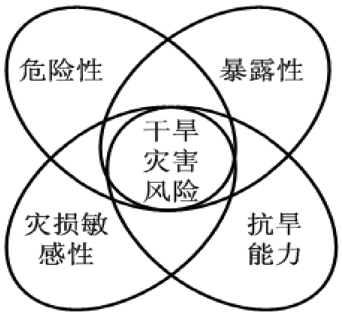
Figure D.3: Drought disaster risk analysis figure



D.3.2 Drought Disaster Risk Elements

According to the systematic theory of natural disaster, based on the occurrence mechanisms of drought disaster, drought risk was determined based on 4 factors: hazard of risk factors, exposure of impacted elements, vulnerability of impacted elements, and resistance of impacted elements as shown in Figure D.4. The hazard of risk factors refers to the severity, scale, and probability of drought risk; exposure of impacted elements refers to the scope of elements under drought impacts and potential losses; vulnerability refers to the sensitive level of impacted elements to drought impacts; resistance of impacted elements refers to the capability of impacted elements taking actions to reduce losses due to drought.

Figure D.4: Drought Risk Elements Diagram



D.3.3 Risk Assessment of Drought

Drought risk assessment is to determine the probability of occurrence of regional drought and the corresponding loss severity. Currently, drought risk assessment methods are mainly two categories:

D.3.3.1 Risk assessment based on risk factors that causes losses due to drought

From the perspective of risk system, based on the philosophy of R (Risk) = H (Hazard) x V (Vulnerability), utilizing the system that evaluate risk factors with hazard, exposure of impacted elements, vulnerability of impacted elements, and resistance of impacted elements the drought risk assessment is done as following:

$$R = f(H, E, V, RE)$$

Where

R (Risk) – Drought risk value (generalized)

H (Hazard) – Hazard of risk factor

E (Exposure) – Exposure of impacted elements

V (Vulnerability) – Vulnerability of impacted elements

RE (Resistance) – Resistance of impacted elements

Advantages:

This method could reflect the sensitive level of each factor, which is beneficial for cause analysis.

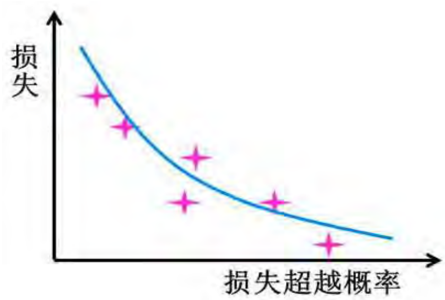
Disadvantages:

Calculated drought risk is relative, which is not comparable with other drought risk value outside the dataset.

D.3.3.2 Risk assessment based on historical frequency distribution of losses due to drought\

According to a historical drought dataset for a specific area, utilizing drought losses frequency analysis to estimate probability distribution of drought losses, use different probability level of different losses to reflect drought risk.

Figure D.5: Risk assessment curve based on probability of losses



Advantages:

The theory is simple and the calculation is simple.

The result is comparable with other historical dataset or dataset from other area.

Disadvantages:

It is not accurate to assume the drought losses dataset is random.

Long term drought losses data may not be available.

This method could reflect impacts of different factors that cause drought losses.

D.4 Initial Drought Risk Maps for Pilot Provinces

In the domestic provincial drought risk analysis of the status quo, as well as foreign drought risk mapping understanding, combined with China Institute of Water Resources and Hydropower research base in this

field, the project team in Liaoning, Gansu and Sichuan three pilot provinces drought risk maps were produced on a preliminary basis.

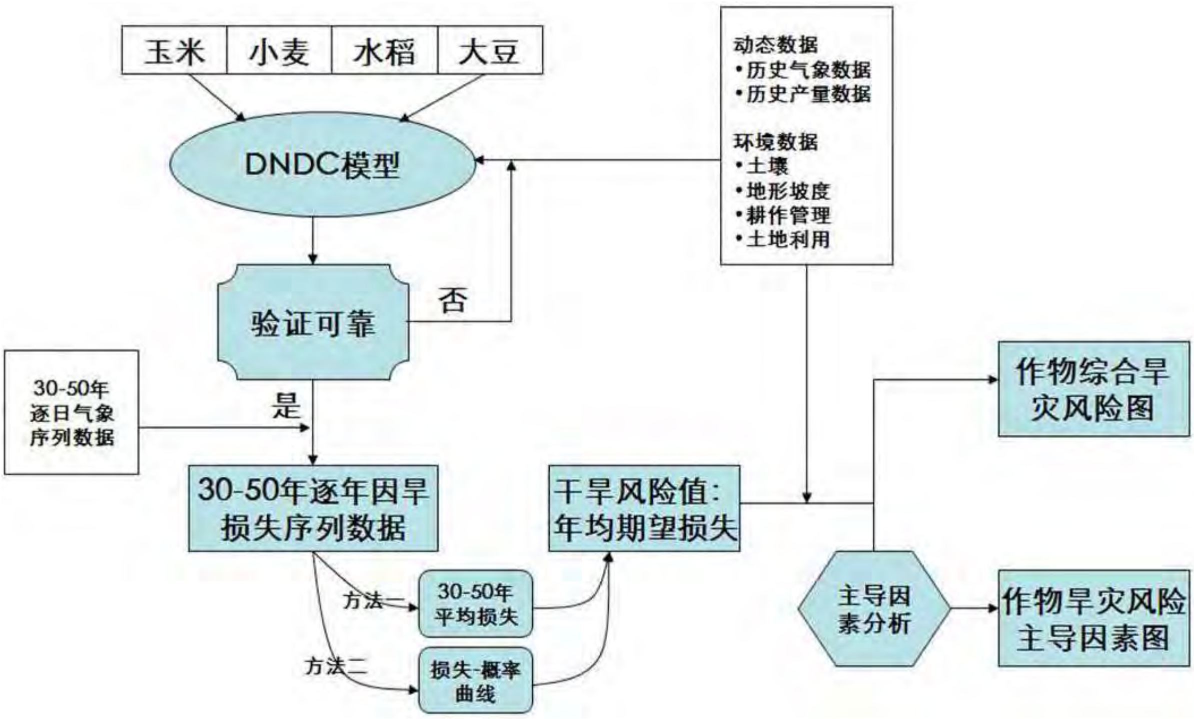
As set forth in other Annexes, because Liaoning Province has relatively good data base and technological strength, and Gansu and Sichuan data base is relatively weak, so this study Liaoning Province and Gansu Province, Sichuan Province will adopt different risk analysis of thinking. For Liaoning Province, mainly based on historical loss frequency distribution of the risk analysis of ideas; For Gansu and Sichuan provinces, mainly based on the constituent elements of the risk of loss of drought risk analysis of ideas.

Currently, the problem of drought disaster risk in domestic is still at the exploratory stage study, mainly concentrated in the colleges and universities and research institutes, there is no specific application above the provincial level. The pilot project of Gansu province and Sichuan province in drought disaster risk management issues has no specific actions, while Liaoning province in drought disaster risk analysis theory and its carry out demonstration research technology in Liaoning province.

D.4.1 Liaoning Province

Shown in Figure D.6 is IWHR technical route of drought disaster risk analysis.

Figure D.6: Risk analysis technology route of the agricultural drought disaster



Using county as a basic unit of analysis, with a comprehensive consideration of agriculture drought risk factors including crops, meteorology, soil, topography, faming (including fertilization and irrigation), based on historical daily meteorological data, utilize DNDC model to estimate grain losses. Utilize grain losses to quantify drought risk value and calculate drought risk value for different crops on different types of ground. Together with dynamic data (meteorological and grain production) and environmental background data (soil and topography), plot the drought risk map for crops and analyze the dominant factors that affect drought risk value. The drought risk dominant factor risk map is also plotted.

DNDC model validation

Choose corn, wheat, rice and soy beans 4 main grains in Liaoning as subjects, collect dynamic data within the analyzing area (including 30 t0 50 years historical meteorological data and grain production data) and environmental data (soil information, topographic slops, faming management changes, and land utilization changes), utilize DNDC model to simulate the growth of 4 grains, and select representative analysis unit to compare simulating data and historical data. The parameters of model are verified to ensure the scientific accuracy.

Drought losses dataset calculation

Utilize validated and reliable DNDC model, based on 30 to 50 years historical meteorological data to simulate the yearly growth of 4 grains for each unit and obtain the 30 to 50 years drought losses data for every analysis unit.

Drought risk value quantification

Utilize drought losses data with proper choice of drought risk value quantification method. The expected annual average grain losses due to drought are calculated and was adapted as drought risk value.

Drought risk map

Based on the range that the drought risk value lies in, propose drought risk classification. This is combined with crops drought risk integrated map and crop drought risk dominant factor map.

D.4.1.1 Case studies

IWHR to the pilot's Liaoning Province, indicating that drought risk mapping. Drought risk mapping is the key to the use of crop growth models on the banks grain loss assessment, but this part of the content involved very much, technology is very complex and is behind the drought risk mapping without complex interactions, so here is not to repeat but merely illustrate the division level of risk and risk mapping problem.

Grain losses under drought risk quantification method to calculate the value of the county-level administrative region of Liaoning Province, drought risk of loss of food value, divided 4 level proposed five years, 10 years, 20 years, 50 years, 100 years, an average of 6 years kind of drought level grain losses

under drought risk grading standards. Liaoning Province, the county administrative grain losses drought risk classification criteria in Table D.1.

Table D.1: Grain loss risk division standard at county level in Liaoning province for drought

	Risk grade（r）			
Drought Grade	I level	II level	III level	IV level
Once in five year	r＞650	650≥r＞450	450≥r＞250	250≥r
Once in 10 year	r＞650	650≥r＞500	500≥r＞350	350≥r
Once in 20 year	r＞700	700≥r＞550	550≥r＞400	400≥r
Once in 50 year	r＞750	750≥r＞600	600≥r＞450	450≥r
Once in 100 year	r＞900	900≥r＞700	700≥r＞500	500≥r
Average	r＞420	420≥r＞320	320≥r＞200	200≥r

D.4.1.2 Drought Risk of Loss of Grain Distribution

According to above analysis results, on the value at risk of losses from dry food, superposition of geographic information, the use of information in remote sensing information, soil and other relevant basic information, the formation of different drought grade for drought risk of loss of grain distribution in Liaoning province. Different drought in Liaoning province level is shown in Figure D.7 to Figure D.12 for it’s the drought risk of loss of grain distribution.

Figure D.7: Liaoning losses of grain drought risk distribution maps five years for a return

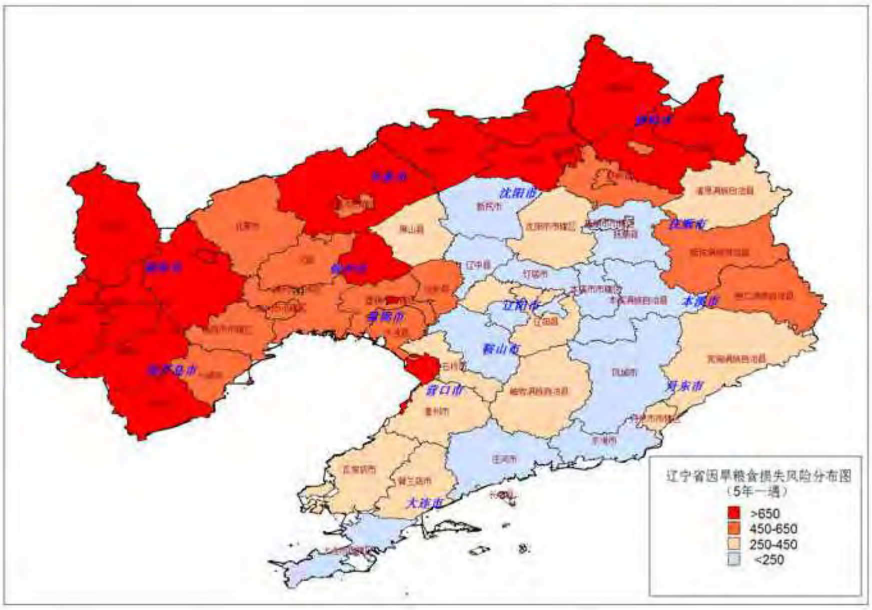


Figure D.8: Liaoning losses of grain drought risk distribution maps for ten years return

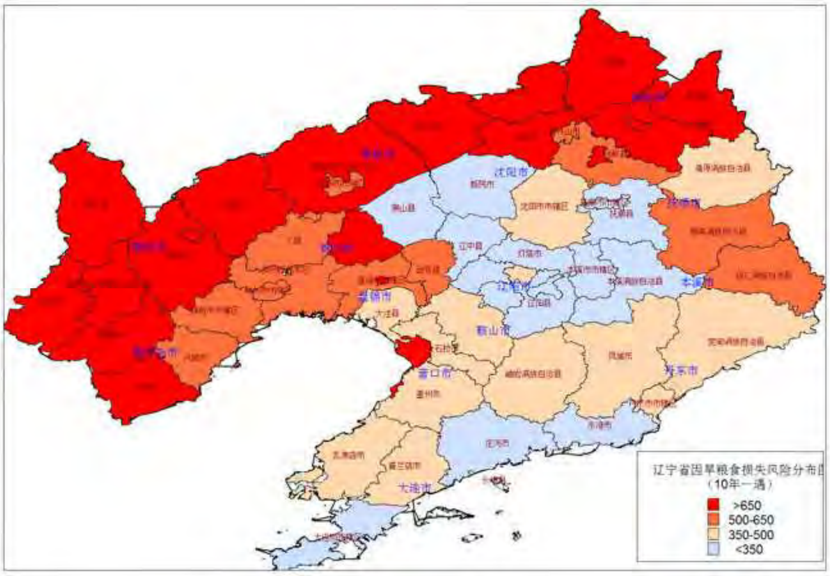


Figure D.9: Liaoning losses of grain drought risk distribution maps for a 20 years return period

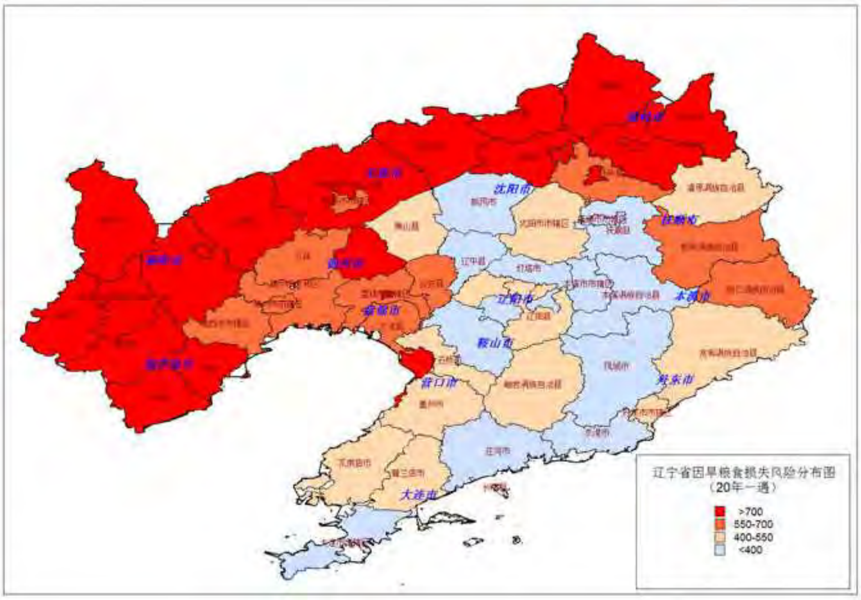


Figure D.10: Liaoning losses of grain drought risk distribution maps 50 years for a return

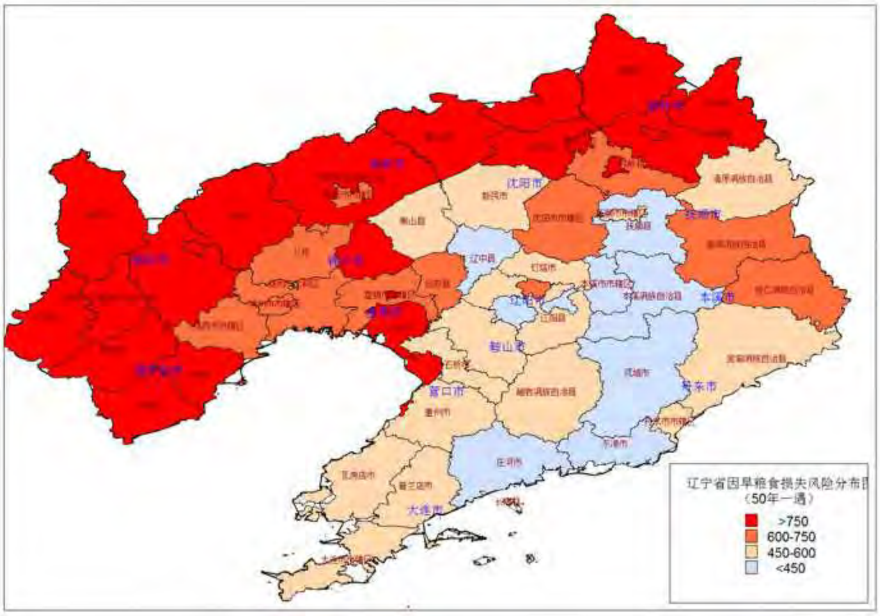


Figure D.11: Liaoning losses of grain drought risk distribution maps 100 years for a return

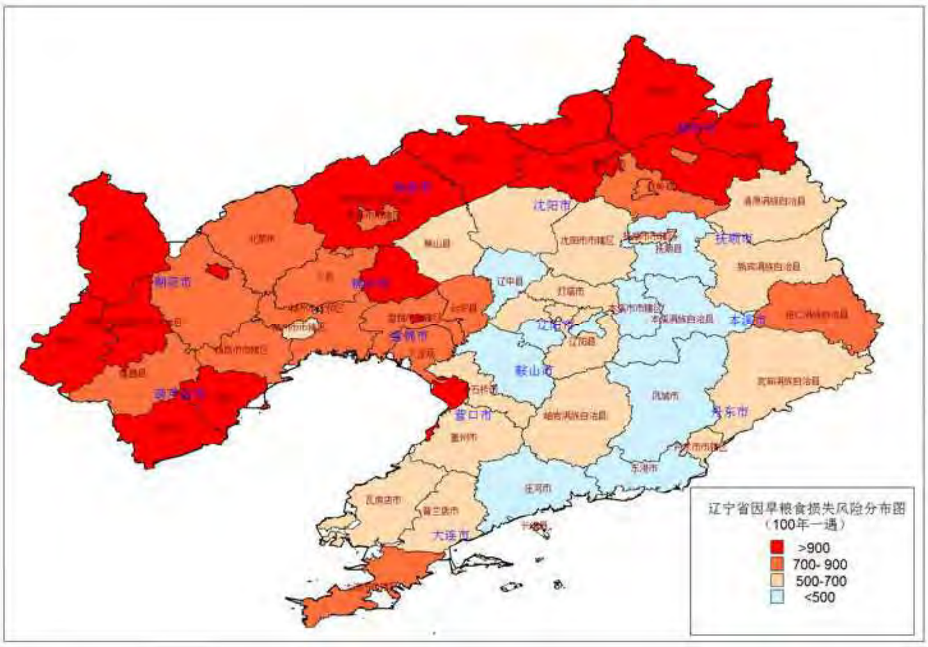
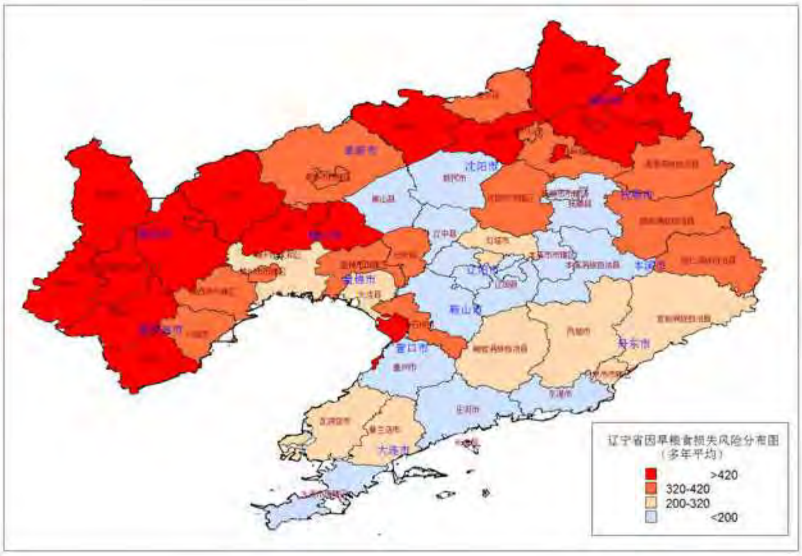


Figure D.12: Liaoning losses of grain drought risk distribution maps on average for several years



D.4.2 Gansu Province

Gansu Province, drought disaster risk analysis using risk factor analysis of ideas, mainly based on historical data of drought, socio-economic data. Figures D.13 to D.16.

Figure D.13: Drought hazard distribution for Gansu

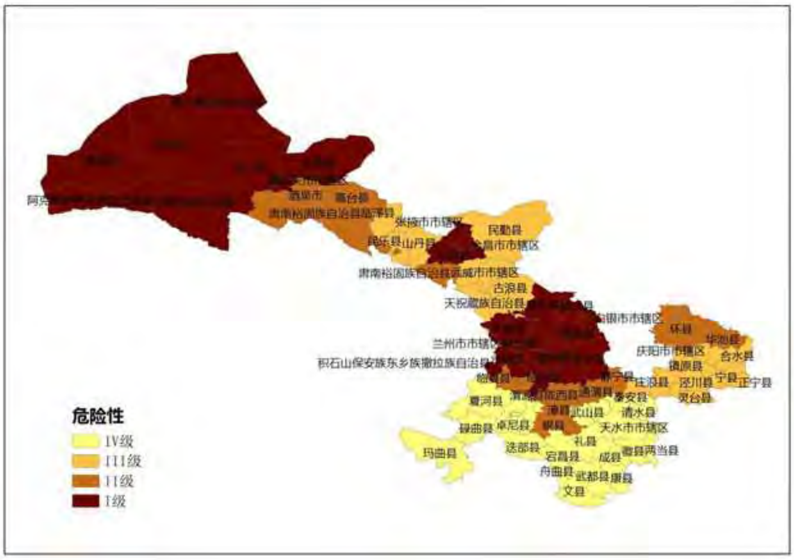


Figure D.14: Drought exposure distribution for Gansu

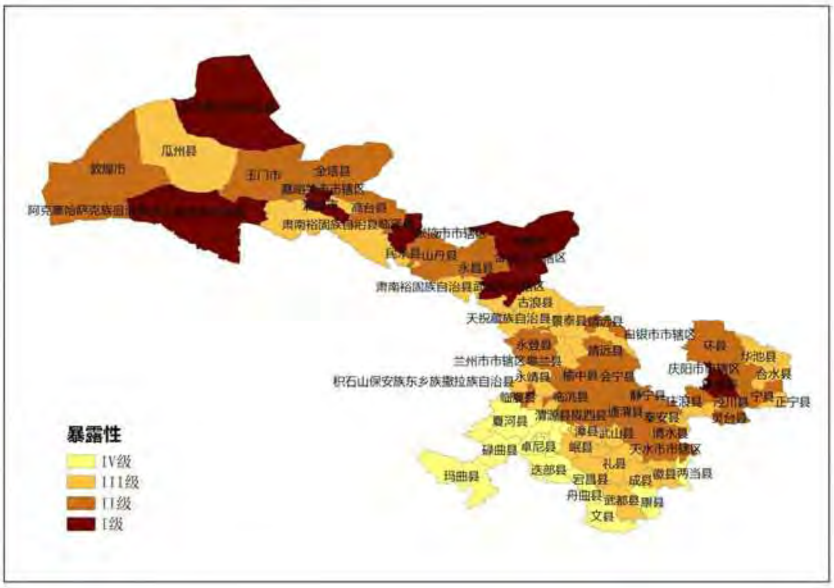


Figure D.15: Drought vulnerability distribution of Gandu

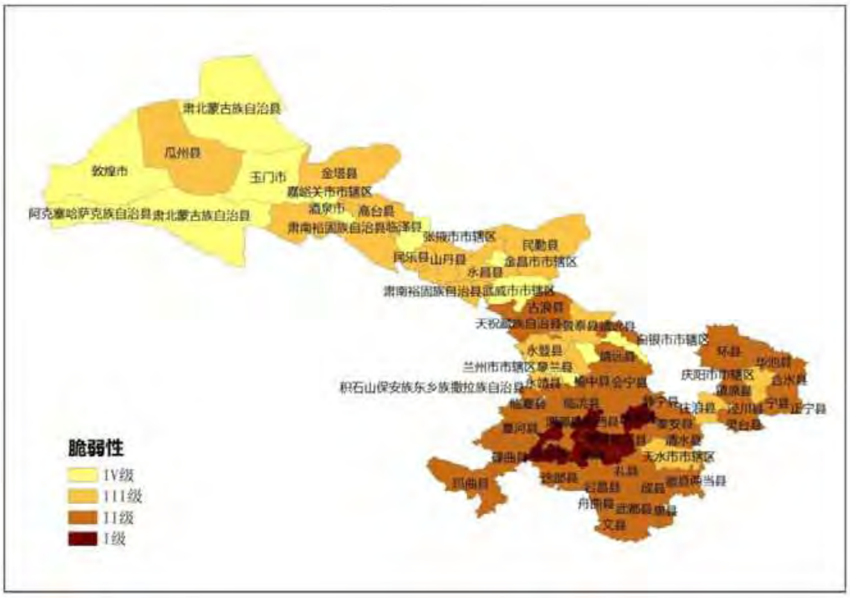
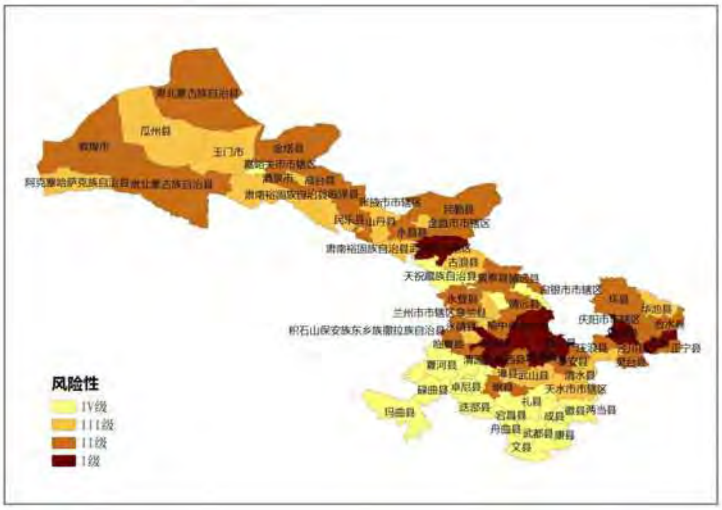


Figure D.16: Drought risk distribution of Gansu



D.4.3 Sichuan Province

Sichuan Province, drought disaster risk analysis is similar to Gansu province using risk factor analysis of ideas, mainly based on historical data of drought, socio-economic data. Figures D.17 to D.20.

Figure D.17: Drought hazard distribution of Sichuan

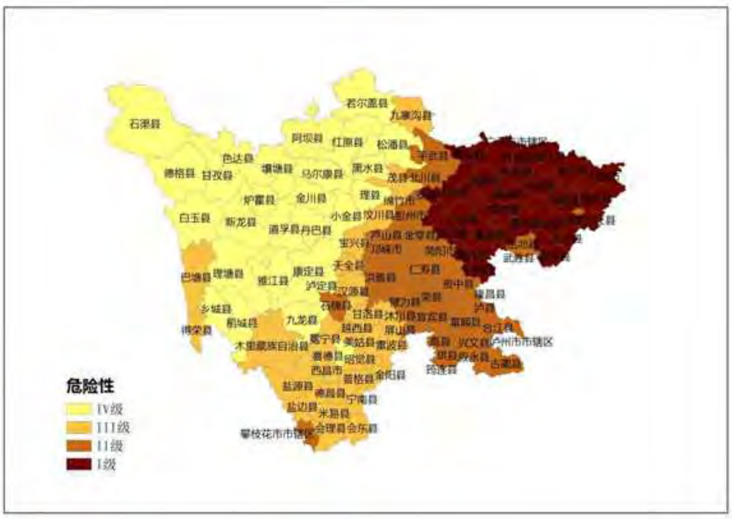


Figure D.18: Drought exposure distribution of Sichuan

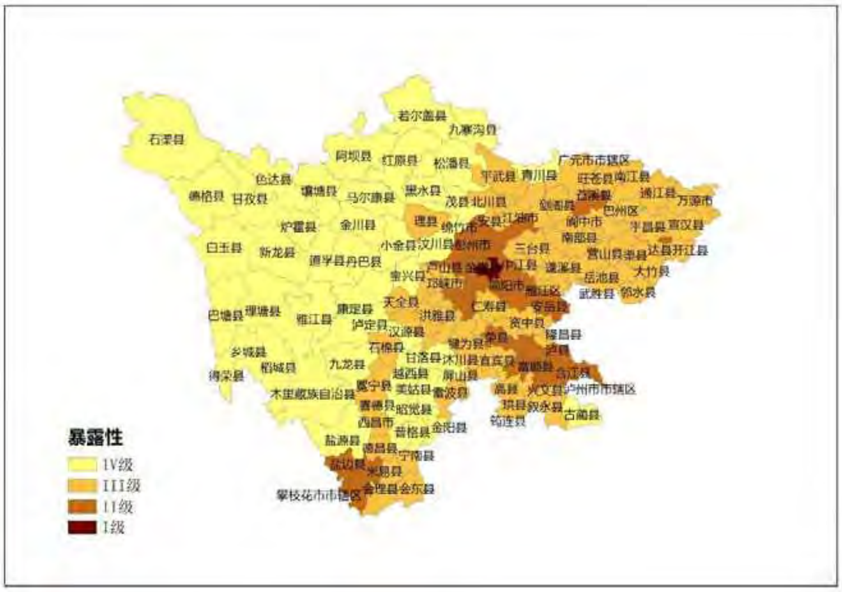


Figure D.19: Drought vulnerability distribution of Sichuan

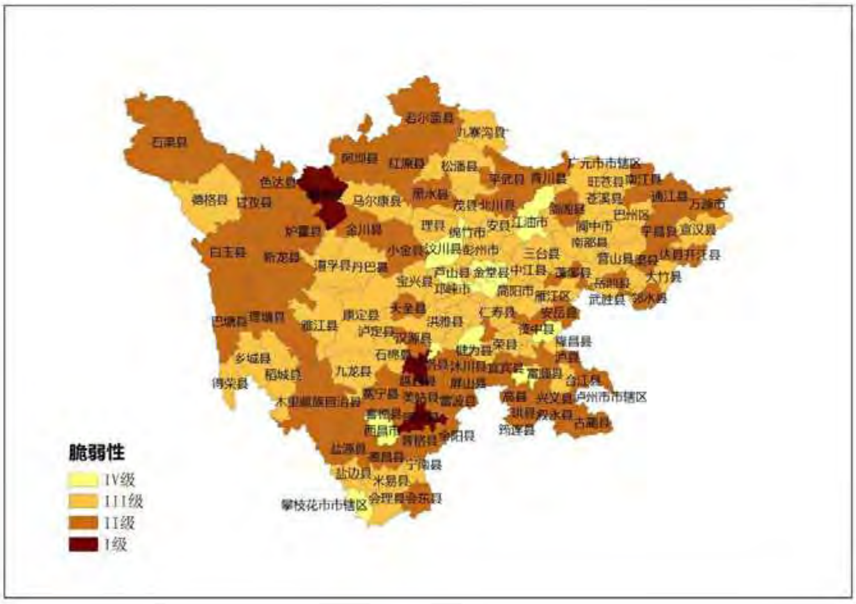
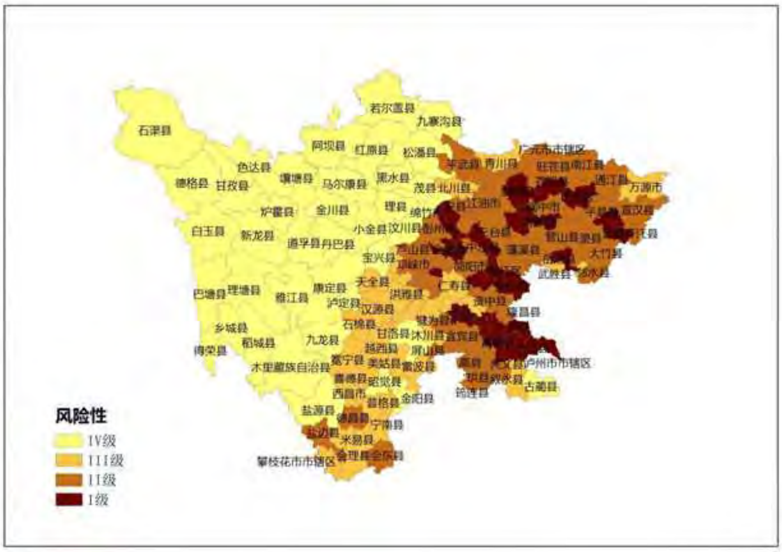


Figure D.20: Drought risk distribution of Sichuan



D.5 Future Enhancements to Drought Risk Mapping

The part is on the basis of the above parts on the summary, not only need to consider the research status at home and abroad, but also need of three pilot provinces, targeted and operational countermeasures and suggestions.

Through the domestic provincial drought risk analysis chart above as well as the status of knowledge of international typical case of drought risk map, one can see that the unified theory method of plotting drought risk map has not yet formed. However, in these studies and practice, plotting the drought risk map with risk factors is dominant. The advantage of this method is that it could reflect the impact degree of different factors of drought with low theoretical complexity, and the flexible demand of data, simple operation; major drawback is only static risk analysis is available.

IWHR conducted extensive research on risk analysis and proposed a new approach to drought risk analysis of drought frequency, and in the province of Liaoning pilot project conducted a preliminary exploration, successfully mapped the drought risk. The biggest advantage of this method is capable of dynamic risk analysis, but the high theoretical complexity, intensive data demand, complex operation.

The above risk elements and drought frequency basis methods to plot drought risk map have been introduced previously. Although this two methods could not cover all drought risk mapping methods, this two methods are representative and scientific, as well as operable and promotional. Therefore, we propose to guide the drought risk mapping in China with the two methods, based on specific situations to plot drought risk map. Taking provincial drought risk map as an example, the specific suggestions are:

- During the initial stage of drought risk analysis, or for the area where the database techniques are poor due to poor data conditions, it is recommended to adapt risk elements basis drought risk mapping method and choose several representative risk elements to analyze risk according to data conditions and local situation.
- For the area with better database and technical support, it is recommended to adapt drought frequency basis dynamic drought risk mapping method
- When possible, it is recommended to adapt both risk mapping methods, which not only estimates the general drought risk value, but also predicts the drought risk in the short future.
- Whether it is static or dynamic risk maps risk maps, background data should be updated regularly, to prevent the risk mapping deviate from the actual situation, resulting in no value for use.
- The results of risk analysis at the provincial level should be communicated to the municipal and county level, especially the dynamic drought risk analysis. The local administration could make appropriate adjustments and take certain measures in response, according to their specific situation.

Other specific aspects, such as the risk mapping for single element, the choice of element for risk analysis and how to calculate the loss of drought and other issues are technical problems are not able to deliberate here and bound to generalize.

Appendix E. Proposed Drought Forecasting and Warning System

E.1 Current Provincial Drought Forecasting and Warning Systems in Place

Currently, China is in the transition from emergency response to risk management. Drought management departments in each province and region have not established a drought forecasting and triggering system. Although provincial and local drought management officers understand some risk forecasting theory, and bring up some valuable ideas, these are not implemented in actual practice. Some regions predict drought development through drought monitoring and experience, but this is not done systematically and lacks of theory support. Although drought management departments from different administrative levels have established drought emergency plan, this plan is pre-planned responsive activities after drought occurs rather than a drought forecasting. Consequently, there is no provincial drought risk forecasting system strictly. This is not only the situations in the pilot province, but also throughout China.

Drought forecasting and drought analysis are similar. Simply put, they are all analysis and evaluations based on the indices and classifications. The difference lies in the working period. Drought forecasting and warning is the analysis of drought development before drought occurs, while drought analysis is the evaluation of drought severity during drought period. Consequently, the indices and classifications are close. Due to lack of the drought forecasting and warning system, considering drought forecasting and drought analysis are similar, the water resources sectorial standard that has been commonly adapted by drought management departments from different administrative levels for drought analysis *Standard of Classification for Drought Severity (SL424-2008)* is summarized here (full text contained in Annex 1). “SL424-2008", implemented in March 2009 applies to most parts of the country. It involves the indicators and grading criteria of assessment for agricultural drought, livestock drought, urban drought and drinking water drought, as well as the regional drought assessment and grading.

Agricultural drought assessment indicators include relative soil moisture, precipitation anomaly percentage, number of consecutive days without rain, crop water stress ratio, and number of days without water. Livestock drought assessment indicators include precipitation anomaly percentage and the number of consecutive days without rain. Urban drought assessment indicators are water deficit rates for cities. Drinking water drought assessment indicators are basic drinking water consumption and drought duration. The classifications for each indicator are also given in the Standard. The classifications are different for some indicators in accordance with the different divisions of the North and South in China, or in accordance with the different levels of the national, provincial, municipal and county.

The implementation of the Standard has played a great role in promoting drought assessment level in the nationwide. So far, drought management and the relevant departments at all levels across the country, and a large number of research institutions have adopted the Standard for drought assessment. However, the Standard is based on the majority of conditions in the country and may in some areas not be very applicable. The three pilot provinces of this project, Liaoning, Gansu and Sichuan provinces, revised some indicators and thresholds of the Standard, and have set up a series of more suitable indicators for themselves. The following will briefly describe the differences and updated indicators and classifications in their daily work for the three pilot provinces.

E.1.1 Liaoning Province

In Liaoning Province, the drought analysis uses the indicators of precipitation anomaly index (Annex 1, 3.1.3), number of consecutive days without rain (Annex 1, 3.1.4), relative soil moisture (Annex 1, 3.1.2), crop water stress ratio (Annex 1, 3.1.5), runoff anomaly index, and crops affected-by-drought area ratios. In these indicators, the first four indicators used similar definitions as in the Standard, while for the latter two indicators in Liaoning province a new index was developed. Among them, the indicators of number of consecutive days without rain and crop water stress ratio used the same calculation methods and grading as in the Standard, while precipitation anomaly index and relative soil moisture calculation methods and grading is slightly different with the Standard. The following will briefly describe the differences for the indicators of precipitation anomaly index, relative soil moisture, runoff anomaly index and crop affected-by-drought area ratio.

E.1.1.1 Precipitation anomaly index

The criterion for precipitation anomaly index in the Standard is not suitable for Liaoning province. Firstly, the time scale used for drought severity evaluation are strictly divided monthly, seasonally, or annually. Liaoning province is mainly affected by drought spanning in two seasons, spring and summer. An artificial split of the drought duration into several periods will affect the accuracy of the results. Secondly, the Standard can only evaluate the drought severity month by month, i.e. 30 days, but the drought sustained time is randomly in any length, say 45 days. But the randomly duration should be evaluated according to the fixed criterion in the Standard; it will inevitably affect the assessing result. So, the assessment is more reasonable if the criteria vary with the duration length. Based on these two points, Liaoning province has modified the criterions for precipitation anomaly index, shown in Table E.1.

Table E.1: Modified precipitation anomaly index levels in Liaoning Province

Drought duration(t)	I	II	III	IV
A month	-60＜Dp≤-40	-80＜Dp≤-60	-95＜Dp≤-80	Dp≤-95
Two months	-55＜Dp≤-32	-75＜Dp≤-55	-87＜Dp≤-75	Dp≤-87
Three months(season)	-50＜Dp≤-25	-70＜Dp≤-50	-80＜Dp≤-70	Dp≤-80

A weight is introduced, denoted as Δ .

$$\Delta = \frac{t-30}{60-30} \quad (30<t<60)$$

$$\Delta = \frac{t-60}{90-60} \quad (60<t<90)$$

$$D_{tU} = (D_{U2} - D_{U1}) \times \Delta + D_{U1}$$

$$D_{tD} = (D_{D2} - D_{D1}) \times \Delta + D_{D1}$$

where： *t* is the drought duration(d)

D_{tU} 、 D_{tD} is the up and down thresholds of each levels;

D_{U1}、D_{U2} is the up threshold of the previous and afterward drought period;

D_{D1}、D_{D2} is the down threshold of the previous and afterward drought period.

E.1.1.2 Relative soil moisture

Liaoning Province modified the relative soil moisture in the Standard considering their geographic, climate and soil conditions. The differences demonstrate in two points.
First of all, the soil moisture is measured in three layers, 0~10cm, 10~20cm, 20~30cm, denoted as θ_1, θ_2, θ_3, respectively.
Then, the soil moisture θ is defined as two models as following:

At planting, emergency and seedling period: $\theta = \frac{2}{5}\theta_1 + \frac{2}{5}\theta_2 + \frac{1}{5}\theta_3$

At growing period: $\theta = \frac{1}{5}\theta_1 + \frac{2}{5}\theta_2 + \frac{2}{5}\theta_3$

Secondly, the thresholds for each level are modified slightly as shown in Table E.2.

Table E.2: Modified soil moisture index levels in Liaoning Province

	I	II	III	IV
W	60>W≥ 55	55>W≥ 50	50>W≥40	W<40

E.1.1.3 Runoff anomaly index

Liaoning Province proposed a new indicator, runoff anomaly index, to assess the drought situation in the aspect of hydrology, which is defined similarly with the precipitation anomaly index. Basically, this indicator is adopted for large river.
The indicator is defined as:

$$I_r = \frac{R_w - R_0}{R_0} \times 100\ \%$$

where: R_w—current water flow in the river, m^3/s;
R_0—average annual water flow, m^3/s.

The criterion is shown in Table E.3:

Table E.3: Runoff Anomaly Index in Liaoning Province

	I	II	III	IV
I_r	-30%≤Ir<-10%	-50%≤Ir<-30%	-80%≤Ir<-50%	Ir<-80%

E.1.1.4 The percentage of area affected by drought

The indicator is based on the drought-hit area of the total cultivated area in accordance with the percentage of drought assessment, drought area including rainfed and irrigated agriculture drought-hit area of the affected area Liaoning province modified SL424-2008 as shown in Table E.4.

The formula is:

$$I = \frac{A_{受旱}}{A_{耕地}} \times 100\%$$

where： I = the percentage of area affected by drought (%);
$A_{受旱}$ = area affected by drought (hm^2);
$A_{受旱}$ = planting area (irrigated and non-irrigated area) (hm^2);

Table E.4: SL424-2008 Area Affected Levels modified by Liaoning Province

levels		I	II	III	IV
I (%)	National	5<I≤ 10	10<I≤ 20	20<I≤ 30	I>30
	Provincial	5<I≤ 20	20<I≤ 30	30<I≤ 50	I>50
	Municipal	10<I≤ 30	30<I≤ 50	50<I≤ 70	I>70
	County	20<I≤ 40	40<I≤ 60	60<I≤ 80	I>80

The index includes the national, provincial, municipal and county scale, in practice, the Liaoning provincial and local drought management departments corresponding to different administrative levels for drought assessment.

E.1.2 Gansu Province

Gansu Province, the indicators used for drought analysis include the number of consecutive days without rain (Annex 1, 1.3.3), precipitation anomaly index (Annex 1, 1.3.2), relative soil moisture (Annex 1, 1.3.1), as well as aspects of river runoff and reservoir storage the index. The first three indicators are in line with the "standard" in the same calculation methods and classification; the latter two indicators are not the exact formula, as they merely compare with river runoff or reservoir and are empirically

E.1.3 Sichuan Province

Analysis of drought indicators used in Sichuan and Gansu Province are basically the same, including the number of consecutive days without rain (Annex 1, 1.3.3), precipitation anomaly index (Annex 1, 1.3.2), relative soil moisture (Annex 1, 1.3.1), and the river runoff and reservoirs indicators.

E.2 International Examples of Drought Forecasting and Warning

TA Team can provide international examples of drought planning work from Australia, Canada, UK and USA. There are differing approaches but some consistent aspects:

- State or regional DMP work focused on various types of precipitation and other high-level indices. These efforts are usually based on providing information to lower levels and coordinating activities.
- Detailed water management and allocation decisions are made at local and water supplier level DMPs. Such DMPs use the high level indices of the state or province and add a suite of appropriate local indices.
- DMPs call for specific institutional roles at Normal, Pre-Drought and Drought conditions. There are usually several levels of pre-drought conditions in a similar fashion as the PRC four levels of actual drought.
- Changes in water use and allocations are prescribed by various triggered actions at each of the pre-drought levels, as well as a suite of legal and administrative actions.
- Local DMP triggered changes in water use and allocation are pre-planned in the DMP and may involve reallocation of available supplies to higher level water uses. This was anticipated in PRC SCD460 which allowed reallocation of abstraction permits during drought.
- Detailed risk reduction and mitigation measures as outlined in previous presentation are based on minimizing economic and human impacts of drought prior to drought fully in place.
- Local DMPs are coordinated by state and provincial level DMPs to assure coordination and consistency of approaches, as well as appropriate response measures for large scale droughts.
- Specific international approaches can be discussed in afternoon work session and there is no one model approach that is best for PRC. The general concepts are consistent but there are many approaches.

Box 1. International Example from Canada, British Columbia Province

- Monitoring Indices
  - Basin snow indices
  - Seasonal volume runoff forecasts
  - 30-day percent of average precipitation
  - 7-day average streamflow
- Triggers and Actions
  - Level 1 (Green). Emphasis is on preparedness and taking action in advance of droughts in order to increase readiness of water users and communities when they inevitably occur. (This work is Normal condition)
  - At Level 2 (Yellow), conditions are dry and first indications of potential water supply shortages are recognized. Minimum reduction of 10%. (Pre-drought)
  - At Level 3 (Orange), conditions are becoming very dry. Use of watering restrictions imposed by water service providers. Minimum reduction of 20%. (Pre-drought)
  - At Level 4 (Red), conditions are extremely dry and there is insufficient supply to meet community or ecosystem needs. Regulatory responses by the provincial government. Maximum reduction. (Pre-drought moving into actual drought)

Box 2. International Example from United Kingdom, Anglian Water

- Monitoring Indices
  - Rainfall Average weekly rainfall for our region
  - Potential Evaporation (PE)
  - Actual evaporation (AE)
  - Soil moisture deficit (SMD)
  - Hydrologic and meteorological data from Environment Agency
- Triggers and Actions
  - Series of management actions defined for each level. (Normal, Pre-drought, Drought)
  - Technical basis for each trigger type above is defined.
  - Supply and demand side measures defined for application during droughts of various levels
  - Detailed environmental management plan included
  - Drought communications plan.

Box 3. International Example from United States, State of Kansas

- Monitoring Indices and Levels
  - Palmer Drought Severity Index (Watch, -2 to -2.99, Warning, -3 to -3.99, Emergency, -4 or below)
  - Standardized Precipitation Index (SPI) (Watch, -0.80 to 1.29 for 3 months, Warning, -1.30 to 1.59 for 6 months, Emergency, -1.60 for six months)
  - Percent of Normal Precipitation (Watch, 70% or below for 3 months, Warning, 65% or below for 6 months, Emergency, 60% or below for 6 months)
  - Soil Moisture Percentile (Watch, 11 to 20, Warning, 6 to 10, Emergency, 5 or below)
  - Crop Moisture Index (Watch, -2 to -2.99, Warning, -3 to -3.99, Emergency, -4 or below)
  - Satellite Vegetative Health Index (Watch, 26 to 35, Warning, 16 to 25, Emergency, 15 or below)
  - 7-day median flow percentile (Watch, 11 to 20, Warning, 6 to 10, Emergency, 5 or below)
- Responses – Drought Watch, Warning and Emergency Levels with ties to public water supply staged water conservation plans.

Box 4. International Example from United States, State of Colorado

- Drought Impact and Vulnerability Assessment
  - The most significant impacts associated with drought in Colorado are those related to water intensive activities such as agriculture, wildfire protection, municipal usage, commerce, tourism, recreation, and wildlife preservation.
  - A reduction of electric power generation and water quality deterioration are also potential effects.
  - The state risk assessment includes an overview and analysis of the State's vulnerability based on estimates provided in both the local and state risk assessments. The plan also identifies those jurisdictions that are most threatened and most vulnerable to loss and damage due to drought.
  - The vulnerability of a county is approximated by looking at previous impacts due to drought and identifying existing conditions, or — metrics, that would cause a county to be more or less impacted during future droughts.
  - The sectors evaluated in the DMP are Agriculture, Energy, Environment, Municipal and Industrial (M&I), Recreation, and Socioeconomic.
- Drought Monitoring and Indices
  - Because drought can be defined differently, based on the cause (lack of supply) and the effect (adverse impacts to water users), several methods have evolved to measure and assess drought.
  - Severity, most commonly used term for measuring drought, is a combination of the magnitude and duration of the drought. In order to assess the severity of a drought event State monitors normal conditions and conditions during drought events.
  - Individual indicators of drought conditions are used as well as indices that combine multiple different indicators to give a more comprehensive set of information. Both traditional maps and graphs of precipitation, snowpack, and streamflow patterns and compilations are valuable for drought monitoring.
  - The most commonly used indices in local drought management planning in Colorado include the Colorado Modified Palmer Drought Index (CMPDI), Surface Water Supply Index (SWSI), Standardized Precipitation Index (SPI), Crop Moisture Index.
  - Research has been underway to improve the drought indices in use in the state and make them more accurate to actual Colorado conditions

E.3 Scenario Analysis of Potential Drought Impacts

Take Liaoning as an example to forecast grain production lost due to drought.Refer to Appendix D, the scenario analysis in risk mapping for ways to illustrate potential drought risks.

Based on historical drought impact review correlated with preceding drought indicator review, it is possible to run scenarios of the likely impacts and damages associated with potential droughts of various levels.

This will be an important part of the decision support system for drought risk management described in a later appendix.

E.4 Proposed Warning System and Triggers for Pilot Provinces

We have briefly introduced the drought monitoring indicators and grading adopted in the daily working for the three pilot provinces. These indicators are mainly based on "Standard of classification for Drought Severity SL424-2008", with some modification and supplement. Although the provincial administrations have not establish a systematical early warning mechanism based on these indicators yet, more or less, they are using these indicators for short-term drought forecasting Although there is no complete early warning system in each province, they have explores a set of local methods in research level. And this is more valuable for our study.

Thus, here we will first introduce the drought early warning prediction research in each province, and then proposed the provincial drought early warning and triggering system.

E.4.1 Existing warning system and triggers

E.4.1.1 Liaoning Province

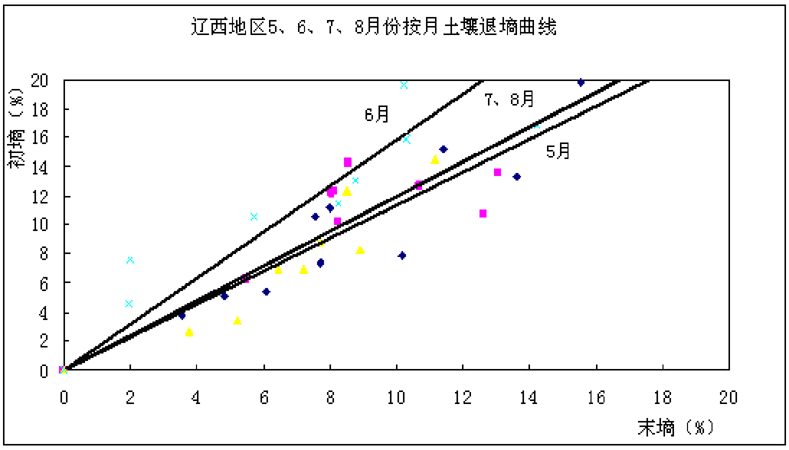
In Liaoning Province, a soil moisture prediction model was developed for the prediction of droughts. It consists of the declining soil moisture empirical model and increasing moisture empirical models.

E.1.1.1 Declining soil moisture empirical models

Soil moisture empirical models are used to predict the case without precipitation reduced soil moisture change process, because a lack of precipitation in case of soil moisture continues to decline, and is called the “declining soil moisture” procedure.

This basic principle of this model is that when precipitation stops, after the disappearance of ground water, soil moisture, evapotranspiration and infiltration role in diminishing into the soil moisture subsided stage. This model ignores the deep groundwater recharge on the role of the upper soil moisture, considers evaporation, distribution and other effects to predict changes in soil moisture. Because of different initial soil moisture affect soil moisture withdrawal process, and the months (i.e,, plant growth stages and different solar radiation energy) also affects the moisture withdrawal process the model considers different months, different initial soil moisture conditions.
Model is based on the initial soil moisture ρ0 as a starting point, draw different months of the soil moisture curve, according to the curve predicted soil moisture at time t ρt, as shown in Figure E.1.

Figure E.1: The soil moisture depletion curve in Western Liaoning for (from left to right) Jun, Jul and Aug (one curve), May

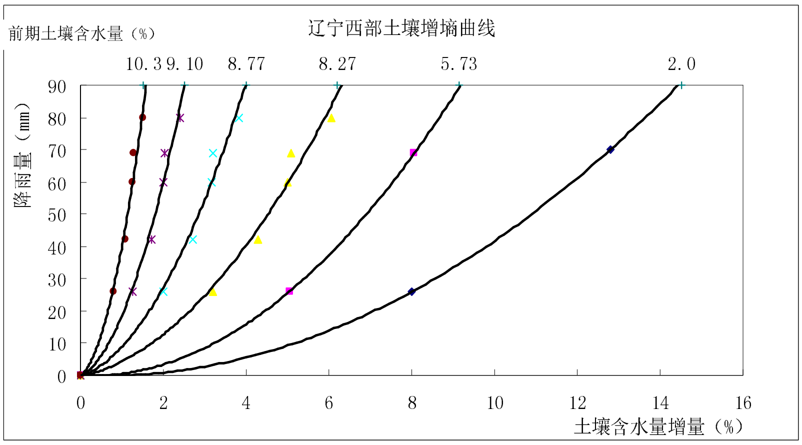


4.1.1.2 Increasing soil moisture empirical model

The increasing moisture empirical model is reversed of the declining moisture empirical model, which is predicting the increasing process of the soil moisture for a short-term after precipitation.

Model precipitation mainly considers the impact on soil moisture content, while ignoring other factors that draw different precipitation P (mm) and soil water content increment Δρ (%) of the correlation, as shown below in Figure E.2.

Figure E.2: The soil moisture increasing curve after a single precipitation event in Western Liaoning



Withdrawal of moisture through the above model and increase soil moisture model, based on the current measured soil moisture ρ0, in which the current month, rainfall P (mm), for t point in time to predict soil moisture, thus achieving early warning drought prediction.

E.4.1.2 Gansu Province

Gansu Province has also developed a number of drought early warning forecasting methods. For example, the FCDRH of Gansu Province uses empirical methods based on observed soil moisture and crop growth characteristics for early warning drought prediction. Gansu Provincial Water Resources Department Improved Penman and Penman Formula to make drought early warning. Gansu Provincial Meteorological Bureau using dynamical model and statistical methods to make drought early warning. Here we will not discuss these methods specifically.

E.4.1.3 Sichuan Province

Sichuan Province is a relatively water-rich area, and only in recent years have experienced frequent severe drought events. Compared to other provinces, Sichuan is lacking experience and technology in drought management and has not carried out work and research on drought early warning and drought prediction.

E.4.2 Proposed warning system and triggers

Through the above analysis, we can summarize Chinese provincial drought early warning forecasting system status quo is in its infancy. Although the early warning concept and risk management idea have been widely accepted by the staffs working on drought management, and a number of innovative approaches have proposed in the research level, these concepts and methods getting into practical application has some way to go. One important constraint is the lack of a guiding framework to construct drought early warning system. Here we will propose a provincial drought forecasting and early warning system as well as triggering actions that are in line with China's national conditions, which is based on the current status of Chinese provincial drought early warning, drawing on international experience on the construction of drought early warning and prediction system, combined with the drought impact assessment with scenario analysis, as well as China's existing drought early warning researches.

We suggest that the construction of Chinese provincial drought early warning system should abide by these basic principles following: 1) In considering the provincial database to support drought early warning system; 2) Provincial levels can select the appropriate local indicators for early warning and prediction; 3) The forecasting and early warning results should issue to the municipal and county levels, and release to the public timely. 4) The early action triggering should correspond with municipal and county levels.

The drought early warning indicators selection should follow the universal, typical and accessible principles. "Universal" refers that the warning indicators within the province should be able to generally applicable. "Typical" refers that the warning indicator itself should be widely adopted, having accurate and reliable results. "Accessible" refers that the early warning indicators calculation method should be simple to use, with fewer constraints.

In view of the above principles, referring to other international advanced experiences, we suggest three basic early warning indicators for provincial early warning and prediction. These recommended indicators

consists of the Standardized Precipitation Index (Standard Precipitation Index, SPI) (Annex 2,) in meteorological aspect, the runoff anomaly index (refer to 1.1.3 runoff anomaly index) in hydrological aspect, and relative soil moisture (Annex 1, 1.3.1) in agricultural aspect. The remote sensing tools also can be used in early warning if possible.

- SPI index as a valid indicator of drought monitoring and early warning has been widely recognized internationally. The calculation method is simple and data acquisition is relatively easy. SPI index is more scientific than the indicators of consecutive days without rain and precipitation anomaly index, and is easier to operate than Palmer precipitation index.
- Runoff anomaly index is a hydrological indicator, which can reflect the regional water resources abundant or deficient. Since runoff anomaly index predicts drought by the water cycle process in the atmosphere - water - soil circulation system, it is suitable for long-term drought early warning. In addition, this indicator is already used in the current drought management departments at all levels in their daily work for drought monitoring, with a popular application foundation. More importantly, the existing “Database” in each province can provide good data support for the calculation.
- Relative soil moisture can directly reflect the level of soil moisture, while the level of soil moisture is closely related with crop growth. Thus, relative soil moisture is considered the most accurate analysis indicator, which is more applicable for short-term drought early warning. But the soil moisture are affected by many factors, the monitoring accuracy and reliability vary in different regions, So, it is required to ensure the accuracy and completeness of monitoring data.

The three indicators to predict drought trends for short-term and long-term are derived from different aspects, meteorological, hydrological and agricultural aspect respectively. In practical applications, each province should take into account their actual situation; selecting either all the three indicators as a comprehensive prediction, or any one or two key indicators to come to a specific result. Here we will not discuss how to analyze these three indicators to do specific predictions, nor talk about the remote sensing forecasting issue.

The grading for each indicator should be determined in accordance with the actual situation of each province. Here we will not provide the threshold range specifically.

Overall, the importance of the provincial drought early warning system is to use universal and typical indicators to forecast the future drought trend, and provide the warning result to local level as reference, but not instead the local level to make decision.

E.5 Proposed Municipal and County Level Drought Warning System

Currently, almost all municipalities and counties have not established drought early warning systems. Most drought mitigation work takes place on or after the drought occurred. The popular drought management workflow in local level is surveying the drinking water situation and agricultural drought situation when the drought happened, then holding a consultation meeting to discuss what measures to take to reduce the drought impact.

Some areas will carry out early warning and forecasting at a critical period, for example, before planting in the spring. The forecasting is mainly based on result from the meteorological department, some combined with soil moisture monitoring results. According to the forecasting result, the following actions includes river dredging, digging wells, adjusting the water storage in reservoirs and other measures to ensure the planting success. But this kind of warning and forecasting is not a daily work, it can also be considered as a part of the drought contingency plan.

Basically, the municipal and counties levels are relative weak in drought early warning technology. Some places do not have drought monitoring data, or drought-related databases. Some places do not have professional and technical staff on drought monitoring and early warning. These have seriously hampered the development of drought early warning.

Overall, either on the side of mechanisms, or on the side of technology, municipal and county levels are far from the real risk management. In view of this, we suggest that it should focus on the current situation to put forward practical local drought early warning system.

Municipal and county level drought early warning system should be closely coupled with the proposed provincial early warning systems. The basic idea is developing a locally appropriate drought early warning system based on the result released by the provincial level.

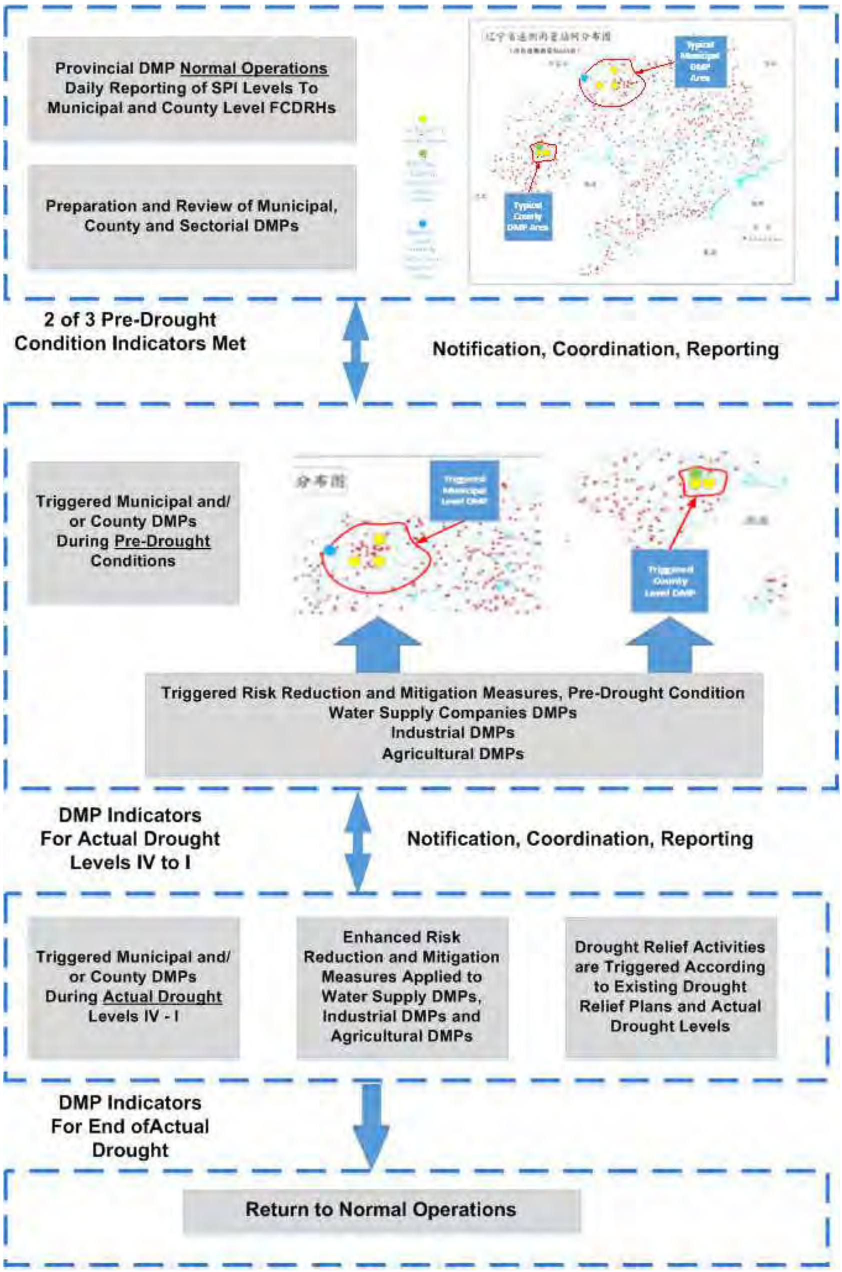
The indicator selection principle is accessible and typical. Accessible is using relatively simple indicators based on local database and technical strength. Typical is taking into account the local natural climatic conditions, hydrology and water resources conditions, soil and geological conditions, agricultural planting structure issues, and some ensured objects, etc., to design typical drought early warning indicators.

Local drought early warning system and provincial drought early warning system are intrinsically linked but different. Of principal, whatever the indicators and the grading, the local level might be the same or not same, decrease or increase on the basis of the provincial level indicators. But we suggest to use the provincial method as much as possible. Because it is easy to achieve for local levels. In a word, Provincial drought early warning is to provide a reference for the local levels, but not a substitute.

Figure E.3 shows an example of a provincial, municipal and county level drought risk triggered system. At the provincial level, the three basic indicators are the standardized precipitation index, runoff anomaly index and relative soil moisture. And the provincial early warning results will be provided promptly to the municipal levels. The municipal level made some modification: 1) Adjusting the threshold interval of SPI; 2) Add more soil moisture monitoring stations for relative soil moisture computation; 3) Using Penman-Menteith to make early warning. Municipal levels both report the early warning result to the provincial level, and convey the result to the county levels. Meanwhile, the municipal level can take actions according to the forecasting results. Similarly, the county level will make drought early warning and triggering on the basis of the municipal level. Protection of key water sectors can be considered. Also, the result is reported to the municipal county and then conveyed to provincial level, and the actions can be triggered according to the forecasting results.

With respect to the triggering action, the municipal and county levels should take appropriate measures according to their drought early warning results, including release information, compressed water entitlements and allocate goods, and so on.

Figure E.3: Illustrative DMP tiering levels and triggers



ANNEX 1

Translation of:

Standard of classification for drought severity

SL424-2008 (implemented in 2009)

Table of Contents

1. Introduction

2. Terminology

2.0.1 Drought
Due to decrease on precipitation or lack of inflow, the water demand of agricultural, industrial, domestic or ecological water demand cannot be satisfied.

2.0.2 Drought Severity
This includes the presence, progress and development of drought, including duration, area affected, developing trend, and intensity.

2.0.3 Agricultural drought
This includes the arable land or crop conditions under drought, i.e., soil moisture is not sufficient to supply water for growth or sprouting, leading to an inhibition on growth or wilt.

2.0.4 Pasture drought
This includes pasture conditions under drought, i.e., soil moisture is not sufficient to supply water for pasture to re-grow, leading to an inhibition on growth or wilt.

2.0.5 Urban drought
This includes domestic water shortage or industrial, commercial water shortage, including duration, intensity, etc.

2.0.6 Regional agriculture drought
This includes regional impacts on agriculture due to drought, including arable land area under drought and intensity

2.0.7 Regional pasture drought
This includes regional impacts on pasture due to drought, including pasture land area under drought and intensity

2.0.8 Regional comprehensive drought
This includes regional impacts on agricultural, pasture, and domestic water use

2.0.9 Drought classification
This is a standard used to describe drought severity

2.0.10 Relative soil moisture
This is the ratio of moisture content in soil to water holding capacity.

The ratio of moisture content in soil to field water holding capacity, in percentage

$$W = \theta / F_c \times 100\%$$

Where

W--------relative soil moisture, %

Θ--------weight ratio of moisture content in soil, %

F_c------Field water holding capacity

2.0.11 Percentage of precipitation anomalies

$$D_p = (P - P_{avg}) / P_{avg} \times 100\%$$

Where

D_p--------percentage of precipitation anomalies
P---------precipitation during target period, mm
P_{avg}------average precipitation during target period of many years, mm

2.0.12 Consecutive days without rain
This is the number of days without rain during crop growth period.

2.0.13 Irrigation water deficiency ratio
$D_w = (W_r - W) / W_r \times 100\%$

Where
D_w-------Irrigation water deficiency ratio
W_r-------actual water demand for crops during target period
W--------available amount of water for irrigation during target period

2.0.14 Consecutive days without water in rice-field
This is calculated during paddy rice growth period, and is the number of days when no visible water surface in the paddy field.

2.0.15 Water deficiency ratio caused by urban drought
$P_g = (Q_z - Q_s) / Q_z \times 100\%$
Where
P_g-----water deficiency ratio caused by urban drought
Q_z-----urban water supply amount during normal conditions
Q_s----actual water supply amount during drought

2.0.16 Drought frequency

$P_i = m_i / (n+1) \times 100\%$

Where
Pi--------Drought frequency
i-------the sequence number of a certain year
n------the number of total years in a statistical period
m_i----the first m year, ie. in the statistical period, the number of years that no less than the certain year.

3. Drought Indices And Classification (For Monitoring Station Use)

3.1 Agriculture

3.1.1 Agriculture drought indices include relative soil moisture, percentage of precipitation anomalies, consecutive days without rain, irrigation water deficiency ratio, and consecutive days without water in rice-filed. The scopes and conditions for each index are listed in Table 3.1.1.

Table 3.1.1 Agriculture drought indices and applicable conditions

Agriculture types	Rain-fed	Irrigated	
		Dry land with irrigation	Paddy field
Indices	Relative Soil moisture Precipitation anomalies Consecutive days without rain	Relative soil moisture Irrigation water deficiency ratio	Water deficiency ratio Consecutive days without water in rice-filed

3.1.2 Relative soil moisture

Calculations of relative soil moistures and the classification table

The ratio of moisture content in soil to field water holding capacity, in percentage

$W = \theta / F_c \times 100\%$

Where

W--------relative soil moisture, %

Θ--------weight ratio of moisture content in soil, %

F_c------Field water holding capacity

Determination of drought level:

Drought Level	Level IV	Level III	Level II	Level I
W %	50 < W < 60	40 < W < 50	30 < W < 40	W < 30

3.1.3 Percentage of precipitation anomalies

Calculations and the classification table

$D_p = (P - P_{avg}) / P_{avg} \times 100\%$

Where

D_p--------percentage of precipitation anomalies

P---------precipitation during target period, mm

P_{avg}-------average precipitation during target period of many years, mm

Determination of drought level:

Drought Level	Dp in %		
	Monthly	Quarterly	Annual
Level IV	-60 < Dp < -40	-50 < Dp < -25	-30 < Dp < -15
Level III	-80 < Dp < -60	-70 < Dp < -50	-40 < Dp < -30
Level II	-95 < Dp < -80	-80 < Dp < -70	-45 < Dp < -40
Level I	Dp < -95	Dp < -80	Dp < -45

3.1.4 Consecutive days without rain

Definitions and the classification table

Determination of drought level:

Season	locations	days			
		Level IV	Level III	Level II	Level I
Spring (Mar-May) Fall (Sept-Nov)	Northern	15-30	31-50	51-75	>75
	Southern	10-20	21-45	46-60	>80
Summer (Jun-Aug)	Northern	10-20	21-30	31-50	>50
	Southern	5-10	11-15	16-30	>30
Winter (Dec-Feb)	Northern	20-30	31-60	61-80	>80
	Southern	15-25	26-45	46-70	>70

3.1.5 Irrigation water deficiency ratio

Calculations and the classification table

$$D_w = (W_r - W) / W_r \times 100\%$$

Where

D_w-------Irrigation water deficiency ratio

W_r-------actual water demand for crops during target period

W--------available amount of water for irrigation during target period

Determination of drought level:

Drought Level	Level IV	Level III	Level II	Level I
Dw %	5 < Dw < 20	20 < Dw < 35	35 < Dw < 50	Dw > 50

3.1.6 Consecutive days without water in rice-field

Definitions and the classification table

Drought level			Level IV	Level III	Level II	Level I
Days	Southern	Spring and Fall	7-10	11-20	21-30	>30
		Summer	5-7	8-12	13-20	>20
	Northern		7-10	11-15	16-25	>25

3.2 Pasture

3.2.1 Pasture drought indices include percent precipitation anomalies, consecutive days without rain

3.2.2 Percentage of precipitation anomalies

Calculations and the classification table

$$D_p = (P - P_{avg}) / P_{avg} \times 100\%$$

Where

D_p--------percentage of precipitation anomalies

P---------precipitation during target period, mm

P_{avg}-------average precipitation during target period of many years, mm

Determination of drought level:

Drought Level	Dp in % Monthly	Quarterly	Annual
Level IV	-70 < Dp < -50	-60 < Dp < -30	-40 < Dp < -20
Level III	-85 < Dp < -70	-80 < Dp < -60	-50 < Dp < -40
Level II	-95 < Dp < -85	-90 < Dp < -80	-60 < Dp < -50
Level I	Dp < -95	Dp < -90	Dp < -60

3.2.3 Consecutive days without rain

Definitions and the classification table

Determination of drought level:

Season	Days Level IV	Level III	Level II	Level I
Spring (Mar-May) Fall (Sept-Nov)	30-50	51-70	71-80	>80
Summer (Jun-Jul)	20-50	31-50	51-70	>70

3.3 Urban

3.3.1 Urban drought indices include water deficiency ratio caused by urban drought

3.3.2 Calculations of water deficiency ratio caused by urban drought

$$P_g = (Q_z - Q_s) / Q_z \times 100\%$$

Where

P_g-----water deficiency ratio caused by urban drought

Q_z-----urban water supply amount during normal conditions

Q_s----actual water supply amount during drought

3.3.3 Classification table of water deficiency ratio caused by urban drought

Determination of drought level:

Drought Level	Level IV	Level III	Level II	Level I
Pg %	5 < Pg < 10	10 < Pg < 20	20 < Pg < 30	Pg > 30

3.4 Drinking Water Supply Stress

Definitions: satisfy both 2 conditions

Conditions			Values
1.	Locations		Reduced during drought
	Water demand (L/capita*d)	Northern	<20
		Southern	<35
2.	Duration (d)		>15

4. Regional Drought Indices And Classifications

4.1 Regional Agriculture Droughts

4.1.1 Regional agriculture drought is evaluated using regional index

4.1.2 Calculations

$$I_a = \sum_{i=1}^{4} A_i B_i$$

Where:

I_a--------Regional agriculture drought index

i----------Agriculture drought level (determined in chap. 3.1)

A_i--------the ratio of cropped land to arable land, %

B_i-------the drought level constant (B_1=1, B_2=2, B_3=3, B_4=4)

4.1.3 Classification based on regional agriculture drought index

Determination of drought level:

	Regional Drought Index Ia			
Levels of administration	Level IV	Level III	Level II	Level I
National	0.05 < Ia < 0.1	0.1 < Ia < 0.2	0.9 < Ia < 0.3	0.3 < Ia < 4
Provincial	0.1 < Ia < 0.5	0.5 < Ia < 0.9	0.9 < Ia < 1.5	1.5 < Ia < 4
Municipal	0.1 < Ia < 0.6	0.6 < Ia < 1.2	1.2 < Ia < 2.1	2.1< Ia < 4
County	0.1 < Ia < 0.7	0.7 < Ia < 1.2	1.2 < Ia < 2.2	2.2 < Ia < 4

4.1.4 Report formatting

4.2 Regional Pasture Droughts

4.2.1 Regional pasture drought is evaluated using regional index

4.2.2 Calculations

$$I_p = \sum_{i=1}^{4} P_i B_i$$

Where:

I_p--------Regional pasture drought index
i----------Agriculture drought level (determined in chap. 3.2)
P_i--------the ratio of cropped land to arable land, %
B_i-------the drought level constant (B_1=1, B_2=2, B_3=3, B_4=4)

4.2.3 Classification based on regional pasture drought index

Determination of drought level:

Levels of administration	Regional Drought Index Ip			
	Level IV	Level III	Level II	Level I
Provincial	0.1 < Ip < 0.5	0.5 < Ip < 0.9	0.9 < Ip < 1.5	1.5 < Ip < 4
Municipal	0.1 < Ip < 0.6	0.6 < Ip < 1.2	1.2 < Ip < 2.1	2.1 < Ip < 4
County	0.1 < Ip < 0.7	0.7 < Ip < 1.2	1.2 < Ip < 2.2	2.2 < Ip < 4

4.2.4 Report formatting

4.3 Regional Drinking Water Supply Stress

4.3.1 Drinking water supply stress uses populations that have difficulties to drinking water as index

Levels Of Administration		National	Provincial	Municipal	County
Level IV	Populations	500-1500	50-100	--	--
	Percentage (%)	--	5-10	10-15	15-20
Level III	Populations	1500-3500	100-400	--	--
	Percentage (%)	--	10-15	15-20	20-30
Level II	Populations	3500-5000	400-600	--	--
	Percentage (%)	--	15-20	20-30	30-40
Level I	Populations	> 5000	> 600	--	--
	Percentage (%)	--	> 20	> 30	> 40

4.3.2 Provincial level could use either total populations or percentage of populations (relative to provincial populations) that have difficulties to drinking water supply as index, whichever one is higher.

4.3.3 Municipal and County level could use percentage of populations (relative to local populations) that have difficulties to drinking water supply as index

4.3.4 Report formatting

4.4 Comprehensive Agriculture And Pasture Droughts

4.4.1 Use Comprehensive Index

4.4.2 Calculations

$$I_{ap} = \alpha I_a + \beta I_p$$

Where $\alpha + \beta = 1$
I_{ap}------comprehensive index for agriculture and pasture
α-------percentage of agriculture contribution in agriculture and pasture sector, %
β-------percentage of pasture contribution in agriculture and pasture sector, %
I_a------regional agriculture drought index (defined in 4.1.2)
I_p------regional pasture drought index (defined in 4.2.2)

4.4.3 Classification Table

Determination of drought level:

For different levels of administration	Regional Drought Index Iap			
	Level IV	Level III	Level II	Level I
Provincial	0.1 < Iap < 0.5	0.5 < Iap < 0.9	0.9 < Iap < 1.5	1.5 < Iap < 4
Municipal	0.1 < Iap < 0.6	0.6 < Iap < 1.2	1.2 < Iap < 2.1	2.1< Iap < 4
County	0.1 < Iap < 0.7	0.7 < Iap < 1.2	1.2 < Iap < 2.2	2.2 < Iap < 4

4.5 Comprehensive Regional Droughts

4.5.1 Comprehensive regional droughts refer to the comprehensive situation of regional agriculture drought, regional pasture droughts, and regional drinking water stress

4.5.2 Compare regional drought index in agriculture, pasture, comprehensive drought and pasture, as well as drinking water stress, use the highest level as the comprehensive regional drought levels.

5. Drought Frequency

5.1 Determination of Drought Duration

5.1.1 Drought duration refers to the beginning, development and recovery of drought, which should include start date, end date, duration time, and highest drought level, four factors in total.

5.1.2 Start date, end date, and time of duration of drought should be determined by regional agriculture drought index and regional pasture drought index.

1. Index is higher than 0.1 and last for more than 10 days could define a start of drought, the date when the index start to exceed 0.1 is the start date.
2. The last day when the index is less than 0.1 is the end date of drought, and the index should be less than 0.1 for more than 7 consecutive days.
3. From the start date to the end date is the time of duration of drought.

5.1.3 The highest drought level should include highest regional agriculture drought index, highest regional pasture drought index, highest regional comprehensive agriculture and pasture drought index, largest land area affected by drought, and highest population that have difficulties to drinking water supply. This is used to evaluate the highest impact level of drought from drought starts to a certain moment in drought period.

5.2 Drought Frequency

5.2.1 Should use regional agriculture drought index or regional pasture drought index or comprehensive regional agriculture and pasture drought index as indices to calculated drought frequency

5.2.2 Drought frequency curve should be plotted as described in the following procedure:

1. For a specific local area, should use regional agriculture drought index or regional pasture drought index or regional comprehensive drought index to calculate the highest value for each one
2. Use annual highest index from many years in historical data to calculate drought frequency.
3. Plot data on frequency graph

5.2.3 For a specific drought, use highest drought index to correlate with the drought frequency of this drought.

Annex 2 – Using the SPI to Assess Drought Conditions

(From WRDMAP, March 2009, Manual 2.4)

1. Introduction

1.1 Role of Indicators for Operational Drought Management

Drought is an insidious hazard of nature which originates from a deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector.

Operational definitions of drought help people identify the beginning, end, and degree of severity of a drought. The threshold value of an indicator marking the boundary between one drought condition and the next more serious state is often referred to as a 'trigger' because it triggers or initiates actions. Depending on the operational procedures the trigger might initiate an early warning procedure, bring in rotational cuts in supply to conserve water, or take emergency actions to alleviate the consequences of drought.

Operational definitions usually specify the degree of departure from the average of precipitation over some time period. This is usually done by comparing the current situation to the historical average, often based on a 30-year period of record.

The China Meteorological Centre has developed a drought warning system based on three indicators as shown in Figure 1.

1.2 Standardized Precipitation Index (SPI)

The Standardized Precipitation Index (SPI) was developed in the USA to quantify the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of the different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, stream flow, and reservoir storage reflect the longer-term rainfall anomalies.

The SPI calculation for any location is based on the long-term precipitation record for a desired period, e.g., SPI(24) for 24-months, SPI(18) for 18-months etc. The authors of the SPI procedure have suggested its use to categorise wet and dry periods as follows:

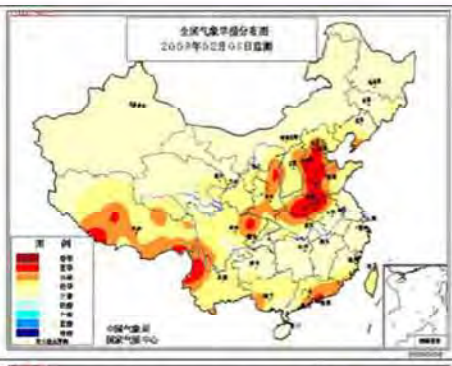
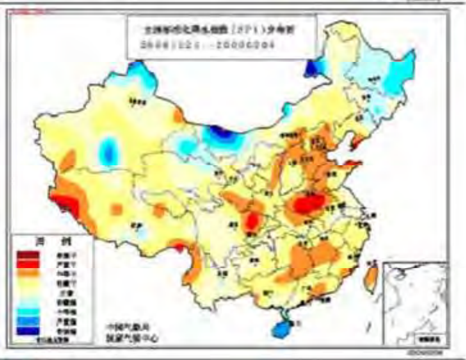
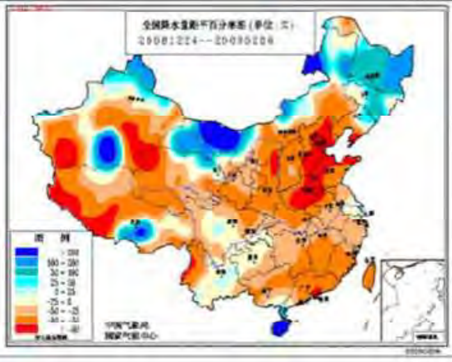
SPI value for chosen period	
2.0 and above	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and below	extremely dry

The SPI index is widely used for drought monitoring internationally, either on its own or as part of a combined assessment approach. Drought categories may be differently defined in terms of SPI (see Figure 1 for Chinese usage).

Figure 1 China Drought and Flood Monitoring

Drought Class	China Index	SPI	Percentage of Precipitation Anomalies (%)
Extreme Drought	CI≤-2.4	-2 and less	< -80
Severe Drought	-2.4 ~ -1.8	-1.5 to -1.99	-80~ -50
Moderate Drought	-1.8 ~ -1.2	-1.0 to -1.49	-50 ~ -25
Slight Drought	-1.2 ~ -0.6	-0.5 to -0.99	-25 ~ 0
No drought	-0.6+	-0.49+	0 +

Example (6th-Feb-2009)

CI	
SPI	
Percentage of Precipitation Anomalies (%)	

Source: China Meteorological Centre

2. Requirements

2.1 Software

SPI is available to download from the internet at no cost from the following site:
http://drought.unl.edu/monitor/spi/program/spi_program.htm

The program is already compiled (it was compiled in C++ for PC) so all the user has to do is run the SPI_SL_6.exe file and follow the instructions on the pop up screen. The fact that this is a compiled program means that the input and output formats cannot be changed by the user. It is necessary to follow the requirements precisely for the program to run successfully.

2.2 Rainfall Data

The SPI is usually calculated for monthly periods and therefore uses monthly data. The meteorological station(s) to be analysed should be chosen to be representative of the area being assessed for drought risk. The quality of the monthly data should be checked for reliability and suitability prior to its use for an SPI analysis. Long records are desirable because SPI is a statistical approach and long records provide more reliable statistics.It is recommended that any gaps in individual station records are infilled prior to use in SPI analysis (by using correlation methods for example).

Then, as in the Upper Daling example, a number of stations are being used to produce a composite rainfall value for analysis it is important to have an identified procedure for infilling gaps that arise during on-going monitoring of the drought index. Inevitably some rain gauges will not maintain 100% records, or there may be a delay in receiving the latest records from some sites. If a different infilling procedure is used every time the SPI analysis is repeated there is a considerable danger that the analysis will become meaningless.

2.3 Input File Structure

Once approved for use the monthly data must be prepared in a specific format to run with the SPI software.

All input files must follow 3-column format: Year, Month, and Monthly Precipitation Value (see sample input files). The precipitation total must NOT include decimals.

Pay attention to column spacing and missing data issues. A missing data flag of -9900 will be read in but will introduce errors in the analysis.

3. Running the SPI Program

The input data file name must have the last 4 characters as ".COR" – the SPI program will not recognise any other file extension. The length of file name is not restricted, but the name must not contain any spaces, use of underscore (_) is also not allowed.

Acceptable file names could be "UpperDaling1970-2005.COR" or "Chaoyang.COR".

When using the program to assess thresholds an input file name like "UpperDaling1970-2005.COR" shows the period used to define the statistics. However, when using the SPI program as part of routine drought monitoring each successive month analysed has new data added to the data set and therefore the input file name might be chosen to show which month is the most recently added eg "UpperDaling1970-2009Feb.COR" as the data file for a program run completed in March 2009.

Care is needed when carrying out series of calculations for routine monitoring that file names are well organised or else different sub-directories are used for different sets of calculations. The data files should be edited using either Notepad or Wordpad. The easiest way to set up a new data file is usually to select

an existing data file, edit it, and then save under a new name. Set up a directory with the SPI executable program file and at least one ".COR" file in it:

From Windows Explorer select the SPI_SL_6.exe file and click OPEN to start the program running.

The program runs in a separate window. Firstly, the program prompts the user for the number of n-month calculations wanted. If the answer is '2' the program will request the period 'n' of the first n-month period eg 3 for a SPI(3) analysis, and then the second 'n'.

The program then prompts the user for the name of the input data file. Type in the name and press Enter.

The program then prompts the user for the output file name to be used. As with input data file naming conventions spaces and underscore symbol should be avoided. One way to organise output files is to use the same name as the input file BUT with a different 4 character extension such as ".OUT". (The extension must not exceed 4 characters including the full stop or period symbol). It is recommended that the user keeps to an organised structure for files and sub-directories when keeping the results of routine monitoring runs.

Once the user has given the output file name the program automatically opens an output file with this name. The screen will clear almost instantly as the program takes only seconds to run.

The ".OUT" file can be opened with Notepad or Wordpad and printed (if required, note that the output can often take many pages to print).

Examples of Input File and Run Time Screen

Figure 2 Layout for SPI Input Data File (Opened with Notepad)

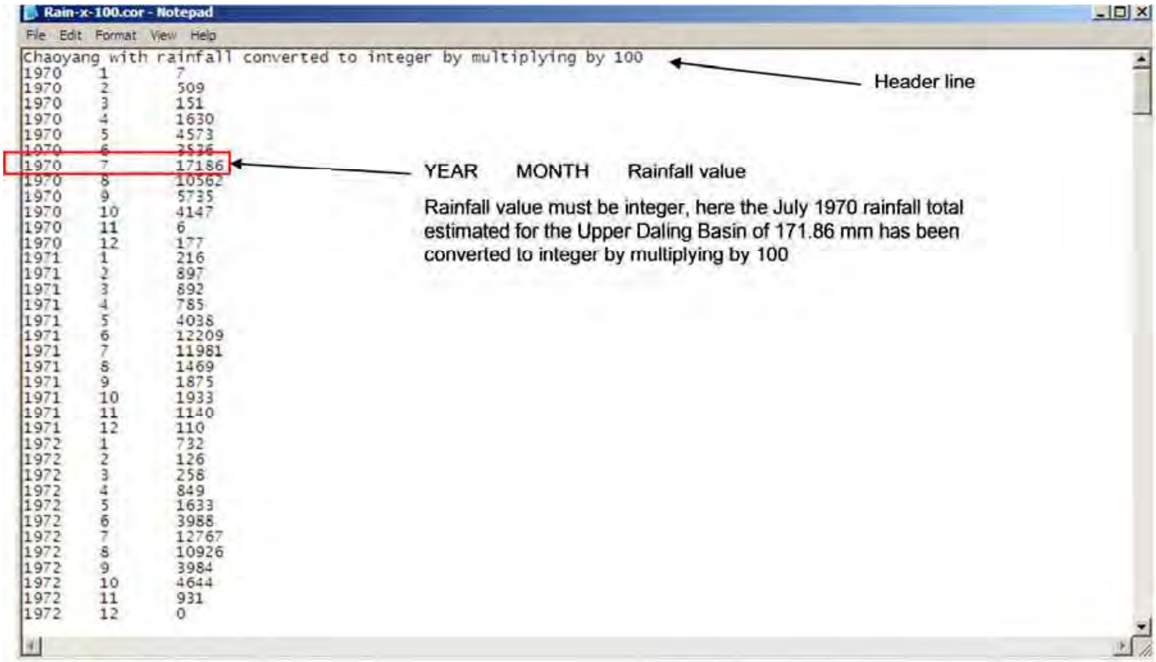
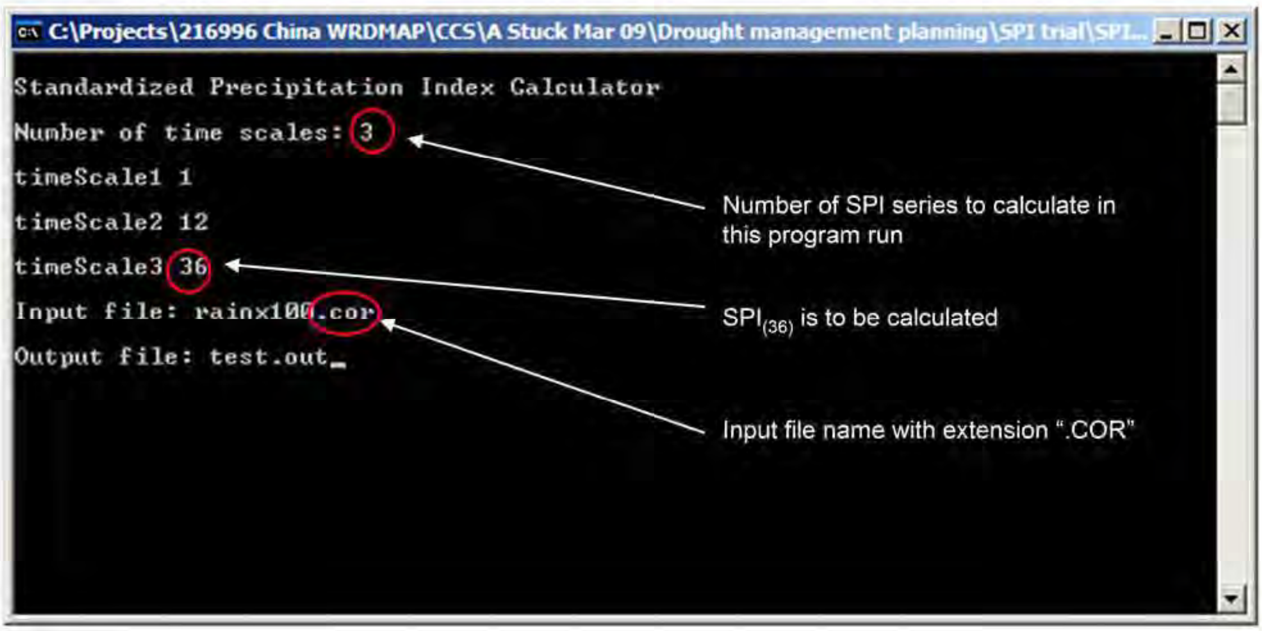


Figure 3 SPI Screen View at Run Time



A point to note is that the SPI program output is rather unhelpful: no record is included to show what n-periods the user chose for the run, and the information is presented without column headings. This makes keeping good notes and having a well organised file naming and sub-directory structure all the more important.

4. Presentation and Use of SPI Series

As noted above the standard output from the SPI program is not very helpful and there is usually a need to undertake some further procedures in order to provide the results in a format which can be presented to drought managers.

To obtain a graph of the variability of SPI values over time, or to use the SPI values in a further calculation – for example to create a composite index based on more than on SPI series, the user may wish to transfer the results into Excel. To do this open Excel. Then using the File Open command select the ".OUT" file (remember to look for "All file types"). Excel will then open the file import wizard.

The following examples demonstrate possible ways of presenting the results of SPI analysis.

Examples of Possible Output Presentation

Figure 4 Layout of Standard SPI Output (Opened with Notepad)

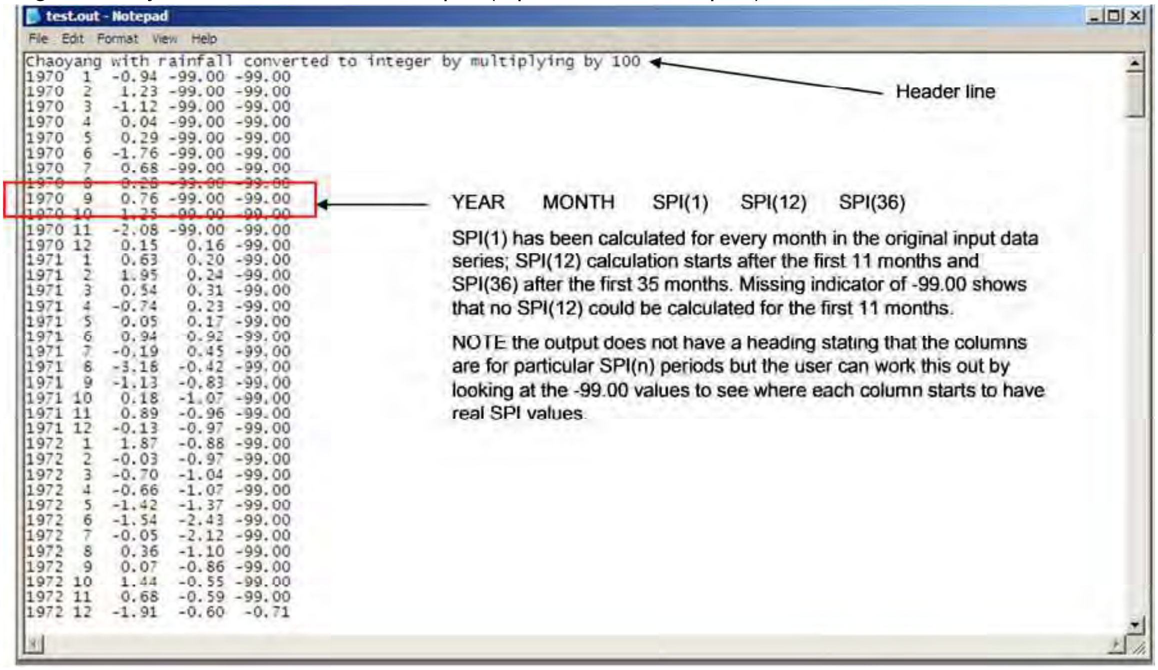


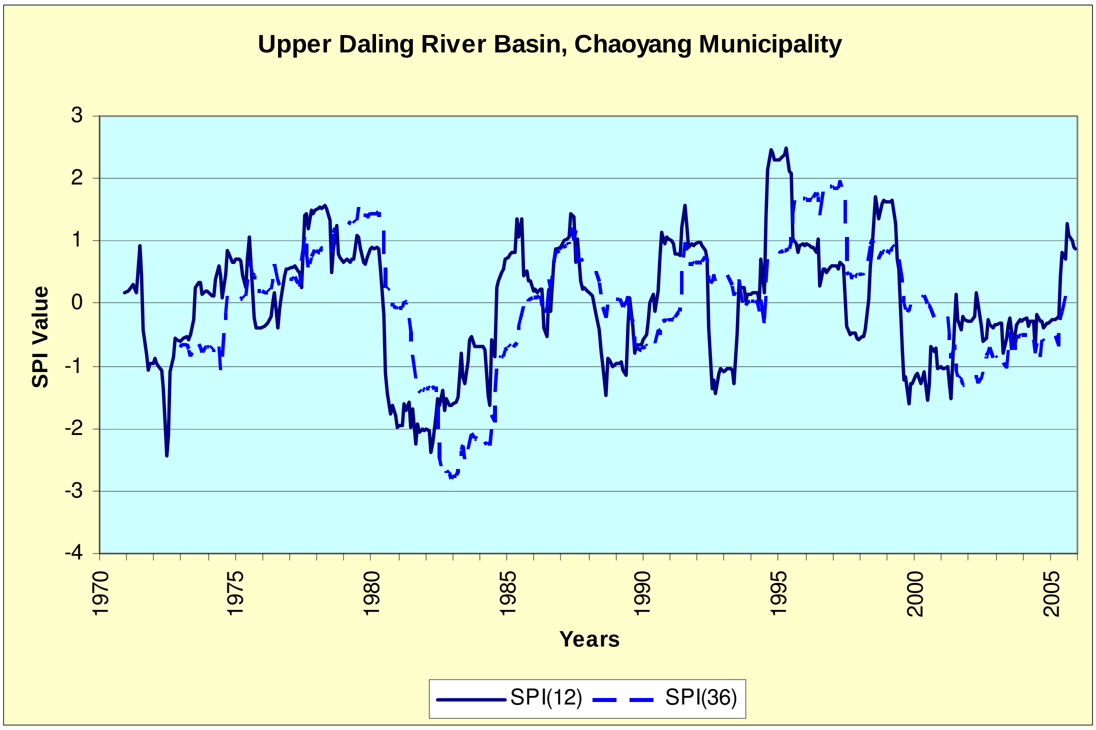
Figure 5 Example of Composite SPI Index for Routine Drought Assessment to Trigger Action based on Drought Management Plan (Prepared using Excel)

Drought Classification by the SPI Method

Year	1980											
Month	1	2	3	4	5	6	7	8	9	10	11	12
Rainfall (mm)	1.8	2.4	4.2	10.0	13.3	63.7	87.4	75.6	12.0	20.8	0.6	3.4
SPI - This Month	0.56	0.43	-0.19	-0.57	-1.70	-0.64	-0.82	-0.47	-1.71	0.26	-1.22	0.61
$SPI_{(3)}$ - 3 Months	1.76	2.06	-0.13	-0.70	-1.85	-1.59	-1.38	-1.25	-1.34	-1.07	-1.64	-0.17
$SPI_{(6)}$ - 6 Months	-0.02	0.25	0.53	0.47	-0.93	-1.67	-1.58	-1.63	-1.88	-1.75	-1.65	-1.38
$SPI_{(12)}$ - 12 Months	0.87	0.85	0.88	0.86	0.54	-0.16	-1.12	-1.35	-1.74	-1.64	-1.80	-1.96
$SPI_{(24)}$ - 24 Months	0.92	0.92	0.90	0.93	0.73	0.57	0.01	-0.30	-0.62	-0.59	-0.59	-0.55
$SPI_{(36)}$ - 36 Months	1.47	1.47	1.45	1.51	1.32	1.15	0.24	0.21	0.19	-0.07	-0.10	-0.14
Combined SPI = $SPI_{(12)}*0.6+SPI_{(24)}*0.3+SPI_{(36)}*0.1$	0.95	0.93	0.94	0.95	0.68	0.19	-0.65	-0.88	-1.21	-1.17	-1.27	-1.36
Drought Severity Class					IV	III	II	II	I	I	I	I

Description of Conditions:
Severe drought occurred in Chaoyang during this year, particular in Chaoyang City and Beiping with extreme drought.
The annual rainfall was only 333 mm in Chaoyang, which was less 153 mm than normal year.
There were more than 7.00 million mu of cropping field irrigated by manually water collection, including 2.51 million mu of cropping field was cropped two times and 510,000 mu of field was cropped three times. The cropping field of 1.30 million mu had no harvest, and 2.50 million mu with little yield.
The work of planting was not end until July 15.
Most of rivers and streams, lakes, reservoirs and wells were in dry. There was no water available to the population of 200,000.

Figure 6 (Prepared using Excel)



Appendix F. Proposed Decision Support Framework for Early Warning

F.1 Decision Support in Drought Management

According to a report by the US National Research Council in 2009[1], decision support consists of a set of processes intended to create the conditions for the production of decision-relevant information and for its appropriate use. Drought related decisions are choices by individuals or organizations, the results of which can be expected to affect water resources or to be affected by drought and its interactions with ecological, economic, and social systems. Choices to mitigate or adapt to drought are obviously included, but also included are decisions about matters that may be only indirectly related to water resources (e.g., types and locations of economic development.) Such issues can be captured in risk and vulnerability mapping and assessments.

Drought-related decision support involves organized efforts to produce, disseminate, and encourage the use of information that can improve drought-related decisions. It includes various kinds of activities, products, and services, including efforts to identify decision makers' information needs; production of decision-relevant information; creation of information products based on this information; dissemination of these products; efforts to encourage the use of decision-relevant information; ongoing communication among producers and users of decision support products and services to evaluate and improve the quality of information, relationships between information producers and users, and ultimate decisions; and development of organizations, networks, and institutions to serve those purposes. Decision support cannot lower actual risks directly or immediately, but it can influence humans' awareness of and responses to risk in ways that can, over time, mitigate threats from the natural world, as well as the vulnerability resulting from human exposure to threats.

The effectiveness of decision support can be judged by the extent to which it increases the likelihood that decision-relevant information is produced and enables and empowers decision makers to use it appropriately. The many elements of effective decision support can be usefully grouped under three categories:

1. Increased usefulness of information. Decision support is effective to the extent that the information provided is considered by the intended users as credible, legitimate, actionable, and salient in terms of their decision deadlines and other concerns.
2. Improved relationships between knowledge producers and users. Decision support is effective when it engages scientists and decision makers in mutual learning and the coproduction of knowledge that could not have emerged from either side alone and when it yields increased mutual understanding, respect, and trust.
3. Better decisions. Decision support is effective when the resulting decisions have the qualities of good decisions (including productive problem definitions and clear objectives) and when the decision makers and key constituencies view the decision as having been improved by the support received.

In principle, drought indices provide a measure of the difference between needed and available water resources and can be part of the "decision support systems" relating to drought. A local water utility might use a drought index to trigger water use restrictions and to inform the public about the availability of water supplies. A river basin authority might use an index to inform about and coordinate the use of water throughout a basin. A province might use an index to measure the availability of water resources in the

[1] Informing Decisions In A Changing Climate, Panel on Strategies and Methods for Climate-Related Decision Support, Committee on the Human Dimensions of Global Change, National Research Council (U.S.), Panel on Strategies and Methods for Climate-Related Decision Support. Division of Behavioural and Social Sciences and Education, 2009.

entire province. At each of these levels indices can be used for reporting, research or management actions. Different users of indices will have different decision support requirements. In general, water managers need indices to measure climatic and hydrologic trends and fluctuations.

F.2 Review of Past and Ongoing Provincial Drought Risk Activities

In 2004, the Ministry of Water Resources proposed "two transformations on flood control and drought relief", i.e., shifting from flood control to flood management and changing from single drought relief to comprehensive drought relief. Comprehensive drought relief referred to expanding the scope and content of drought relief according to requirements of social and economic development. In the past, drought relief mainly served agriculture and rural economy.

Comprehensive drought relief requires covering the whole social and economic society, not only focusing on agricultural benefits but also considering social, economic and ecological benefits. This is a new strategy of drought management in China that requires to changing from passive drought relief to proactive drought prevention in order to minimize economic losses and impacts on environment.

Drought-management plans, guidelines, rules, and regulations, such as drought relief guidelines and emergency plans have been prepared by the national, provincial, and local governments and there is some active pre-planning for drought relief (such as emergency supplies, stockpiling of relief materials, etc). The major shortcoming of these measures has been that drought-relief actions are generally passive responses to crises caused by droughts, after they have already occurred.

The PRC has been primarily focused on supply-side water infrastructure development whereas as drought impacts become more severe, the traditional approach of using structural measures becomes less practical or economically feasible. Structural measures cannot meet all requirements for drought management, and other measures such as drought monitoring, forecasting and warning, and water conservation remain to be fully explored and implemented.

Drought Relief Regulations (DRR) at the national level were released in 2009, supported by Drought Classification Rules in 2009. However, these documents are formalizing the drought relief planning requirements but have yet to fully drive a risk management approach to drought management, and this project is designed to assist the FCDRH and MWR in their efforts to facilitate a more scientific and risk management approach to drought management in the provinces.

The IWHR guidance on drought relief plans (Compilation Guidelines for Drought Response Plan (SL 590-2013)) is a comprehensive planning tool for managing droughts once they are underway. The TA team proposes to overlay a drought risk planning approach on the front end of the existing drought risk planning protocols before a drought occurs, but not propose immediate replacement of these existing systems. As the drought risk management processes mature, some of the triggered actions in the existing drought relief plans will also focus more on risk reduction, but this may be a long term proposition.

F.3 Spurring Cooperation between Agencies for Managing Drought Risk

Drought risk reduction and mitigation activities can involve multiple agencies or departments of the system working collaboratively. The various PRC agencies or departments of the water and drought management system must find ways to cooperate for the drought risk management activities. According to the project's

research work combined with China's current management practices and drought mitigation, forecasting and early warning of drought monitoring work is still relatively weak. Therefore, the relevant institutions or inter-sectorial cooperation should be strengthened. The cooperation between the hydrological and meteorological agencies or departments should also be encouraged, because this smooth cooperation between the departments directly affect the drought monitoring and forecasting and early warning, and then influence decisions and drought mitigation measures correctness, timeliness and validity. Hydrological and meteorological sector cooperation mainly refers primarily to information sharing, which is not conducive to drought monitoring and early warning forecast. Information cannot be shared for many reasons, but the main reason is that there is no established information sharing mechanism for drought mitigation.

Many organizations are directly and indirectly involved in water management in the PRC as is widely known. It is commonly stated in bureaucratic terms that a number of ‘dragons’ (or government agencies) compete for control of the water resources. This is in contrast to Integrated Water Resources Management (IWRM) which stresses stakeholder cooperation and where possible collaboration.

The DFID Water Resources Demand Management Assistance Project (WRDMAP, 2005-2010) case studies included the issue of sometimes reluctant inter-sectorial cooperation. The project experimented with various approaches to improve this cooperation in terms of several different elements of water management. This was primarily in the areas of water quality management and groundwater management but the concepts relate to all aspects of water resource management. Specifically, the project investigated the potential application of Memorandum of Understanding (MoU) and Memorandum of Agreement (MoA) to water resource issues and shared responsibilities between PRC institutions.

MoUs have been defined as “a document describing a bilateral or multilateral agreement between parties. It expresses a convergence of will between the parties, indicating an intended common line of action. It most often is used in cases where parties either do not imply a legal commitment or in situations where the parties cannot create a legally enforceable agreement.” “A Memorandum of Understanding or MoU is put in place to establish a clear understanding of how the deal will practically function and each party’s role and compensation (cost sharing).

One advantage of MoUs over more formal instruments is “they can be put into effect in most countries without requiring parliamentary approval.” It is common practice to have senior officials/leaders of an agency or enterprise enter into a Memorandum of Agreement (MoA) that sets out in general the areas the parties would cooperate and collaborate. The details and specifics are then left up to the particular departments involved at various levels of the organization.

MoUs can be short or long, formal or informal, general or detailed, but they are almost always written and signed by responsible parties with authority to carry out the commitments set out in the MoU. In reality, you can make the MoU as simple or complicated as is necessary for the comfort and mutual consensus of those involved. For example, the MoU could be a simple statement e-mailed to the other party with a response saying they agree. MoUs are generally not contracts. Unlike a contract, the MoU can rarely be enforced by a court of law for breach or non-compliance. MoUs are generally considered an expression of voluntary compliance in the area of cooperation, like a good-faith promise. There may be many reasons why one or other party to the MoU cannot comply to the specifics of the MoU, but rarely can there be a legal process to enforce the MoU. An inter-agency MoU may encourage compliance to the best abilities of the parties as part of performance evaluation in achieving the MoU objectives based upon the results that

are expected. In some cases, depending on the exact wording, MoUs can have the binding power of a contract; for instance, on sharing or reimbursing costs.

MoUs can be very short, a paragraph, or very long, with many pages and attachments. However, there are certain key features that most successful MoUs contain and that are recommended whenever the MoU is used as an interagency agreement (between two or more governmental agencies) to cooperate for improving water resources management and protection. These are:

- The date of the MoU
- Describing the situation of the parties involved and how they relate to each other.
- The objectives and expected results coming from the cooperation of the parties, which may provide a stated set of goals and interim target dates to measure accomplishments.
- What services each party contributes to the deal before, during and after the MoU.
- The names and contact information of each party.
- Any probationary or trial period.
- Any set dates to review activity, performance, or satisfaction and reporting requirements.
- What parts of this deal are open to change or negotiation and how.
- What aspects of the deal should require formal notification and how.
- How differences or disputes will be settled.
- When the deal starts (on a certain date, during a limited event, as soon as the parties can bring together the necessary inputs and assurances of compliance).
- How long it lasts (for a certain period, indefinite until someone ends, at the end of an event).
- How the deal is terminated (by one or both parties, under what circumstances, how the ending is to be carried out.)
- What happens at the end of, or after the expiration of the MoU?
- Any restrictions to either party
- Any disclaimer statements, for example, if data is not available, if a monitoring station fails, etc.
- Any privacy statements (such as sharing data with the parties to the MoU but not to be made available to other by any party)
- A place for all parties to sign the agreement.

The MoA is a higher level mutual agreement supplemented by MoUs for a number of specific topics to reflect varying conditions in local conditions and agency capabilities. MoUs can be entered into by provincial, municipal and country water and environment agencies, as well as other stakeholders to improve expected results. The following are important aspects of the MoU:

- **Targets** – Setting annual outcomes or result levels.
- **Strategic Plans** – Each agency prepares annual and short/long term strategic plans of action for water management. Each participating agency should keep the others fully informed of all such plans, or changes to plans, so that effective coordination can be maintained.
- **Activities & Responsibilities** – Each participating agency will identify their independent and joint activities and responsibilities as mutually agreed to, with the aim of improving efficiency and effectiveness, clarifying ambiguities, and minimizing redundancies and conflicts. Collaboration is promoted to leverage inputs for optimum outputs.
- **Data Sharing** – Sharing data and information is one of the most important topics of agreement; without sharing adequate data and information in a timely manner, analysis and decision-making will be impaired, performance hampered and targets missed. Fundamental water resources data, should be standardized for systematic collection, storage and access and combined into integrated databases.

Access should be gained to information collected by other government and non-government stakeholders, and this information should be added to the database system.
- **Agency Coordinators and Coordination Meetings** – Water management staff of the institutions who will serve as the contact persons for implementation of this MoA and MoUs entered into under this MoA. These Coordinators shall be responsible for meeting schedules, notices and agendas. Coordinators and relevant staff at the respective levels shall meet quarterly to review conditions, progress and adjustments as reported their own agency level; urgent or special formal or informal meetings can be called as needed.

The use of formal MoUs and MoAs may not be the only way to spur collaboration and cooperation but the principles embodied in these concepts could be used to facilitate improved data sharing and cooperation in the water management agencies, which would greatly enhance the opportunities for drought risk management concepts to be implemented.

F.4 Improving Drought Related Decision Support

It is important to identify the various types of drought decision-support methods that are available and have been utilized for drought management. According to a World Meteorological Organization Conference on drought in 2011 (Towards a Compendium on National Drought Policy, WMO, July 2011), the most common approach, and the one most often followed by both developing and developed nations, is post-impact government (or nongovernment) interventions (such as drought relief work in the PRC). These interventions are normally relief measures in the form of emergency assistance programs aimed at providing money or other specific types of assistance (e.g., livestock feed, water, food) to the victims (or those experiencing the most severe impacts) of the drought. This reactive approach is seriously flawed from the perspective of vulnerability reduction since the recipients of this assistance are not expected to change behaviors or resource management practices as a condition of the assistance. The more traditional approach of providing relief is also flawed in terms of the timing of assistance being provided. It often takes weeks or months for assistance to be received, at times well beyond the window of when the relief would be of greatest value in addressing the impacts of drought.

A second type of drought decision-support is the development of pre-impact government programs that are intended to reduce vulnerability and impacts. In the natural hazards field, these types of programs or measures are commonly referred to as mitigation measures. These types of measures are numerous but appear to be less obvious to many when associated with drought since impacts are generally non-structural and less visible to stakeholders. These measures would include establishing comprehensive early warning systems, improving seasonal forecasts, increasing emphasis on water conservation (demand reduction), increasing or augmenting water supplies through greater utilization of ground water resources, constructing reservoirs, interconnecting water supplies between neighboring communities, drought planning, and awareness building and education. Insurance programs, currently available in many countries, would also fall into this category of policy types.

The final type of drought decision-support is the development and implementation of preparedness plans and policies, which would include organizational frameworks and operational arrangements developed in advance of drought and maintained in between drought episodes by government or other entities. This approach represents an attempt to create greater institutional capacity focused on improved coordination and collaboration within and between levels of government and with stakeholders in the plethora of private organizations with a vested interest in drought management (i.e., communities, natural resource districts or

managers, utilities, agribusiness, farm organizations, and others). This is the long-term goal of the risk based drought management planning prescribed in this TA.

For the proposed tiered provincial and local drought management plans such as recommended in this TA, objectives that should be considered include the following:

- Collect and analyze drought-related information in a timely and systematic manner.
- Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.
- Provide an organizational structure and delivery system that assures information flow between and within levels of government.
- Define the duties and responsibilities of all agencies with respect to drought.
- Maintain a current inventory of government programs used in assessing and responding to drought emergencies.
- Identify drought-prone areas of the state/region/nation and vulnerable economic sectors, individuals, or environments.
- Identify mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.
- Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
- Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the World Wide Web).
- Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
- Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state or region.

"Change detection" is critical in natural resources management including drought risk management. Due to the complex nature of droughts, a comprehensive and integrated approach that would consider numerous drought indicators is required for drought monitoring and early warning. Location-specific environmental changes (i.e. ecosystems changes, loss of biodiversity and habitats, land cover/land changes, coastal erosion, urban growth, etc.) become critical. Satellite data can be used to show environmental changes providing multiple, synoptic, global coverage of high-resolution having multi-spectral imagery allowing for change detection over time. Drought monitoring thus requires a comprehensive and integrated approach to determine the drought extent and impacts. Central to detection is the characterization, monitoring, and understanding of land cover and land use change, since they have a major impact on sustainable land use, as well as land-atmosphere interactions affecting regional climate change.

According to a World Meteorological Organization Conference on drought in 2011 (Towards a Compendium on National Drought Policy, WMO, July 2011), the following are recommended components of national drought policies and drought decision support:

<u>A. Drought Monitoring and Early Warning System</u>

1) Evaluate the availability of comprehensive, integrated drought monitoring systems which couple multiple climate, water and soil parameters and socio-economic indicators to fully characterize the magnitude, spatial extent and potential impacts of droughts.
    a) Establish and support a comprehensive integrated drought monitoring system at the national level;
    b) Ensure that relevant parameters for climate, water, and soil and the indicators for socio-economic parameters are collected and made available through the system;

   c) Place more emphasis on supporting research to characterize the magnitude, spatial extent, persistence length and potential impact of droughts;
   d) Use an appropriate classification system on different types of droughts, i.e., meteorological, agricultural and hydrological droughts, while communicating information on droughts on a routine basis.
2) Assess the adequacy of meteorological and hydrological networks and data quality.
   a) Ensure that an adequate network of meteorological and hydrological stations is established in the country to provide good spatial characterization of droughts and other climatic features;
   b) Take full advantage of the advances in instrumentation technology such as Data Collection Platforms (DCPs), automatic weather stations, telemetry, hydroprobes in automating the data collection;
   c) Encourage the wider availability and use of remote sensing data and products and provide training on the proper interpretation of these products for natural resource managers and policy makers;
   d) Implement an effective data quality control system consistent with WMO quality control procedures;
   e) Ensure the long-term sustainability of meteorological and hydrological networks in order to provide the user community relevant information on a regular basis.
3) Examine the current procedures for coordinating the collection and analysis of meteorological and hydrological data and eliminate fragmentation between many agencies and ministries at the different administrative levels.
   a) Encourage close collaboration among meteorological, hydrological and other relevant agencies in the collection of comprehensive drought data;
4) Establish a centralized authority for the analysis of meteorological and hydrological data to generate integrated products related to droughts; Evaluate existing procedures for data sharing and their applications of drought monitoring, preparedness, mitigation and response.
   a) Encourage regular interaction between all relevant agencies and institutions at the national, regional, and local levels in developing appropriate drought products for application in all sectors affected by droughts.
   b) Adopt agreed upon standards for sharing of data and products with all sectors concerned with the impacts of droughts;
   c) Promote a policy of free and open exchange of data and products with all interested agencies and institutions in the public and private sectors;
   d) Establish a rigorous monitoring system to ensure that data and products are shared freely between institutions and agencies in a timely manner.
5) Assess the availability of early warning and decision-support tools and methodologies in support of drought preparedness planning and policy development.
   a) Undertake a comprehensive assessment of drought risks; identify potential threats and establish the degree of vulnerability of local populations and economic sectors to droughts and how these vulnerabilities vary by region within a country;
   b) Evaluate the existing capabilities in the country for early warning of droughts, identify the gaps and take appropriate steps to develop and strengthen the national capabilities to provide effective drought early warnings;
   c) Collaborate with the Global Producing Centers for Long-range Forecasts (GPCs) and the Regional Climate Centers (RCCs) to augment the ability in the country to provide seasonal and inter-annual forecasts for the drought outlook and decision making;
   d) Strengthen research capacity at the national, regional and local levels into the causes and effects of climate variations and long-term climate prediction to provide drought early warnings;
   e) Evaluate existing decision-support tools in close collaboration with the user community in different sectors which are impacted by droughts and improve these tools by taking advantage of current advances to provide better and more timely information for decision making;
   f) Promote multidisciplinary collaboration among meteorologists, hydrologists, soil scientists,

ecologists, agronomists, the social/behavioral sciences, and others in the collection of data and generation of drought products for the user community.

6) Evaluate the four phases in early warning systems, i.e., mitigation or prevention, preparedness, response and recovery.
   a) Establish an evaluation procedure for each of the four phases of the early warning systems in the country i.e., mitigation or prevention, preparedness, response and recovery;
   b) Implement a feedback process in the drought cycle to learn from past practices in the mitigation or prevention, preparedness, response and recovery strategies;
   c) Ensure that the early warnings are delivered to the decision makers in a timely fashion and in appropriate formats and that preparedness, response and recovery plans are in place.
7) Examine the need for the development of useful end products or decision-support tools for delivery to the end users.
   a) Ensure that the user community in different sectors impacted by droughts is involved right from the beginning in the development of useful end products or decision-support tools in order to ensure that the products meet their needs and expectations;
8) Develop appropriate decision support tools and products to assist the users in their decision making in drought risk management. Assess the delivery systems for disseminating data to users in a timely manner to enhance their usefulness for decision support.
   a) Establish a procedure/survey to ensure that the needs of the decision makers are being adequately met by the delivery system and modify the system as required;
   b) Design the presentation of data and products to meet the specific needs for different decision makers (do not make users search through all data but provide access to different products for different groups, e.g., agriculture, education, policy makers);
   c) Use the most cost effective and modern methods for information delivery including Internet, social media (Facebook, Twitter, etc.), mobile phones, radio, TV, etc., which are appropriate to the local conditions;
   d) Place emphasis on training of the user communities in the use of decision support tools and products.

<u>B. Vulnerability Assessment and Impacts</u>

9) Understand the natural processes and human activities that contribute to vulnerability and community resilience and how these will be integrated to inform risk reduction and management.
   a) Address the gaps in knowledge, methodologies and types of information that are preventing the effective application of these methodologies. A key goal is the enablement of affected populations.
   b) Assist communities facing hazards to manage their own environments more responsibly and equitably over the long term by joining in a global structure that supports informed, responsible, systematic actions to improve local conditions in vulnerable regions.
   c) Encourage governments and institutions to support, provide incentives, coordinate data and decision support, and legitimize successful approaches to increasing capacity and action
10) Characterize and integrate drought-related impacts, vulnerability and risk information.
11) Define spatial scale of assessment using biophysical and socio-economic boundaries (watershed, city, agricultural community, ecosystem, etc.).
12) Elicit key stakeholder problem framing and needs (for seasonal and longer climate-sensitive information).
13) Describe socio-economic and management characteristics, capacity-mapping and trends in the countries/communities of concern, and include standards for data collection.
14) Develop risk assessments and profiles showing physical, social, economic and environmental pressures on a community from global, regional, and local scales.
15) Understand effective decision-making in the context of drought risk management – what it is and how it can be improved- research on decision making and risk perceptions, and applied research on implementation of risk management and mitigation programs.

   a) Include critical actors at each jurisdictional level; the actors' risk assumptions; their needs for different types of information; and the design of an information infrastructure that would support their decisions at critical entry points

16) Develop, test and improve methodologies and measure progress in reducing vulnerability and enhancing community capacity—e.g., drought risk management, cost-effectiveness of methodologies and analyses, and societal impacts of catastrophic events. Strengthen cross-sectorial coordination of impacts assessments and partnerships among state, academia and the private sector for conducting impacts assessments.
   a) Assess impediments and opportunities to the flow of information including issues of credibility, legitimacy, compatibility (appropriate scale, content, and match with existing practice) and acceptability.
   b) Develop and test common drought risk reduction practices, coordinating information flow from different organizations into easily understandable language for all affected communities in countries and communities at risk.
17) Develop and mainstream effectiveness of Early Warning Information Systems that include warning of potential impacts on livelihoods.
18) Enable affected populations through support from governments and institutions, provision of incentives, and legitimization of successful approaches to increasing capacity and action at the local level.
   a) Conduct risk profiles prior to the onset of droughts, and capture drought impacts on vulnerable populations. Risk profiles should consider vulnerable groups, including but not limited to women, children, the elderly, the landless, farmers, pastoralists, marginalized communities; and indigenous communities and populations
19) Record drought impacts on and conduct risk assessments for vulnerable economic sectors, including but not limited to:
   a) Rain-fed agricultural production
      i. *Impact(s):* Reduced yields
      ii. *Potential mitigations:* Imports (short term); choosing to sow different crops or do not sow at all (short term)
   b) Irrigated agricultural production
      i. *Impact(s):* Reduced yields
      ii. *Potential mitigations:* Water rationing; water allocation review; sowing dryland crops.
   c) Livestock production
      i. *Impacts:* Weight loss; mortality; destocking; increase in incidence of diseases; lower fertility and reproduction rates
      ii. *Potential mitigations:* Destocking; feed distribution; cattle parking/relocation of herds; nomadic migration; reserved areas (stock routes and stock reserves)
   d) Water
      i. *Impacts:* degraded water quality; surface water shortages; overdrawing and depletion of groundwater; increased competition and conflict over water.
      ii. *Potential mitigations: Ex ante* identification of supplemental and alternative sources of water; use of reserve sources of groundwater; technical optimization of water resources; water laws and rules for special circumstances dry-year options (sale, expropriation, restrictions) using critical drought thresholds; development of critical thresholds; prediction of future water use to determine zoning.
   e) Environment
      i. *Impacts:* Ecosystem degradation; loss of biodiversity; species migration and extension; landscape change and wind erosion; increased risk of wildfires; fisheries impacts
      ii. *Potential mitigations:* maintenance of environmental flows
   f) Transportation
      i. *Impacts:* Reduced transportation and navigation

g) Health
   i. *Impacts:* Morbidity; incidence of wind-, dust- and vector-borne diseases and respiratory illnesses; degradation of sanitation; levels of nutrition, happiness, depression, trauma and suicide; increased use and dependence on drugs and alcohol
   ii. *Potential mitigations:* Food supplements; stockpiling food; more robust social safety nets; improved access to mental and physical health care
h) Tourism and recreation
   i. *Impact(s):* Loss of recreation areas
i) Energy
   i. *Impacts:* Decreased hydropower production; brownouts; increased demand; destruction of transmission lines
   ii. *Potential mitigations:* Energy restrictions; improvements in efficiency; alternative energy supplies; diversification of energy sources
j) Society
   i. *Impacts:* Migration and loss of community; decreased marriage rates; increased divorce rates; increased conflicts; loss of assets and reduced property values; increased theft and crime; impacts on cultural practices
   ii. *Potential mitigations:* Social protection and cash-transfer programs; diversification of rural livelihoods
k) Education
   i. *Impacts*: School dropout rates (short-term); lower school enrollment (longer term)
   ii. *Potential mitigations:* Targeted social protection
l) Dues/costs of responding
   i. *Impacts:* Amount spent on relief and response
m) Secondary and tertiary impacts on economic productivity:
   i. *Impacts:* Loss of income and productivity*;* opportunity costs*;* higher personal debt levels

20) Identify and assess vulnerable people and communities,
21) Develop criteria to weigh the importance drought impacts and vulnerability factors, and to identify high-leverage mitigation actions.
22) Develop mitigation options at multiple time scales.
   a) Use drought impact records to develop probabilistic drought-risk assessments and facilitate proactive planning and drought risk management.
23) Systematically monitor and record local drought impacts in real time.
   a) Measure and control data quality; and
   b) Ensure that drought information systems are designed to reach (used by) local communities.
24) Develop common methodologies and terminology to assess drought vulnerability to facilitate the assessment of drought risk at multiple spatial scales and across political borders.
25) Link drought vulnerability assessments with assessments associated with other hazards.
   a) Use climate models and to integrate drought vulnerability assessments into climate change adaptation plans.

F.5 Proposed Decision Support for Pilot Provinces

Currently, there is regular hydrological and meteorological data reporting from the water resources department to the FCDRH in the provinces. Annex 1 provides examples from Liaoning Province of 10-day report, monthly report and spring reporting. Although there appears to be somewhat comprehensive reporting during Normal operations, in the PRC little is actually triggered or done with this information unless the drought damages begin and an actual drought level declaration is declared (IV to I).

The FCDRHs at various levels are doing early action drought relief planning work but little in the way of monitoring drought indices, predicting droughts and taking early action risk reduction and mitigation

measures based on the predictions. Given this background, the TA is not proposing improvements to an existing decision support framework for drought management but proposing a completely new way of doing business with drought management activities at all stages of the drought cycle (Normal, Pre-Drought, Drought, Post-Drought).

The TA has proposed a **layered decision support early warning framework** that uses the NCC meteorological drought forecasting at the provincial level FCDRH (as well as available hydrologic and agricultural monitoring) to establish triggered notices to affected local areas (basins, municipalities, counties). Once the triggered notices of potential drought are received at the lower level FCDRHs, the use of the current hydrologic indices and other hydrologic data is expanded to evaluate the probability of drought based on the provincial warning. Depending on these combined meteorological and hydrological assessments and probability analyses, the local level DMPs are triggered for early action water reductions and water conservation measures. Depending on the severity of the potential drought, additional triggers for re-allocation of water abstractions may be considered with the Water Affairs Bureau based on the drought risk assessments and triggers outlined in the local DMPs.

Based on work in the DFID WRDMAP, some of the early actions and Triggers during potential drought conditions at the local level could include:

- Implement Drought Action Plan as quickly as possible once a trigger is passed.
- Place Drought Team in operational mode
- Activate key specialists if necessary
- Check and update drought communications plan
- Intensify monitoring of effective rainfall, groundwater or river levels and incidents of water stress
- Notify stakeholders of potential drought status
- Implement risk reduction and mitigation measures including potential reallocation of available water supplies according to priority water needs to minimize impacts of potential drought
- Coordinate meetings with local government and key water users
- Implement abstraction and discharge permit variations for non-essential uses
- Implement drought management plans/re-allocations of essential water users
- Publish weekly situation reports

As discussed in the appendix on the provincial drought management plan, the tiered and interconnected provincial-local management system is somewhat of a long-term vision for drought risk management in the PRC. In the interim period until local drought management plans are developed and capacity is improved, the provincial drought management plan may be the key guiding document for these triggered actions.

Annex 1. Typical Reporting of Water Resources to FCDRH, Liaoning Province

Ten days reports

Liaoning Provincial Water Resources Intelligence Department

Sep.21, 2013

During mid of September 2013, the average provincial precipitation is less than multi-year average. Up to Sep 21, the water levels in major reservoirs are less than the water levels during the same time period of 2011 and 2012. Major river levels are stable.

1. Precipitation

During mid September, the provincial average precipitation is 9 mm, which is 52.1% less than many years average value (18.8mm). Among these, the average precipitation in western area (Chaoyang, Jinzhou, Huludao, Fuxin) is 3.3mm, which is 77.6% less than many years average value (14.7 mm).The average precipitation in middle and northern area (Shenyang, Liaoyang, Anshan, Tieling, Fushun) is 10.4 mm, which is 49% less than many years average value (20.4 mm). The average precipitation in eastern and southern area is 12.1 mm, which is 41.8% less than many years average (20.8 mm).

2. River Hydrology

On 8 am September 21, the flow rate in Liao River is 102 m^3/s measured by mainstream Tieling Hydrology Station; Liujianfang hydrology station 180 m^3/s; Hun River flowrate 25 m^3/s measured by Shenyang Hydrology Station; Taizi River 6.9 m^3/s measured by Xiaolinzi hydrology station; Daling River 0.59 m^3/s measured by Chaoyang hydrology station; Yalu River 915 m^3/s measured by Huanggou hydrology station.

3. Reservoir water level

On 8am Sep. 21, 27 major water reservoirs held 5.784 billion m^3 of water, which is 0.482 billion m^3 less than that of same period of last year (6.266 billion m^3), and 5.51 m^3 less than that of same period of 2011 (6.335 billion m^3). Among that, 9 provincial major water reservoirs hold 3.647 billion m^3, which is 0.483 billion m^3 less than that of the same period of last year (4.130 billion m^3), and 0.526 billion m^3 less than that of same period of 2011 (4.173 billion m^3).

On 8am Sep 21, 74 medium size water reservoirs hold 0.91 billion m^3 of water, which is 67 million m^3 more than that of the same period of last year (0.843 billion m^3).

On 8am Sep 21, 280 provincial minor(1) water reservoir hold 0.296 billion m^3 of water, which is 7 million m^3 more than that of the same period of last year (0.289 billion m^3).

Monthly report by the water resources bureaus, (sent to the FCDRH)

Liaoning Provincial Water Intelligence Department

Sep 1, 2013

Executive Summary

In August 2013, the provincial average precipitation is less than many years average value. On Sep 1, the water level in major reservoirs are less than that of the same period of 2012. In this month, due to precipitation change, flood appears in several rivers. Major rivers water levels are stable up to date.

1. Precipitations

August, the province's average precipitation 137.0 mm, 159.1 mm less than the average for many years by 13.9%. Among them, the western region (Chaoyang, Jinzhou, Huludao, Fuxin) average rainfall 88.2 mm, 120.8 mm less than the average for many years by 27.0%; central and northern regions (Shenyang, Liaoyang, Anshan, Tieling, Fushun) average precipitation 189.6 mm, 166.9 mm more than the average for many years by 13.6%; eastern and southern regions (Benxi, Dandong, Panjin, Yingkou, Dalian) average precipitation 123.3 mm, 189.4 mm less than the average for many years by 34.9%.

2. River flows

At 8:00 on September 1, Liao River flow rate is 365 m^3/s measured by Tieling mainstream hydrological station; 898 m^3/s measured by Liujianfang hydrological station; Hun River flow rate is 135 m^3/s measured by Shenyang hydrological station; Taizi River flow rate is 48 m^3/s measured by Xiaoilinzi hydrological station. Daling River flow rate is 0.95 m^3/s measured by Chaoyang hydrological station. Yalu River flow rate is 1080 m^3/s measured by Huanggou hydrological station.

3. Water levels in reservoirs

At 8:00 on September 1 the province's 27 large reservoirs of total water storage capacity of 5.756 billion cubic meters, more than last year 5.952 billion cubic meters storage capacity less 196 million cubic meters, of which: nine provincial reservoir storage capacity 3.597 billion cubic meters, more than last year the amount of 3.889 billion cubic meters water less 292 million cubic meters.

At 8:00 on September 1 the province's 74 medium-sized reservoirs of total water storage capacity of 933 million cubic meters more than last year 830 million cubic meters storage capacity more than 103 million cubic meters.

At 8:00 on September 1 the province's 280 small (1) reservoir of total water storage capacity of 303 million cubic meters more than last year 288 million cubic meters storage capacity more than 015 million cubic meters.

Drought Forecasting of Liaoning Province

in 2010 Spring

1. Precipitation

Period for October 1, 2009 to March 1, 2010

The average precipitation 84.9 mm, 58.7 mm more than the average for many years 44.6% more than last year 60.7 mm by 39.9%. Among them, the western region (Chaoyang, Jinzhou, Huludao, Fuxin) average rainfall 36.1 mm, 36.8 mm less than the average for many years by 1.9% less than last year 44.2 mm by 18.3%; central and northern regions (Shenyang, Liaoyang, Anshan, Tieling Fushun) average annual rainfall 120 mm, 63.7 mm more than the average for many years 88.4% more than last year 68.8 mm more than 74.4%;; eastern and southern regions (Benxi, Dandong, Panjin, Yingkou, Dalian) average precipitation 105.3 mm, more than mean years of more than 41.0%, 74.7 mm, 70.2 mm more than last year 50.0%;.

Period for November 1, 2009 to March 1, 2010

The average precipitation 45.1 mm, 24.8 mm more than the average for many years 81.9% more than last year 39.9 mm by 13.0%. Among them, the western region (Chaoyang, Jinzhou, Huludao, Fuxin) average rainfall 19.9 mm, 12.1 mm more than the average for many years 64.5% more than last year 18.9 mm by 5.3%; central and northern regions (Shenyang, Liaoyang, Anshan, Tieling Fushun) average rainfall 63.3 mm, 26.9 mm for years mean 2.35 times, more than last year 20.8% 52.4 mm;; eastern and southern regions (Benxi, Dandong, Panjin, Yingkou, Dalian) average rainfall 54.9 mm, compared with mean years of more than 60.5%, 34.2 mm, 49.8 mm more than the same period last year of 10.2%;.

Period for January 1, 2010 to March 1, 2010

The average precipitation 19.6 mm, 11.9 mm more than the average for many years 64.7% 29.2 mm less than the same period last year by 32.9%. Among them, the western region (Chaoyang, Jinzhou, Huludao, Fuxin) average precipitation 8.7 mm, 5.4 mm more than the average for many years 61.1% 18.1 mm less than the same period last year of 51.9%; central and northern regions (Shenyang, Liaoyang, Anshan, Tieling Fushun) average rainfall 33 mm, for many years was 2.6 times the mean 12.6 mm, 35.3 mm less than the same period last year by 6.5%;; eastern and southern regions (Benxi, Dandong, Panjin, Yingkou, Dalian) average rainfall 20.6 mm, compared with mean years of more than 21.9%, 16.9 mm, 34.7 mm less than the same period last year by 40.6%;.

Period for November 11, 2009 to February 11, 2010

This winter (Gregorian November 11 to February 11) above normal precipitation over half compared to years ago, western and north-central ones eighty percent; representing one percent less than normal, the objective to help the spring sowing plug. However, the province Daejeon rainfed agricultural areas of major crops - corn sowing in late April (maize growth cycle is generally 150-180 days in late April-May, the mid-sowing to mature in early September), to increase the spring when the soil intermediation, moisture loss accelerated, the need to pay close attention in April, May precipitation conditions.

2. River & reservoirs

water flow

At 8:00 on March 1, 2010 Most of the river flow is less than the value of last year. Liaohe River

hydrological flow of 2.5 cubic meters per second, Tieling, compared to 9.8 cubic meters per second; six rooms hydrological flow of 5.68 cubic meters per second, compared to 10.5 cubic meters per second; Hun River in Shenyang Hydrometric Station 3.94 cubic meters per second, compared to 6.03 cubic meters per second; Taizihe small woods Hydrometric Station 8.10 cubic meters per second, compared with 6.31 cubic meters per second; Daling Chaoyang Hydrometric Station 0.44 cubic meters per second, compared with 0.77 cubic meters per seconds; Daling Linghai Hydrometric Station 1.25 cubic meters per second, compared with 3.78 cubic meters per second; xia oling gangyao mouth hydrological discharge of 0.16 cubic meters per second, compared with 0.12 cubic meters per second; six stocks River hydrological flow of 0.81 cubic meters per second, SZ, compared with 2.01 cubic meters per second.

reservoirs water levels

At 8:00 on March 1, 2010, the province's 27 large reservoirs of total water storage capacity of 4.256 billion cubic meters, compared with 5.687 billion cubic meters last year 1.431 billion cubic meters less than the same period in 2008 5.807 billion cubic meters less 1,551,000,000 cubic meters. Where: nine provincial reservoir storage capacity 3.022 billion cubic meters, more than last year 3.884 billion cubic meters storage capacity 862 million cubic meters less than the same period in 2008, 3.888 billion cubic meters storage capacity 867 million cubic meters less.

3. Soil moisture

Soil moisture before frozen

From September 21 observation stations to monitor the province's representative soil moisture analysis: Western Chaoyang, Fuxin, Jinzhou, Huludao parts of north-central Shenyang, Tieling parts of the southern region of Dalian, soil moisture (10 to 20 cm) of 6% -16%; (20 to 30 cm) of 7% -18%, poor soil moisture. Elsewhere soil moisture (10 to 20 cm) was 11% -20%; (20 to 30 cm) of 15% -22%, soil moisture condition is better.

March 1, 2010, the province's representative to monitor soil moisture observation site Analysis: West Chaoyang, Fuxin, Jinzhou, Huludao parts of north-central Shenyang, Tieling some areas, soil moisture (10 to 20 cm) 8% -16%; (20 to 30 cm) of 9% -18%, soil moisture is poor. Elsewhere soil moisture (10 to 20 cm) of 15% -22%; (20 to 30 cm) of 17% -26%, soil moisture condition.

Forecasting the precipitation, water flow and levers by the water resources bureau.

According to 2009 the province's rainfall, river base flow, snowfall last winter and spring, etc., analysis and prediction of the eight provincial reservoir runoff from March to April 2010 a total of 693 million cubic meters, more than 17.5% higher over the same period. Where: dahuofang water to 221 million cubic meters, Guanyinge Reservoir 124 million cubic meters, Shenwo was 1.89 billion cubic meters, Qinghe reservoir of 042 million cubic meters, the reservoir is 028 million cubic meters Chaihe, Tanghe Reservoir 034 million cubic meters, Naodehai reservoir 015 million cubic meters, Baishi reservoir is 040 million cubic meters.

Forecast Liaoning too muddy March-April 2010, three major rivers runoff totaled 358 million cubic meters, more than 15.8% higher over the same period. Where: Liaohe River (represented by Tieling hydrological station) is 197 million cubic meters; Hun River (as represented in Shenyang hydrological station) is 078 million cubic meters; Prince Edward River River (represented by Liaoyang hydrological station) is 083 million cubic meters.

Forecasting the weathers by the meteorological bureau.

Precipitation: Precipitation is expected in spring 2010, the province's general trend as normal ones, including Chaoyang, Huludao, Jinzhou western, Dalian normal below normal, normal ones elsewhere. Western Liaoning, Southern Liaoning drought may occur.

Temperature: the province is expected in spring 2010, the average annual temperature is normally high, but warmer spring temperature instability, low season there may be periodic.

Comprehensive winter precipitation, river runoff, river water storage reservoirs, soil moisture change and climate predictions about the spring of 2010 in western Liaoning Province and Dalian, regional soil moisture situation is not optimistic about the spring production will have a certain impact.

Appendix G. Approach to Capacity Development Program, Implementation

G.1 Introduction

This section outlines the role and working method of FCDRH and its relations with other institutions as a backdrop to designing the capacity development program, which is presented in a separate report. The following section outlines the preconditions for making such a capacity-building program effective, and the final section of this appendix outlines the development process for the capacity-building program and presents the program itself

G.1.1 Role and Structure of Flood Control and Drought Headquarters (FCDRH)

The Chinese government has formed the Flood Control and Drought Headquarters at all levels, to lead the organization and management of drought relief work. This brings together representative from the water sector, the agricultural sector, the meteorological department, the financial sector, the civil affairs department, the broadcasting sector, the transport sector and the military, etc. (see Table G.1).

Table G.1: Main member units of FCDRH and their responsibilities

Agency	Role	Responsibility
FCDRH	Headquarter	Command and coordination
Water sector	Member unit	Responsible for drought relief industry management, provide timely rainfall regime, water, drought, disaster.
The military	Member unit	Take the emergency drought resistance related tasks
The meteorological department	Member unit	To provide weather information
The national development and reform commission	Member unit	For examination and approval of significant resistance line construction project examination and approval
The broadcasting sector	Member unit	Drought resistance and mobilize the propaganda
Police office	Member unit	The disaster area public security guarantee
The civil affairs department	Member unit	The disaster area and the victims of the disaster relief
The financial sector	Member unit	Disaster relief funds management of examination and approval
The transport sector	Member unit	Relief supplies to transport
The agricultural sector	Member unit	Guidance of agricultural drought
The ministry of health	Member unit	Disease surveillance and treatment

G.1.2 Operational Mechanism for FCDRH

The operational mechanism of FCDRH can be summarized in three parts: the composition and management; working arrangements; and cooperation.

The FCDRH is structure into four levels: national, provincial, prefectural (city) and county-level offices, while the major river systems also have a basin-level office. Organizations at all levels are responsible for the management of drought mitigation. County office of organization are responsible for management of the county's drought mitigation, prefectural (city) level are responsible for organization and coordination of

the county's drought disaster management work, the provincial office are responsible for the organization and coordination throughout the province (city)-level-drought-mitigation, the National FCDRH are responsible for coordination of national drought mitigation and management through the provincial office of organizational leadership.

Cooperation is required between the member units, such as water resources, meteorology or agriculture, in two situations, during droughts, and preceding droughts. Currently, the first co-operation mechanism works well for comprehensive development of drought-related information, and is conducive to drought monitoring and forecasting and early warning; the second aspect is not working smoothly enough during the non-drought period.

G.1.3 Spurring Cooperation between Agencies for Managing Drought Risk

Drought mitigation involving multiple agencies or departments of the system working, the various agencies or departments of the organic cooperation is very necessary and important for the good drought relief work. According to the project's research work combined with China's current management practices and drought mitigation, forecasting and early warning of drought monitoring work is still relatively weak, such as the drought early warning method of forecasting is merely in half of the region, forecasting drought in most parts of the city has no warning method and various agencies or departments cooperation between periods of drought are better than poor cooperation during the non-droughts, etc. Therefore, the relevant institutions or inter-sectorial cooperation should be strengthen, for now, the cooperation between the hydrological and meteorological agencies or departments is urgent need to strengthen, because this smooth cooperation between the three departments directly affect the drought monitoring and forecasting and early warning, and then influence decisions and drought mitigation measures correctness, timeliness and validity.

Hydrological and meteorological sector cooperation mainly refers to information sharing, which is not conducive to drought monitoring and early warning forecast. Information cannot be shared for many reasons, but the main reason is that there is no established information sharing mechanism for drought mitigation.

G.2 Program Institutional and Capacity Development for Managing Drought Risk and Saving Water

Institutional and water user surveys were undertaken and a discussion exchange meeting held to assess the need for capacity building. Based on the results (Appendix A and B), the capacity development program was planned, to focus on the following aspects:

1. improve the drought risk management capacity of FCDRH at all levels
2. conduct targeted drought risk management trainings for staff of FCDRH at all levels;
3. evaluate the inadequacies of existing policies and regulations on drought risk management and water saving management and
4. develop sound policy and regulations.

This research shows that there are significant limitations in drought disaster management capacity h, which is manifest in the provincial office staff having a relatively strong awareness of disaster risk, whereas as municipality (city) level and county-level management staff have a weak awareness. All levels of office lack forecasting, drought monitoring and early warning capabilities, they lack some relevant technical standards

and specifications, and relevant knowledge of related laws and regulations. Society as a whole lacks sufficient water-saving and drought awareness. A number of measures must therefore be taken in addition to capacity building

G.2.1 Improved Regulatory System and Drought Mitigation

According to the results of the project research work, most of region in drought resistance has incomplete laws and regulations. Most drought relief work is according to the Water Law and regulations of the People's Republic of China, but there is no specific law on Drought. The lack of corresponding legal rules makes it difficult to give specific instructions in relation to drought resistance and disaster mitigation work. At the same time, some areas lack drought contingency plans so that it is hard to do active drought resistance measures. Drought disaster is a perennial challenge for human society and involves all aspects of society and economy, so establishing and perfecting laws and regulations for the system of drought management is one of the basic requirements.

G.2.2 Improve Technical Standards Related to Drought Mitigation

Monitoring and early warning drought and drought assessment is a basic aspect of drought resilience and disaster mitigation; it is also very important to the drought relief decision-making and action. However, a lot of places are suffering from the lack of guidance related to drought monitoring, early warning drought assessment and relevant technical standards, despite the "standard of drought classification" enacted by the Ministry of Water Resources in 2008, This has a guiding role on evaluation methods for country (city) and county administrative region, but lacks features of appropriate monitoring and warning, and guidance on the evaluation index and classification.

Therefore, we need to technical standards that can be adapted to different regions, to provide consistent standards for drought resistance and disaster mitigation.

G.2.3 Establish an Information Sharing Mechanism for Drought

Drought management agencies including MWR, meteorological and agricultural sector, need timely access to hydrological, meteorological and agricultural information for making drought evaluations, etc. But, at present we can't do related drought information sharing, which directly affects the objective of drought assessment in time, and thus the decision-making and command of drought relief work is severely hampered, restricting the social capacity for drought resistance and disaster mitigation. For enhancement of the whole society to a comprehensive drought relief capacity, the importance should be laid on setting up an mechanism of drought resistance and disaster mitigation information sharing, to achieve the objective assessment to drought, and make timely and correct drought relief efforts.

G.2.4 Strengthen drought monitoring and forecasting warning systems

Research and discussion results show that the three administrative region at all levels of pilot provinces have virtually no drought monitoring and forecasting warning system. In order to transform from passive drought resistance to active management, drought monitoring and early warning system is essential. There is an urgent need to strengthen the construction of drought monitoring and early warning system in the pilot provinces.

G.3 Recommendations for Further Capacity Development

China's drought management organization configuration is comprehensive, so to improve drought disaster management ability it is necessary to focus on two aspects to strengthen the construction of drought monitoring and forecasting warning ability:

1. Build up the drought disaster information sharing mechanism as soon as possible.
2. Capacity building for drought monitoring and forecasting warning needs all levels of government to attaches great importance to, not only investing in the research of drought monitoring and early warning indicators but also establishing the data analysis software and infrastructure.

Therefore, governments at all levels should give input on the fiscal side, set up as soon as possible for drought monitoring and forecasting warning system in the region. At present, information about the drought relief spread in hydrological, meteorological and agricultural departments and so on, due to the lack of information sharing mechanism, just relevant information is not yet in the service of drought resistance and disaster mitigation work management, so we should establish the mechanism of drought resistance and disaster mitigation information sharing as soon as possible, to realize information sharing so as to greatly improve the drought-resistant decision making.

G.3.1 Recommendations Based on Workshops and Training

Through discussion exchange meeting we determined that drought relief authorities should be strengthened in two aspects. First, to further improve the management of personnel at all levels of drought and drought disaster risk management theory level through the enhanced training institutions, especially to (city) and county agencies and drought management, because they are facing drought mitigation issues more specific and more directly. Second, pay attention to (city) and county drought management in the management of personnel, because there some place (city) and county agencies of the drought management have the problems of lacking the staff, not enough to cope with the increasingly severe drought mitigation.

Based on the results of the institutional capacity survey, and considering the fact that provincial and county level drought risk management have different focuses, the proposed capacity building program will enhance drought risk management capacity through a training program and a drought risk management capacity training plan. To ensure the implementation of the recommended training, implementation modalities will be included including a work program with course outlines. The work program would include information related to training organizers, implementation institutes, training objects, teachers, training contents, training methods, and training budgets.

G.3.2 Training program

The workshops described above provided capacity-building to higher level personnel in FCDRHs and related organisations. The study tour to Portugal and Spain was also a part of the capacity development program. However the capacity and competence of drought management professional at all levels need to be strengthened in a regular basis to enable them to cope better with droughts, especially given their increasing frequency and impacts. Recommendations for further capacity development have therefore been. A capacity building program has been drafted as outlined in this section, and includes information related to training organizers, implementation institutes, teachers, training content, training methods and

budgets. The chapter outlines list the key contents of training course in tabular form with key issues and concepts highlighted.

G.4 Capacity Development Program

G.4.1 Objectives

The objectives of the capacity development program are to promote understanding and knowledge of the following topics, and ensure that FCDRH staff are capable of using this knowledge in their daily work:

- Drought policies and regulations; technical standards
- Drought vulnerability and risk assessment
- Drought prediction and early action
- Proposed tiered drought management planning responsibilities
- Co-operation between agencies for managing drought risk

G.4.2 Participants

The main participants will be the provincial and county level drought management staff from Liaoning, Gansu and Sichuan. The greatest need is for training for these low-level staff in FCDRH, who currently have the weakest understanding of the concepts. Ultimately the program should be extended to other provinces, drawing on the experience, methods and materials from the pilot provinces.

There are 316 FCDRH at different administrative levels in three pilot provinces (detailed in Table G.2). Assuming each FCDRH send 2 staff for training, the number of total staff to be trained would be 630. In order to ensure good training outcomes, the staff would be grouped and given training in batches.

Table G.2: Number of FCDRH at each level in the Pilot Provinces

Level	Liaoning	Gansu	Sichuan	Total
Provincial	1	1	1	3
Municipal	14	14	21	49
County	44	86	134	264
Total	**59**	**101**	**156**	**316**

Source: Project studies

G.4.3 Lead institutions

Training for provincial FCDRH staff should be organized and provided by national FCDRH, county level FCDRH by provincial FCDRH. Specialized research institutes should also be involved in developing and implementing the training

G.4.4 Lecturers

The lecturers should be organized by national FCDRH, and should be research scientists from drought research institutions, drought management staff from national FCDRH and drought researchers from universities.

G.4.5 Course contents

The course contents include three main aspects:

1. Drought management policies and regulations, including institutional arrangements and related technical standards
2. Drought monitoring, forecasting and triggering, including data sharing and management
3. Drought risk management

The main contents under each heading are listed in Table G.3. The overall contents for the state, provincial and county level training are similar, but the level of detail and technical content will vary. Capacity building for government staff from related organizations will mainly include the overview sections to regulations and to drought risk management.

Table G.3: Drought Risk Management Capacity Building Training

Category Of Contents	Main Contents		
	State Level	Provincial Level	Municipal And County Level
Laws, regulations and technical standards	PRC laws related to drought	PRC laws related to drought	PRC laws related to drought
	PRC drought relief regulations	PRC drought relief regulations	PRC drought relief regulations
	Technical standards related to drought	Technical standards related to drought	Technical standards related to drought
	Institutional arrangements	Compilation guidelines for drought plans	Compilation guidelines for drought plans
		Institutional arrangements	related drought management policies, regulations and technical standards in the province
			Institutional arrangements
drought monitoring, forecasting,	drought monitoring stations arrangement	drought monitoring stations arrangement	drought monitoring stations arrangement
	drought monitoring techniques	drought monitoring techniques	drought monitoring techniques
	drought database building	drought database building	drought database building
	Data-sharing and drought information management	Data-sharing and drought information management	Data-sharing and drought information management
	Latest updates in the development of drought monitoring technology		characterization of droughts within the province
			water resources distribution in time and space within the province
drought risk management	basic knowledge of drought	basic knowledge of drought	basic knowledge of drought
	drought risk theory	drought risk theory	drought risk theory
	drought risk management techniques	drought risk management techniques	drought risk management techniques
	drought risk management framework	drought risk management framework	drought risk management framework
	drought risk mapping categories	drought risk mapping categories	drought risk mapping categories
			drought monitoring, forecasting and triggering situation in the province

G.4.6 Training methods

There are several training methods which could be adopted. Online training could be used for some aspects, but most will be covered by formal training courses. Separate training materials could be prepared by water professionals, but in some cases it may be sufficient to add drought-related material into existing courses. The presentations used during this TA should be useful material, and other material can be developed from the guidelines and DMPs. In additional, short classroom courses could be employed. It's also a good opportunity for people to share experience by bringing people together.

It is anticipated that the full course would be broken down into around 5 blocks of 2 day training in order to ensure that it can be accommodate within the constraints of other commitments and pressures on staff time. The local staff would assemble in either the capital of the province or major cities to take the training courses. The training methods would be largely lecture-based using centrally prepared material as a starting point. These would be adapted to the local context as there is considerable variation across the provinces. Participatory methods would be used to the extent possible to ensure effective learning outcomes

G.4.7 Funding

The capacity building program will largely be undertaken during the course of normal working activities, so it is anticipated that the funding would come from the existing drought management budgets at each level, although additional specific budget might be needed for initial preparatory activities.

G.4.8 Extend Capacity Building Program to Other Provinces

Currently, all provinces and drought mitigation management capabilities are similar and wait to be further improved. After activities are well-developed in the pilot provinces, the programs and methods should be transferred to other provinces as well.

Appendix H. Provincial Workshops and Field Trip

H.1 Summary of Initial Provincial Workshop and Field Trip (5-6 Sep 2013)

H.1.1 Purpose and Proposed Agenda

The purpose of this workshop was to introduce drought risk management and risk-based drought management plan, getting more information and perspectives from provincial and local levels, getting agreement on how to introduce risk-based management methods into existing system and get it improved.

The workshop was hold in the 5th floor meeting room in Jinjing Holiday Inn Hotel in Lanzhou, about 30 people attended. Most attendees were from different regions in Gansu province, with one or two from Liaoning and Sichuan each Provincial FCDRH. Mr. Liu Baojun from state FCDRH also attended. After presentations from CDTA team, discussions were guided by Mr. Zhu Jiang and Ms. Lv Juan. Findings / observations and suggestions on followed workshop and training program is shown in Table H.1. Detailed attendee list please refer to Table H.2.

The agenda was prepared with Gansu FCDRH and CDTA team. It's a combination of one day indoor workshop and field trip in the following day.

Table H.1: Workshop agenda

DAY 1: Workshop	
09:00-09:15	Opening Speeches (Mr. Zhu Jiang) -Welcome: - Background introduction:
09:15-09:45	Project Overview and Drought Risk Management Concepts - Dr. Larry Quinn (Consultant Team Leader)
09:45-10:00	Tea break
10:00-10:30	Drought Response Planning Versus Drought Risk Management -Lv Juan (Deputy Consultant Team Leader)
10:30-11:00	Water Conservation and Water Saving – Normal Operations Versus Triggered Drought Risk Reduction and Mitigation Measures Marieke Nieuwaal, Consultant Water Saving Specialist
11:00-11:30	Pilot Province Risk-Based Drought Management Plans: Framework and process - Dr. Larry Quinn (Consultant Team Leader)
11:40-13:30	Lunch Break
14:00 -16:30 (15:00 Tea break)	Working Groups / discussion: Applying Drought Risk Management framework to existing drought response planning. Local municipal/county drought management planning relationships to provincial drought management plans. Selection of drought indices and triggers for drought risk reduction and mitigation measures (local/provincial). Normal Operations Versus Triggered Drought Risk Reduction and Mitigation Measure
16:30-16:50	Presentation of Working Group Findings
16:50-17:30	Discussion on data sharing and preparation of the pilot province drought management plans; next workshops to present pilot province draft DMPs in March 2014

DAY 1: Workshop	
DAY 2: Field Trip	
08:00	Departure to Anding district, Dingxi City
10:00	Visiting West Mountainous Rainfed Agriculture Development Zone
12:00	Lunch in An’ding district
13:30	Visiting Tao River Transfer Project (under construction)
15:30	Return to Lanzhou

Table H.2: Attendee list of the first provincial workshop in Gansu

	姓名 Name	单位 Unit	职务 Title	签名 Signature
1.	朱峰	水利部外资办	副主任	
2.	刘宝军	国家防办	副处长	
3.	孙岩	水利部外资办 亚行技援项目咨询专家组	副处长 专家	
4.	吕娟	中国水利水电科学研究院 亚行技援项目咨询专家组	所长 副组长	
5.	苏志诚	中国水利水电科学研究院 亚行技援项目咨询专家组	副所长 专家	
6.	吴玉成	中国水利水电科学研究院 亚行技援项目咨询专家组	副总工 专家	
7.	孙洪泉	中国水利水电科学研究院	工程师	
8.	Lawrence Quinn	亚行技援项目咨询专家组	博士 组长	
9.	Marieke Nieuwaal	莫特麦克唐纳公司 亚行技援项目咨询专家组	节水专家	
10	于淼	莫特麦克唐纳公司 亚行技援项目咨询专家组	技术助理	
11	张翼	莫特麦克唐纳公司 亚行技援项目咨询专家组	技术助理	
12	武哲如	水利部外资办	项目官员	

姓名 Name	职务 Position	单位 Unit	签名
[illegible]	副主任	[illegible]	
[illegible]	副局长、防办主任	[illegible]	
[illegible]	防办副主任	[illegible] [illegible]	
[illegible]	副局长	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	副局长	[illegible]	[illegible]
[illegible]	副主任	[illegible]	[illegible]
[illegible]	副主任	[illegible]	18993019252
[illegible]	副主任	[illegible]	[illegible]
[illegible]	主任	[illegible]	18919187896
[illegible]	科员	[illegible]	[illegible]
[illegible]	副局长、主任	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

姓名 Name	职务 Position	单位 Unit	签名
[illegible]	主任	[illegible]	[illegible]
[illegible]	科员	定西市防办	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
王中	副主任	酒泉市防汛办	[illegible]
[illegible]	处长	[illegible]	[illegible]
[illegible]	副主任	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	副主任	[illegible]	[illegible]
[illegible]	副调研员	庆阳市水务局	[illegible]
[illegible]	副主任	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	副主任	[illegible]	[illegible]
[illegible]	副主任	[illegible]	[illegible]

H.1.2 Workshop Summary

The first provincial workshop was held in Lanzhou, Gansu Province with participation by all three pilot provinces during September 2013 to discuss the following topics:

- Introduction of relevant concept on drought
- Methods for evaluation of drought risk
- Concept of drought risk management and implementation internationally
- Framework of drought risk management

- Proposed methods for developing drought risk management plans (DMPs) for provinces under the TA, and how these provincial DMPs relate to local drought risk management planning.

During the Inception workshop, the provinces asked the consultant to show case studies and examples of Chinese successes and international best practice. Sources for examples (mainly on water demand management) include:

- Charting our Water Future, Economic frameworks to inform decision-making, with detailed case studies on China, India, South Africa and the state of São Paulo in Brazil, 2030 Water Resources Group 2009
- Drying Up, What to do about droughts in the People's Republic of China, With a case study from Guiyang Municipality, Guizhou Province, By Qingfeng Zhang, Yoshiaki Kobayashi, Melissa Howell Alipalo and Yong Zheng, ADB 2012.
- Water Resources Demand Management Assistance Project WRDMAP reports, such as
  - Overview Paper 2: Water Demand Management – an International Perspective
- Water Resources Demand Management Assistance Project WRDMAP case studies, including on:
  - Case study Gansu 1: IWRM planning for Shiyang River Basin
  - Case study Gansu 2: Water saving society in Jinchang and Wuwei
  - Case study Gansu 3: Shared water management in Minqin
  - Case study Liaoning 1: IWRM planning for the upper Daling river basin
  - Case study Liaoning 2: Integrated water abstraction and wastewater discharge permitting in Chaoyang
  - Case Study Liaoning 3: Water tariff reform and and efficiency in Beipiao
- The Global Water Partnership Toolbox (www.gwptoolbox.org) including case studies on (many more available):
  - China: Innovative Water Resource Conservation Measures in the North China Plain (#348)
  - China Hebei: Storage and use of rainwater (#352)
  - Spain: Managing water demand in the upper Guadiana basin (#18)
  - Central Asia: Experiences in drought management best practices (#434)
  - Morocco: Demand management in urban water supply (#103)

Table H.3 provides a brief summary of the discussions and main issues raised at the provincial workshop. Detailed meeting notes are in Annex 1 to this Appendix.

Table H.3: Summary of workshop discussions and main issues

Item	Feedback	Future needs / suggestions
Drought management	Most people thought current drought management practice is emergency drought relief, rather than risk based drought management in an integrated way. They agreed the risk based management method could supplement current drought relief practice and improve drought management in China.	International cases are more acceptable and easy to understand the risk based concept. More cases or examples could provide to inform people.
Monitoring and indicator system	Liaoning has good basis on data collection and sharing. But most places in Gansu and Sichuan have not many monitoring stations, especially on soil moisture. Tiered approach can be adopted. Early warning or information sharing can start with primary meteorological data, mainly precipitation based indicators.	Data sharing could be a problem due to some institutional issues. Inter agency cooperation needs to be strengthened. The power of FCERH on coordination and cooperation needs to be improved. According to local situation, monitoring stations could be planned based on current station map within different organisation. Overlap of stations should be avoided. Practical suggestions on local indication selection could be given to guide local people to implement the indicators and triggers.
Institutional issues	It's difficult for FCDRH to implement drought management work throughout the hundred percent time of daily work. The risk based drought management should be embodied into strategic documents and policies and implemented under the leadership of the government at different levels.	Suggestions can be provided to higher level and included into policies and regulations. Data sharing and inter agency cooperation needs to be strengthened. Integrated water resources management should be improved after several years implementation to include drought risk management and mitigation into the daily operation of related organisations.
Natural conditions (water shortage) Vs drought management	Especially in Gansu and mountainous areas in Sichuan and Liaoning, people talk about water shortage due to natural climatic conditions. Drought caused by abnormal climatic conditions, mainly by less precipitation could be the focus of drought management by FECRH and hence some actions in pre drought conditions need to be prepared.	Coping with water shortage problem should be included in the integrated water resources management. FCERH should focus more on emergent drought responses and coordinate on risk reduction measures during pre drought condition. Emergent drought responses in pre and drought conditions should be included in daily operation of different organisations, with FCDRH's role on coordination and corporation.
Infrastructure focus	They all mentioned the engineering measures to cope with drought covering both supply and demand sides, including rainwater harvest, water storage, water transfer and water saving irrigation and cultivation.	Focusing on infrastructure and the physical construction is common in China. More training program need to be provided to expend the interests to other non-engineering measures.

Item	Feedback	Future needs / suggestions
	Some of them think strengthening the infrastructure should still be one of the future focuses.	GDP driven performance assessment should be swift to performance based evaluation. Should be a long term goal.
Drought relief service group	According to relevant policies and documents, drought relief service groups were set up for counties. Central government provided 2 million RMB to support the development of such organisation, mainly on purchase vehicles and pumps for transporting or pumping water during drought seasons.	In the light of water resources institutional reforming, drought relief service group could be part of the integrated service provider at lower level. The principle should be sharing the risks with the public and increasing the participation of the public in drought management to make it efficient and effective.
Public participation on drought management and relief	Lacking of labour in rural area is a problem in terms of water transportation and carrying for irrigation during drought. Small piece of land reduces the incentive of individual farmers to save their agriculture losses and paying for insurance, if there is.	It's common in most rural areas in China. How to provide enough incentive for farmers to participate the drought relief and risk reduction activities?
Lacking of funding	Most of the drought management budget has not been included in local financial annual plan, which makes the drought mitigation measures been less implemented. Without financial supporting, drought relief actions embodied in the daily operations are hardly to be implemented.	Strengthening IWRM and including some of the drought risk mitigation activities into daily operation of other organisations. Get supporting from local financial department or bureau.

H.2 Drought Disaster Risk Management Discussion Exchange Meeting Overview

H.2.1 Synopsis of Meetings

In order to understand the status of the pilot province of drought disaster risk management and response to drought related measures and methods, combined with the drought disaster risk theory knowledge training, etc., the project team in national anti-drought and pilot provinces anti-drought support and help, on September 4 to 6, 2013, held in Lanzhou city, Gansu province has three related pilot provinces in drought management discussion of drought management personnel to participate in the exchange.

The professional staff of nearly 30 people attended the forum, including 1 national director of anti-drought management personnel, director of Liaoning province anti-drought drought management personnel (2 people), 1 person anti-drought personnel engaged in drought management in Sichuan province, Gansu province, and country (city) and county anti-drought as well as the related department personnel more than 30 people, 3 foreign affairs office, the ministry of water resources project management institutions and the project team of Chinese and foreign experts (7 people).

In the symposium, the team leader Lawrence Quinn, project team deputy team leader Lv Juan and water-saving expert Marieke Nieuwaal respectively makes a brief report around the drought disaster risk management, China's response to drought disasters and management, water saving and water protection theme. Three pilot province anti-drought competent personnel management of drought and drought management in their respective provinces respectively condition are introduced, more than 20 from Gansu

province (city), county anti-drought representatives are their situation and problems about the drought management are introduced. On this basis, the delegates on relevant aspects of drought disaster management have carried on the thorough discussion and the exchange.

In addition, under the arrangement of the Gansu province anti-drought, Chinese and foreign experts organized research study on drought relief work in Gansu province and practice of soil and water conservation field site investigation.

H.2.2 Main Conclusions Of Discussion Seminar Meeting

The exchange of drought disaster risk management discussion meeting discussion shows that the pilot province have many aspects need to be strengthen in order to meet the needs of drought disaster risk management. The main strategic conclusions over this meeting were as follows.

1. City and county personnel engaged in drought management are relatively few.
2. Three pilot provinces is generally lack of drought monitoring and early warning means and methods.
3. Drought disaster risk management knowledge of drought management personnel at all levels is limited.
4. The relevant policies, regulations and technical standards of drought assessment requires improvement.

H.3 Field Investigations

Gansu province is located in the geographic center of mainland China part, beside the Yellow River upstream of the loess plateau, with its continental monsoon climate, is one of the provinces of our country most affected by the drought. Although there are many aspects need to be strengthen in the field of drought resistance and disaster mitigation, but in the long drought in practice has accumulated a lot of good practices. A field trip was organized for a day to tour some of these local practices.

Rainwater collection cisterns in the rural area in Gansu province production has played a huge role, especially in the mountains. Less precipitation in Gansu province, and the distribution is extremely uneven precipitation years, precipitation in June and September accounts for 65% ~ 75% of annual rainfall, for people in the mountainous area of production water is very bad of peasants' lives. In order to adapt to the adverse conditions of drought, many parts of rural households have been 2 or 3 piece water cellar, through reservoir flood season rainwater for life and production.

Although the less precipitation in Gansu province relative to other provinces, but rainfall distribution is relatively concentrated and located in the loess plateau, Gansu province is one of the provinces for serious soil and water loss in China. Not only it causes the farmland soil erosion and damages the ecological environment, flooding disaster, but also increasing the drought disaster vulnerability enhancement. Gansu province, in recent years, has achieved a lot great experience in soil and water loss control. The project team went to Dingxi city, the stable area has area of 3306 km2, soil and water loss in 91% of the land area and the unremitting efforts, since the 80s of the 20th century until 2009, has control the soil erosion area of 2361 km2, accounting for 71.4% of the original soil erosion area, which mark beautiful mountains and rivers and fertile land in those losses land again.

The big ridge double line is a kind of farming method, namely, change traditional single ridge cultivation for big ridge line double row planting. Big ridge double row planting than single ridge cultivation line, reducing

the surface evaporation area and the effect of evaporation, which is helpful to keep moisture, which not only have the effect of the drought but also conducive to agricultural production.

H.4 Improved Policies and Regulations to Move to Drought Risk Management

Implementation of drought risk management will make human society more actively respond to the increasingly serious drought well, so as to minimize the loss and impact of drought. At present, China's drought management focus even more on the disaster in drought management, implementation drought disaster risk management should not only focus on the management, also should focus on pre-disaster and post-disaster management. At present, China's relevant policies and regulations drought mitigation mostly focus on disaster management in the context of the designation, in order to adapt to drought risk management, which still need to study and formulate relevant policies and regulations, including the relevant technical norms and standards.

H.5 Provincial Workshops of March 2014

In March 2014, a second set of provincial workshops were undertaken to introduce the draft provincial DMP contents and discuss the following topics:

- Framework of drought management plan.
- Relationship of provincial DMP to local level DMPs.
- Warning systems proposed and triggers for actions, various levels of DMPs.
- Systems incorporated into the DMPs
- International best practices on implementation of DMPs.
- Discussion of provincial obstacles or constraints to implementing the drought risk based DMPs

Speakers for the provincial workshops included the TA team leader, deputy team leader and international water saving specialist. Local specialists with knowledge of the drought problems in the respective provinces were also invited to participate.

The provincial level FCDRH staff and related ministerial members of the FCDRH were invited to the workshops, as well as some municipal and county level FCDRH staff.

Based on input received from these workshops, the draft Provincial Drought Management Plans the DMPs were revised and finalized, and presented in the final project report and final workshop in Beijing.

H.6 Final Workshops of June 2014

The provincial drought management plans and draft drought risk management guidelines were reviewed with the State FCDRH, MWR, pilot provinces and ADB during a final project workshop in June 2014. Many of the same discussions were heard about the perceived value of the approaches but the major constraints of lack of funding and lack of strategic direction from national government makes implementation of these techniques difficult. The focus and funding is now tied to drought relief activities.

Several suggestions were made by the workshop participants which have been incorporated into the drought management plans, draft drought risk management guidelines, and draft Final Report.

Annex 1 – Detailed Meeting Notes in Provincial Workshop

Project Title	ADB: Pilot Implementation of the Drought Management Strategy	Division	CNE
项目名称	亚行：干旱管理战略实施试点项目	部门	CNE
Subject 主题	Provincial workshop for drought risk management and discussion 干旱风险管理省级研讨及讨论	Project no. 项目编号	322424
Location	5th Meeting Room, Jinjiang Sun Hotel, Lanzhou, Gansu Province	Date of meeting	05-09-2013
地点	甘肃，兰州，锦江阳光酒店，五层会议室	日期	2013-9-5
Attendees 参加人员	National FCDRH: Liu Baojun Foreign fund PMO of MWR: Zhu Jiang, Wu Zheru Gansu provincial FCDRH: Zhu Jianjun, Jin Xiaobing, Ji YaohongJi Yuehong, Cao Xiying Sichuan Provincial FCDRH: Xu Guoqiang Liaoning provincial FCDRH: Kang Guichun, Yu Lingfeng Gansu local FCDRH: JiuQuan Municipality, DunHuang Municipality, Zhang Ye Municipality, Lanzhou Municipality, Qi Lihe district, Yong Deng county, Yuzhong county, Gaolan County, Linxia prefecture, Dongxiang County, Ding Xi municipality, An Ding district, Tongwei County, Tianshui municipality, Gangu County, Pingliang municipality, Kongdong district, Jingchuan County, Qingyang county Gansu local WRB : Su Zhou district, Gan Zhou District, Ji Shishan County, Huanxian CDTA Team: Lawrence Quinn, Marieke Nieuwaal, Lv Juan, Su Zhicheng, Wu Yucheng, Sun Yan IWHR Team: Sun Hongquan Mott MacDonald supporting: Yu Mia, Zhang Yi 国家防办：刘宝军 水利部外资办：朱绛、武哲如 甘肃省防办：朱建军、金晓兵、姬跃红、曹希英 四川省防办：许国强 辽宁省防办：康贵春、郁凌峰 甘肃防办系统：酒泉、敦煌、张掖、兰州、七里河区、永登县、榆中县、皋兰县、临夏州、东乡县、定西市、安定区、通渭县、天水市、甘谷县、平凉市、崆峒区、泾川县、庆阳市 甘肃水务局：肃州区、甘州区、积石山县、环县 技援团：劳伦斯、马利卡、吕娟、吴玉成、	Time of meeting 时间	9:00-17:30

苏志诚、孙岩
中国水科院防洪抗旱减灾所：孙洪泉
莫特麦克唐纳：于淼、张翼

Item 要点	Text 内容	Led by 主导
Opening 致辞	- ZJ: One of the main consequences of climate change would be the increase of extreme events frequency, including flooding and drought. Comparing with flooding, the studies on drought have not been taken that much in China. Drought impact is much broader and profound. Integrated water resources management and implementing the most strict water management system are part of the solutions, which also cover establishing of water saving society. - ZJ: The experiences and lessons we learnt from China could be shared with other countries in the future. - ZJ：气候变化的主要后果之一就是极端事件发生频率的增加，其中包括洪水和干旱。同洪水研究相比，我国的干旱研究还不多，但干旱的影响面广，且深远。水资源综合管理和实施最严格的水资源管理制度都是与干旱管理有关的内容，有助于我们应对干旱，其中也涉及到节水型社会建设，节水是一项重要的措施。 - ZJ：中国的干旱工作经验和教训今后也可以与其他国家分享。 - ZJJ: This workshop would provide good opportunity for who has drought management role to communicate with each other. - ZJJ: Drought is quite common in Gansu Province; usually there is nine years with drought conditions out of ten years. Drought management and relief work has been given significant importance in Gansu and the working method has been changing from ‘isolated way’ to ‘integrated way’ and from positive to proactive. Several water sources had been taken into account including surface water, groundwater and rain using by water supply infrastructures in different sizes. Water saving agriculture has also been promoted comprehensively. Rain water collection and reuse has also been adopted in many places, both for irrigation and potable water supply. - ZJJ：本次研讨会对于各省参与抗旱工作的人员提供了一次宝贵的学习和交流机会。 - ZJJ：甘肃省可以说十年九旱，年年有旱，省里非常重视抗旱减灾工作，也在不断的更新工作思路，正在从单一抗旱向综合抗旱转变，从被动向主动转变。通过一系列大中小型供水工程，正在实现地表、地下、天上之水一起抓。全面实施了节水灌溉项目，在旱作农业区推行了雨水收集。	ZJ: Zhu Jiang ZJJ: Zhu Jiangjun
presentations 报告	- LQ: Introduce drought risk concept and ideas. - LQ: Drought risk management is part of the integrated water resources management, which China has been promoted for a few decades by now. IWRM is trying to incorporate drought management into hundred percent times of supply – demand management of water resources. The No. 460 Order of State Council allowed the water allocation changes in drought	LQ : Lawrence Quinn

Item 要点	Text 内容	Led by 主导
	conditions. - LQ: ADB phase I and phase II projects and goals. - LQ: We are going to include pre-drought planning before taking actions in current drought relief plan in three pilot provinces from what some recommendations could be provided to the whole PRC to look at. - LQ: We are going to propose a layered approach and want to get some feedback from all of you about how much is appropriate at provincial level or municipal level. The approach may include three steps: 1, database (mostly meteorological based indicators but with some hydrological data)(data sharing is not easy although); 2. More localized information about drought. With specific local data, local people can flag area with consideration and there should be some normal roles and pre-drought roles of related organisations. 3. Local people should report the situation back to the provincial level for them to coordinate with other areas. - LQ：介绍了干旱风险理念和想法。 - LQ：干旱管理是水资源综合管理的一部分，中国已经推行了十多年的水资源综合管理。水资源综合管理就是努力要把干旱管理纳入到日常的水资源供需管理当中来。国务院第 460 号令允许了在干旱时期对配水量做出调整。 - LQ：亚行一期项目和二期项目的概述及目标。 - LQ：我们想在启动目前的抗旱预案之前，加入一些干旱前期的风险管理，在三个试点省份开始，之后根据在试点省的实施情况，对全国提出一些实施建议。 - LQ：我们会提出一个有层次的管理方法，希望之后能听到大家的反馈意见，看哪些对于省级或市级是适宜的。这种方法大概可以分为三个步骤：1，数据库(大部分是基于气象的数据，也可以有一些水文数据)(虽然数据共享仍存在问题，也无法一夜之间得以解决)；2，更多的基层干旱信息。有了更具体的当地信息，当地就可以标出重点区域，而且各部门的职责和工作应区分哪些是日常的管理行为，哪些是可能发生干旱期间的行动；3，当地应把旱情再上报给省级，以便省级与其他地区开展协调。 - LJ: Drought history of China and drought management work progress during last few decades. - LJ: Future prospects of drought management in China include inter sector coordination and cooperation, public awareness raising and participation and moving from passive drought management to proactive risk based management. - LJ：我国干旱灾害基本情况和抗旱减灾管理的发展历程。 - LJ：我国未来的干旱管理发展趋势包括跨部门的协调与协作、公众意识提升和参与、以及从被动抗旱向主动抗旱和风险管理转变。 - MN: Water saving society establishment in China from 2000 and related supporting regulations / policies.	

Item 要点	Text 内容	Led by 主导
Feedbacks From Liaoning 辽宁省反馈	- MN: Different water saving measures including administrative measures, economic measures, institutional measures and technical measures covering agriculture, industrial and urban sectors, and other supporting measures. - MN: Most of the water saving measures are applicable under normal conditions. For pre-drought and drought conditions, additional / enhanced water saving measures can be triggered, such as limits to water abstraction permit. - MN: UK examples on temporary reduction in water use and water allocation, and drought orders and permits - MN：从 2000 年中国开始的节水型社会建设和相关的支持政策和法规。 - MN：各类节水措施，包括行政措施、经济措施、政策措施、技术措施(按农业、工业和城市分)和其他的辅助措施、 - MN：大部分节水措施都是在常规条件下开展的，属于长效措施。对于干旱前期和干旱期间，可以启动额外的、强化的节水措施，比如对许可取水量加以限制。 - MN：英国有关临时缩减用数量、配水量，以及英国干旱令和干旱许可的案例。 - YLF: Introduce basic natural information and drought features of Liaoning. Because of the geological conditions, Liaoning Province has the high appearance of both flood and drought. - YLF：介绍了辽宁省的自然条件和旱情基本情况，由于地理位置的原因，辽宁省水旱灾害频发。 - YLF: Drought management measures Include engineering and non-engineering measures covering both supply and demand sides: - YLF：省里采取的干旱管理措施包括工程措施和非工程措施，既包括开源也包括截流； Engineering measures: 1. Building water storage / reservoirs and distribution system to meet agriculture, urban and environment water demand; Some water transferring projects are mainly for urban water supply. 2. As the water supply network expanding, some of the groundwater wells stop working and serve as standby emergency water resource; 3. Securing drinking water supply for rural area. 4. Canal lining and water efficient irrigation, eg. Sprinkler irrigation, pipe irrigation, and drip irrigation. Water saving agronomic practices and better field water management, eg greenhouses, mulching, drought resilient species and adjust cropping structure. 工程措施：	LJ: Lv Juan MN: Marieke Nieuwaal YLF: Yu Lingfeng KGC: Kang Guichun

Item 要点	Text 内容	Led by 主导
	1. 建设水利工程和配水系统，满足农业、城市和生态用水需求，还将建设其他一些水资源配置工程(引水调水工程)，主要用来解决城市用水。 2. 随着供水工程和管网的建设，之前一些机井就关闭了，封存起来可以作为干旱应急水源备用； 3. 农村引水安全工程的建设； 4. 渠道衬砌和高效节水灌溉，比如喷灌、管灌和滴灌等。节水型耕作和更好的田间用水管理措施，比如大棚、地膜、耐寒作物和种植结构调整； Non-engineering measures: 1. Provincial and municipal / county level FCDRH established. 2. Provincial and lower level Drought Management Plans(most of the municipalities and counties done), completed ‘Drought mitigation planning of LN Province’, ‘Implementation plan of LN drought mitigation planning’ and ‘Drinking well planning for drought management in LN’. Working on ‘Emergency Inter-basin water allocation plan for drought mitigating’. 3. Monitoring and forecasting: Within hydrology department: 1700 precipitation stations, 38 Evapotranspiration stations, 94 river table and river flow stations, 396 reservoir water table stations, 77 manual soil moisture stations and 90 automatic. There are also plenty of monitoring stations of precipitation and evaporation within meteorological departments. 4. Data sharing: The data sharing mechanism is in place between water resources department and meteorological department on real time precipitation data. For soil moisture data, needs to request when necessary. 5. Database software: There is a ‘flood control and drought mitigation database of LN’, and app can be installed in smart phone to enable real time data inquiry online, including precipitation, soil moisture and weather forecasting for short and mid term, and can also access the status of drought mitigation management actions and storage situation of the materials and equipment. 6. Early warning: Did some search study with IWHR on agriculture drought monitoring and early warning based on meteorological, hydrology, soil moisture and crop water demands. It’s more in study stage rather than practical. Data hunger is one of the main barriers to make it more applicable. 7. Drought relief materials and equipment reserve and action team establishment. 8. Agriculture insurance: Trial in 2008 according to No.1 document of 2004. Several insurance companies were engaged and most of the fees are subsidized by the government, 35% from central government, 25% from provincial financial department, 20% from	

Item 要点	Text 内容	Led by 主导
	local county financial bureau and 20% from individual farms. In 2009, 87% maize areas (in total 990,000mu) were covered by this insurance. The basic cost was 16.80 RMB/mu and additional 10RMB /mu for drought event. The 20% of the total cost including drought insurance was about 5.36 RMB/mu and the compensation was 140 RMB/mu for almost 0 yield, and 70 RMB/mu for partly losses. There is no compensation for area where the production is above 30% than average standard productivity. In the light of the severe drought in 2009 in Liaoning, and lacking of risk reallocation such as reinsurance and major loss risk fund, the insurance companies almost collapsed by collecting 73 million RMB insurance fee and paying as high as 287 million RMB. This reduces the interests and enthusiasm of insurance companies to stay in this area and keep going. 非工程措施： 1. 建立了省、市、县三级防汛抗旱指挥机构； 2. 省级、和市县一级编制了抗旱预案(14 个市和大多数县均已完成编制)，编制完成了《辽宁省抗旱规划》、《辽宁省抗旱规划实施方案》和《辽宁省抗旱饮水保命井规划》。目前正在编制《辽宁省跨流域抗旱应急水量调度预案》； 3. 监测与预警：水文局在全省拥有 1700 个雨量站、38 个蒸发站、94 个河道水位(流量)站、396 个水库水位站、77 个人工墒情站和 90 个自动墒情监测站。此外，气象部门也建设了大量降雨、蒸发等测站； 4. 数据共享：辽宁省水利部门和气象部门在降雨量观测方面实现了数据资源实时共享，但在墒情监测方面还未实现完全共享，水利部门如有需求，可与气象部门联系，气象部门会提供降水量分析、墒情监测等有关资料。 5. 数据库及软件：已建设‘辽宁省防汛抗旱信息平台’，有供智能手机安装的 app 客户端。可以在线查询实时的水雨情、墒情、气象预报(短期、中期)，抗旱工作动态管理、省级抗旱物资储备及管理等信息。 6. 早期预警：与防洪减灾所合作研究过一种农业旱情监测与预警方法，该方法综合了气象、水文、土壤墒情和作物需水量等信息。目前这种方法仍处于研究阶段，尚未投入实际应用。数据需求量大也是主要限制其投入应用的主要原因之一。 7. 抗旱物资储备和抗旱服务组织建设； 8. 农业保险：2004 年，根据中央 1 号文件精神，在部分地区启动了农业保险试点工作，2008 年，选择了一些保险公司。保费大部分由政府补贴：35%从中央财政补贴，25%由省财政补贴，20%由市县一级政府补贴，剩余 20%的保费由投保农户负担。2009 年，朝阳县 87%的玉面种植面积(总面积 99 万亩)参加了大田玉米保险，基本保险费为 16.8 元/亩，附加旱灾险保费为 10 元/亩，其中农户承担 20%，也就是 5.36 元/亩。 绝收面积每亩按 140 元理赔，部分损失面积平均每亩按 70 元理赔，收成在 3 成以上的不予理赔。2009 年朝阳市旱灾损失巨大，由	

Item 要点	Text 内容	Led by 主导
	于没有建立农业保险风险分担机制(包括再保险机制和巨灾风险基金)，保险公司亏损，朝阳市种植业保险费保费 7300 万元，赔款支出高达 2.87 亿元。直接影响了保险公司经营种植业保险业务的积极性。 - YLF: The IWRM has been strengthened under the project in 2005, water norms and GW management were introduced. There are some daily operations in per drought condition, eg, in dalian we have limits on water supply hours in the summer. - YLF：从 2005 年的项目以后，水资源综合管理得到了加强，实行了用水定额和地下水用水管理。在干旱前期有关部门也有一些行动，比如大连夏季的限时供水。 - YLF: we hope to relate the drought risk management theories to the drought management practice and learn the experience from the international examples. - YLF：我们希望可以把干旱风险管理的理念融入到干旱管理工作中，从其他国家的案例中学习管理经验。 - KGC: The IWRM should be strengthened further to incorporate drought mitigation into the daily work of many related organisations. - KGC：水资源综合管理和水务一体化还需要加强，把干旱风险控制与各个部门的日常管理职责结合起来。 - KGC: The concept and proposed system and plans are really good providing a good basis for us to work on. One consideration in rural area, where has the highest drought vulnerability is there is not many labours living in the villages now, most people are elder people with their grandchildren. This makes the implementation of DMP actions and drought mitigation actions more difficult. Also the monitoring stations in water income and water level, precipitation are sparse in most areas. - KGC：干旱风险管理的理念对干旱管理很有指导意义。但根据国情，有些东西到农村实现不了。农村现在没人，没劳力，预案下去以后无法一条条的做，应急灌溉的自动化水平也不够，对水源、来水量的监测站也不够。 - KGC: Localized demands from three pilot provinces could be raised and addressed in this project. This year 2013, the drought feature of Liaoning was quite abnormal: the soil moisture data didn't show any problem because the high GW level, also nor water level in servitor and precipitation data and the drought or water shortage happens 15cm below the surface. This drought appearance is quite odd. We hope this can be stressed. (Check the logic) - KGC：各省可以提出自己想研究的问题，加到研究中去。今年，辽宁省的旱情就很奇怪，由于地下水位较高，土壤墒情的监测数据显示没问题，水库水量和雨量也都不少，但就是土壤 15cm 以下缺水，表层缺水。不知道这种旱情该怎么预警。 - KGC: It's really difficult letting FCDRH to manage all drought mitigation actions between different agencies. Better to leave this coordination and leading role with the government at each level.	

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Feedbacks From Sichuan 四川省反馈	- KGC：如果让防办来协调各个部门的话，很难，最好是由政府出面，由政府来协调各个部门。 - KGC: The drought mitigation investment has not included in the planning of the local financial department yet, which brings the implementation of drought relief and mitigation measures some difficulties. - KGC：抗旱的资金目前还没有纳入财政预算，虽然国家有要求，但省财政不按那个执行，只承认财政部的文件。没有预算，一些干旱减灾的工作就很难落实。 - KGC: It's better to share the outputs and recommendations of this project with higher level staff, such as the state council, which will help the implementation of the outputs requiring inter-organisation cooperation. - KGC：项目的研究成果和建议最好能够拿到国务院去，有助于成果的落实。 - XGQ: The topography in Sichuan varies from plain to mountainous area on the plateau. Nine from ten years would suffer from drought conditions. Drought features also changes as the climate changing during these years. In 2006 and 2009, Panzhihua area had continuous drought for 187 days. - XGQ：四川省的地貌特点多样，有平原也有高原山区。可以说十年九旱。近些年随着气候变化干旱的特别也发展的变化。2006 和 2009 年，攀枝花地区出现了长达 187 天的连续干旱。 - Last year, IWHR flood control and drought relief centre helped us on drought early warning mainly with meteorological data, based on which FCERH can make decisions. - 去年，在水科院防洪抗旱减灾所的帮助下，我们也推进了一些早期预警方面的工作，主要采用气象指标，防办根据来水的情况再进行判断。 - Drought mitigation system has been established at each level together with the responsible system. - 目前已经在各级建立了抗旱制度和办法，落实了责任制。 - There are 126 counties having their own drought mitigation service team and each of those got 2 million RMB from the government for establishing and operating last year. There are 188 counties in Sichuan as a whole. - 目前有 126 个县有抗旱服务队，去年每个队从政府获得了 200 万元的支持。目前四川共有 188 个县。 - As lacking of labour in rural area, the DMP and actions will be difficult to be implemented at lower level. - 由于农村缺乏劳动力，一些抗旱预案中的行动在基层无法落实、 - The major action group would be the public not the government, although the government is more positive now. There is not much incentive for community / public to reduce drought impacts and participate drought relief actions. The size of single piece of land normally is less than 0.1mu	XGQ: Xu Guoqiang

Item 要点	Text 内容	Led by 主导
Feedbacks From Gansu 甘肃省反馈	(less than 67 m2), which is easily to be abandoned by the farmers versus carrying / transporting water or pumping water to reduce the losses. - 抗旱的主体应该是群众，但现在主要是国家主动，农民参与，而且不愿意参与。农民抗旱的积极性不够，单块地不到 1 分，天气旱了就放弃了。 - Water saving irrigation would be applicable for plain area not the mountainous area, where the water infrastructure is insufficient. The main focus of water supply infrastructure in mountainous area is potable water supply for people and livestock. After the big earthquake, some water sources can't be accessed or run out of flows, which apply new challenges to water supply in mountainous area. - 节水灌溉在平原比较好推行，但山区就很难解决，山区水源工程薄弱。山区的供水工程主要以解决人畜饮水为主。地震后，水源也发生了一些改变，有些山泉、溪流都断流了，人畜饮水还要分区域分情况对待。 - JiuQuan: Locates in arid area with very less precipitation with most area covered by desert and Gobi. There are some reservoirs and wells for water supply. Most irrigation infrastructures are aged and in poor conditions. There is almost a gap in data monitoring. - JiuQuan: Water supply infrastructures are top needed. - 酒泉：位于干旱地区，降雨很少，大多数地区都被荒漠和戈壁覆盖。 有几座水库和一万多眼机井。大多数田间配套工程都已老化失修，信息采集基本是空白。 - 酒泉：还是需要多修水源工程。 - Dunhuang: Belongs to Jiuquan city. There are 470,000 mu arable lands. The long term averaged annual precipitation is 39 mm/a. Seasonal drought often happens during June to July, with the most severe situation lasts for about 15 days. We have cash crop of grape and cotton. Water saving irrigation was implemented, of which the upstream sections are paid by the government and field pipes are paid by individual farmers. 2 million RMB was invested mainly for drought relief during the peak 15 days using watering trunk, pump and pipes. - 敦煌：隶属于酒泉市，耕地面积大约 47 万亩。多年平均降雨量 39mm，主要是季节性旱情，发生在 6-7 月份，最严重的集中在 15 天左右。经济作物有葡萄和棉花等。采取了节水灌溉，骨干到地头是政府出钱修，田间的设施由农民出钱铺设。投入了 200 万抗旱资金主要购买了大中型洒水车、水泵和管道，主要用来缓解最严重 15 天的抗旱需求。 - Suzhou: Natural conditions: 85 mm precipitation, 2000mm evaporation. Water storage and reservoir regulation capacity is not sufficient to regulate water flows to cope with supply – demand gaps. There is no monitoring station on precipitation and soil moisture. The drought relief work should not only rely on FCERH and it is difficult letting FCDRH to implement those actions and cooperate with other organisations. In extreme drought, there were some cases to reallocate water from some industries to agriculture, and all government initiated and enforced.	CXY: Cao Xiying

Item 要点	Text 内容	Led by 主导
	- 肃州：降水量 85mm，蒸发量 2000mm 左右。水源时空分布不均，调蓄工程少，基本没有任何雨量和墒情测站。抗旱工作只靠防办无法执行。特旱的时候，在面临绝收的条件下也会关闭一些企业用水调给农业，都是政府采取的强制措施。 - Ganzhou: Natural conditions are all similar. The drought mitigation measures include canal lining, cropping structure adjustment and public awareness raising. After the E Ji'na water transferring project completed, downstream irrigation conditions haven been improved. Pre-drought preparedness is not been done well. Because of lacking of financial supports, the situation would be more like 'free' style, i.e. subsidising a bit according to the financial affordability, losses can't be covered by government subsidies would need to be accepted and bear by farmers. - 甘州：自然条件都差不多。采取的工程措施主要有渠道防渗、种植结构调整和宣传教育。额济纳调水以来，较好地完成了下游的灌溉任务。干旱的前期预防还是不到位，因为财政缺钱，灾情出来以后就是能补的补一点，补不了就损失一点。 - AnDing District: Rainfed agriculture domains in arid and semi-arid area. Groundwater has been over abstracted with the depth of 30-40m in 1960s and 160-170m in recent years. Drought mitigation measures have been taken include cropping structure adjustment, rainwater harvest and water conservative cultivation such as mulching. The main crops are potato and maize. From 1991 to 2003, the rainwater harvest programme in front and behind the house in rural area were implemented in a large area, with the main purposes of drinking water supply and irrigation for self-consumptive crops. The Tao River transferring project is under construction, which is mainly for securing potable water supply and also for part of the irrigation. - AnDing: Some thoughts and suggestions helps with drought mitigation include 1) cropping structure adjustment; 2) securing potable water supply; 3) increasing urbanization rate. Urban area has the advantage of resident density hence the network could be installed much cost-effectively. And it follows the natural development trends as almost half population left the villages and moved to the towns and cities. 4) There are some institutional problems in drought management and related organisation. FCERH has plenty of work loads but always be stuck at data collection and coordination points with other organisation. The whole management system needs to be strengthened and improved. - 安定区：属干旱半干旱地区，主要是旱作农业。地表水主要是季节性河流，地下水超采严重，水位下降很明显。60 年代水位在 30-40m 左右，这几年到了 160-170m，浅层井都干枯了。采取的措施包括调整种植结构、发展地膜玉米和全膜玉米。城市的饮水主要归城建部门管，城市的用水基本不成问题。从 1991 年 2 月到 2003 年 4 月，实施了集雨水窖的建设，主要解决吃水和口粮问题，房前屋后两眼水窖，靠硬化的集流场收集雨水。正在建设引洮工程，兼具人饮和农业灌溉的用途，但主要是人饮。 - 安定区：个人认为最有效的干旱措施主要是种植结构调整、安全饮水项目和提高城镇化率。人口集中居住以后，便于管网的建设，目前人居住地比	

Item 要点	Text 内容	Led by 主导
	较分散。农村有的社 40-50 户人，有一半人离开，在乡镇和县城留下来。城镇化也是顺应了这种趋势。另外，管理机构职能也存在一些问题，每年的抗旱工作任务重，但工作起来不顺，数据要不来。抗旱管理工作要系统地抓起来，提高机构的综合协调能力。 - Lanzhou: in 2012, rainfed agriculture area with drought damage was about 1.18 million mu. Two of the main reasons were there is not surface water available in mountainous area and the water resources has not been used efficiently in a rational way. Most of the irrigation infrastructures have been used for 30-40 years and in poor conditions now. Some aged reservoirs need to be repaired and strengthened. The drought risk management concept is new to us, which has not been incorporated into our daily work and daily operation. Risk management should be introduced at strategic level and be implemented through a set of regulations and policies. The database and local triggers should be localized and targeted to present the gap between supply and demand sides and determine the risk. - 兰州：2012 年，有 118 万亩旱地受灾。主要问题有两个：1，缺水，山区没有地表水；2，结构型缺水，水资源未得到合理利用。大部分灌溉设施已经用了 30-40 年，老化失修，一些病险水库需要加固。干旱风险管理对我们来说是一个新的理念，跟日常工作还没有结合起来。干旱风险管理应纳入战略层面，指标要有针对性，能够反映用水需求和供需缺口，并确定风险。 - Pingliang: It’s good to design the indicator system and planning the monitoring stations and data sharing scheme. Data and indicators would be very helpful to decision making. Drought management improvement is a long term goal, which could involve water resources and its quality protection, capacity building and public participation with government guidance. Detail targets need to be designed for different audiences in the capacity building, which should also be a long term program. Government should provide guidance to the public through a full range of supporting policies, guidance and disseminations. Spending too much money on reserving materials and equipment what can only be used for once within several years doesn’t work efficiently. - 平凉：建立指标体系和测站、数据共享机制对于抗旱工作有帮助。数据和指标对决策非常有用。改善干旱管理应该是一个长效目标，应包括水源保护和水质保护、能力建设，以及政府引导群众抗旱。能力建设要在国家和基层层面建什么东西确定下来，一如既往的按着这个思路走，是一个长远的过程。政府应通过一系列配套的政策来引导群众抗旱，加大宣传。花了那么多钱增强抗旱物资储备，几年就浇了一次水就撂下来了，也没什么意思。 - Qingyang: Suggestions include some biological measures can be used to improve micro environment, such as planning trees, and whereas the natural conditions are not positive to local development, ecological resettlement can be initiated. Resettling from poor area to other places have more resources will help with avoiding building up infrastructures in an inefficient way.	

Item 要点	Text 内容	Led by 主导
	- 庆阳：个人认为可以采用生物措施，比如植树造林，来改善小气候环境。对于自然条件不好的地方，不需要加大基础设施的投入，应采取生态移民的办法。北部有分期分批地实施过生态移民，但由于观念问题，有些人不愿意，但从长远的角度来看应该移民。有的地方，花 32 万修一座桥，就为一户人家。 - CXY: The involving of risk based management and public community participation should be introduced to strategic level. At the same time, infrastructures should be improved further. One of the constrains on implementing warning system based on monitoring data and corresponding indicators is lacking of data and poor data quality due to some interest conflict. - CXY：甘肃是抗旱的重点省之一，全国只有甘肃一个省叫抗旱防汛指挥部，把抗旱放在前面。旱情基本年年发生。我们在抗旱节水方面采取了一些措施，水利和农业的措施都有。雨水集蓄工程启动的也比较早。农业上采用了节水灌溉和全膜耕种种植技术，还调整了种植结构。个人认为我们的项目很好，围绕增强抗旱减灾工作，应该由政府主导群众参与，成果应上升到战略层面。从实际出发，还需加强工程建设，加大力度。数据不够，以及有时候数据有水分，数据虚报，也是阻碍指标体系实施的问题。 - Tianshui: Drought is common in Tianshui and is the top natural disaster causing the most losses. The priority is potable water supply to human and livestock and then high value / cash crops. After the development of rainwater harvest wells for several years, the potable water access during drought season is almost solved. (Under drought conditions, farmers can carry water from water sources close by and storage in the rainwater well within their yard. The cost is about 150 RMB/m3, mostly for transportation.) How to include drought management into daily work of related organisations is a question. Water saving irrigation and cultivation technologies were promoted broadly, such as mulching, which brings another problem of mulch disposal. The current DMP is hardly to be really triggered and implemented. There is another issue of the operation and maintenance of the drought relief service group, if need to be funded by the government and embodied into local budget planning. - 天水：干旱是天水的主要灾害。基本上 10 年 10 旱，旱灾的损失最大。抗旱工作主要以保人畜为主，农业上的灌溉也是优先经济作物，干旱时期小麦和玉米可能就放弃了，抗旱难度大。房前屋后的两眼集雨水窖建成以后，这几年遇到严重旱，人畜饮水没有出现严重问题。春季旱的时候，农民就拉水吃，150 元/方(从就近的水源地拉，基本都是运输成本)，拉过来灌到水窖里。现在抗旱预案各级基本都有了，也成立了抗旱服务队，配备了 100 多辆拉水车，1000 多台水泵。干旱管理应该从干旱前期入手，但目前都是旱情发生后。监测不是重点，重点是预警值发生以后怎么办，日常的抗旱管理怎么做。农业上采用了节水灌溉和种植技术，比如地膜小麦和地膜玉米，保墒作用明显，但又带来的新的问题，地膜铺一次能用 2-3 年，之后怎么办？无法降解，农村地里出现了白色污染和黑色污染的问题。目前的抗旱预案启动了也很难实施，启动了也没什么力度。另外一个问题就是抗旱服务队的定位问题，财政是否支持？跟现在的水利改革怎么	

Item 要点	Text 内容	Led by 主导
	配套？需要政策研究中心研究。 - Dingxi: Drought management could be better managed by higher level government due to the inter-sectorial and inter-organisational natures. - 定西：干旱管理涉及多个部门，具体参数的收集和布点是否合理，数据质量能够保证？应由上级政府部门主管更好。 - Linxia: Daily activities coping with drought mainly stay within agriculture sector, such as water saving irrigation and cultivation, pest control etc. There are 76 meteorological monitoring stations managed by meteorological departments. The data sharing is good between water resources and meteorological departments, the soil moisture data can be provided at semi-monthly basis by meteorological department. Some biological measures, i.e. tree planting were promoted to improve micro environment and hence increase local precipitation. - 临夏：常态化的抗旱管理主要在农业口，包括土地整治、地膜、旱作农业技术，病虫害防治等。目前气象局有 76 个气象站，包括降雨、蒸发、墒情等信息，平常我们用的都是气象部门的数据，水利部门会用自动雨量站的数据来和气象部门交换数据，实现共享。土壤墒情数据时半个月测一次，半个月给一次。通过采取一些生物措施，植树造林，当地的小气候得到了改善，降水量有所增加。	
Conclusions 总结	- LJ: Some conclusions from discussion include: 1. Most people think it's better to inform top level decision makers with the outputs or recommendations from this project to get them implemented strategically. 2. The outputs and recommendations should be practical and representative to different areas; 3. Due to the difficulties in inter organisational corporation, drought management work is better to be managed by the government at each level, rather than led by a single organisation. 4. Drought management activities and related costs and expenses should be included in the financial budget locally. 5. In terms of the drought relief and management, government takes too many responsibilities and manages too much work. The public participation should be increased with the guidance from government. Drought management responsibilities should be shared between government and individuals. 6. It mentioned that the monitoring station is in absent and sparse in Gansu Province, where establishing monitoring stations could be one of the next focuses. 7. Cropping structure adjustment is also one of the drought mitigation measures taken in Gansu Province. 8. Risk based management needs to be supported and incorporated into related legislations, regulations and policies to make it happen in	LJ: Lv Juan LBJ: Liu Baojun LQ: Larry Quinn

Item 要点	Text 内容	Led by 主导
	reality. 9. Proposed indicators need to be practical. Some suggestions on indicator selection could be provided. 10. Some suggestions on the sustainability of development of drought relief service group could also be included in policies and regulations to establish a good basis for this new organisation. - LJ：主要总结几点： 1. 大家一致认为，这个项目的最终成果和建议应该上升到战略层面，得到高层的认可，有助于成果的执行，我们可以朝这个方向努力； 2. 项目成果应因地制宜，能够反映当地的情况，可操作性强一些； 3. 抗旱工作应由政府管理，光靠一个部门不好做，配合起来有困难； 4. 干旱管理工作应纳入政府财政预算，经费有提前量； 5. 就抗旱减灾来说，政府承担的太多了，责任太大。应由政府主导，群众参与，人人有责； 6. 甘肃目前监测设施比较落后，应作为下一步工作的重点； 7. 甘肃省，农业种植结构调整是一项有效的抗旱手段； 8. 干旱风险管理，应体系化，通过一系列法律、法规和政策得以落实和实施； 9. 指标应细化，对地方有可操作性，对指标的选取提出一些建议； 10. 关于抗旱服务队的建设与发展有哪些政策方面的建议，也可以向高层建议，写进政策和法规文件，便于落实； - LBJ: Drought management work is hardly to be done solely by water resources department. In order to improve current situation, FCDRH was established under different level of government with different organisations involved, although some difficulties remains due to some institutional constrains. - LBJ: Central government paid great attention on drought management work. Drought Emergent Water Allocation Plans are under preparing for seven river basins. - LBJ: The current focus of state FCDRH is emergent drought relief. The introduction of risk based drought management in hundred percent time passes messages about how we could do thing differently or from different angles to us. - LBJ：抗旱工作难度大，不能光靠水利部门，本着把工作做好的出发点，成立了防办，有很多成员单位参与，但由于一些体制的原因，实施过程中仍存在一些难度。 - LBJ：中央政府高度重视抗旱工作，目前七大江河抗旱水量调度预案正在编制当中。	

Item 要点	Text 内容	Led by 主导
	- LBJ：目前，国家防办是从应急抗旱的角度开展工作的，干旱风险管理理念把干旱管理纳入了日常的工作当中，使我们很受启发。 - LQ: We meant to provide some information and cases on risk based drought management although we all know those constrains can't be solved in next month, for example, data sharing and institutional issues. The IWMR concept included drought management principles which need to be improved. - LQ: Infrastructure can't solve all problems and drought is always there. In terms of drought, agriculture is the hardest one to solve all over the world. Drought management should be done in a tiered and integrated way, and the separated management for urban and rural area should be upgraded to regional or district level. - LQ: Economic leverage can be used to pay for agriculture compensation. Agriculture losses can be covered both by the insurance bought by farmers and paid by urban water users. - LQ：我们想为大家展示基于风险的干旱管理思路和一些案例，我们也知道有些问题无法立即得到解决，比如数据共享和体制问题。水资源综合管理的理念就包括了干旱风险管理的内容，水资源综合管理的实施还需要加强。 - LQ：工程不能解决所有的问题，干旱总是会发生。靠工程今天可以解决 20 年一遇的干旱，但解决不了百年一遇的。在全球，农业都是干旱管理难度最大的行业。干旱管理应该采用一种分层级的、综合的方法，目前城市和农村分开管理的模式应该被区域或地区的综合管理所替代。 - LQ：可以使用经济杠杆来支付农业的一些损失，农业损失可以由农民自身购买的保险和城市用水户的用水补偿来同时支付。	

Appendix I. Study Tour

I.1 Study Tour Objectives

The intended goal of the study tour was to allow China decision-makers to understand the status of drought, water resources management and drought management programs, and structural and non-structural control measures employed in a couple of European countries.

I.2 Plan For Study Tour

I.2.1 Selection of Countries

Several European countries were assessed for relevance related to the proposed international study tour. Spain and Portugal were selected as containing representativeness related to drought issues. There are a variety of topographic and hydrologic regions in Spain, so it is a good country for the Study Tour to review how drought management is handled in diverse regions.

Administration of water is performed at basin scale by Basin Agencies (Confederations Hydrographical) since early in the 20th century, and water laws enforce the design and implementation of Basin Plans (BP), since 1985, and of Special Drought awareness and mitigation Plans (SDP) at basin and local scales, since 2000. Since the year 2000, Spanish water law requires the basin agencies to develop Special Drought Plans (SDP) in order to turn the traditional reactive crisis management approach into a proactive approach. SDPs are managed at the basin level in Spain, and are a specific requirement of the river basin management plans. Spanish SDPs include the following components:

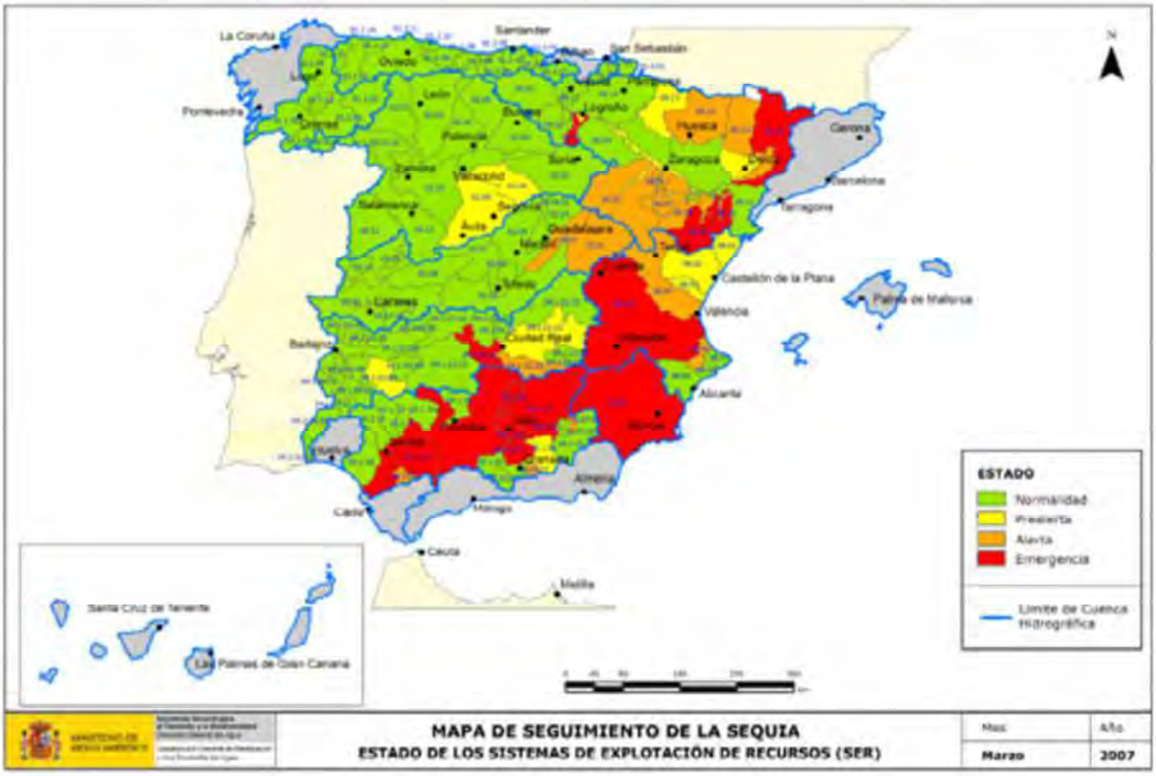
- Diagnosis
- Identify and characterize territorial and environmental elements.
- Zonification
- Analysis of historical droughts and drought characterization
- Definition of indicators, thresholds and drought phases
- Program of Measures (POM)
- Definition of general measures and specific ones for each area to be applied in each drought phase
- Management and follow-up system
- Organization and management systems
- Definition of indicators for the implementation follow-up and effects

The selection of indicators in Spain is based on:

- Identification of the origin areas of resources associated to specific demand units.
- Selection of indicators types according to how well they represent the resources' supply.
  - Precipitation
  - River inflows in natural regime
  - Stored volume in surface reservoirs
  - Piezometric levels in aquifers

Figure I.1 shows a drought map for Spain as well as relevant drought classification system.

Figure I.1: Drought Map and Classification System for Spain



TYPES OF MITIGATION MEASURES							
Indicator	1-0.5	0.5-0.4	0.4-0.3	0.3-0.2	0.2-0.15	0.15-0.1	0.1-0
Status	Normal	Pre-alert		Alert		Emergency	
Objective	Planning	Information-control		Conservation		Restrictions	
Type of measure	Strategic			Tactics		Emergency	

Portugal was added to the study tour agenda since it is close to Spain and contains other geographical features and management systems of interest.

I.2.2 Results of Study Tour

An international study tour to Spain and Portugal was held in December 2013 to study the drought management techniques used in some EU countries that have faced significant drought problems in recent years. The full Study Tour report is in Annex 1. The following are some important lessons from the Study Tour for PRC drought management:

(1) The national system for monitoring of drought risk

Spain and Portugal shifted some time ago from drought relief to drought risk management, with real time monitoring since 1985. A joint EU internet-based drought monitoring and prediction system for European drought has been set up and has evolved to offer timely and authoritative information. This provides real-time of monitoring and drought forecast information for each area and river basin, including drought monitoring indicators (SPI, soil moisture) and drought classification. It provides a platform and standard format for shared data, with an annual seminar for the exchange of knowledge.

(2) The introduction of water saving management is needed to avoid the risk of drought

Drought restricts agricultural development which is critical for Spain's economy, so water-saving irrigation has been highly developed and promoted by the government. Modern techniques such as drip and spray irrigation are used on 90% of the land. Water distribution systems are automated, with accurate measuring and control equipment, and all data is compiled and managed efficiently. Farmer cooperatives are actively involved in management, thus reducing the management costs.

(3) Water conservancy construction to regulate drought risk

Water storage dams have been built for thousands of years, and are very important for mitigating droughts. In addition, water transfers from the wet north to the dry south are very important for this purpose.

4) The development of drought management plans to address drought risks

The new Water Law in Spain in 2001 required each basin to prepare drought management plans and these have been approved at ministerial level. These ensure adequate water supply to guarantee the human life and health; minimize the ecological impact of low flows; and determine priorities for water allocation at time of drought on public water supply.

The drought management plans draw on:
- Diagnosis of the drought situation – basin characteristics, historical trends, drought indicators, thresholds and standards.
- Development of drought response measures. With the development and intensification of droughts, the response gradually rises from information management to water-saving measures, and finally to restrictive measures. Drought mitigation measures include new wells, canals, desalination plants, and non-engineering measures, such as changing priorities of water, and increased abstraction of groundwater. Conjunctive management of surface and groundwater has proved to be very effective
- Public consultation, stakeholder collaboration, and integration of local knowledge and practices into different levels of water management.

(5) Through the introduction of agricultural insurance systems to divert the drought risk

Drought risk insurance is high risk, low income in comparison with other types of insurance. However, Spain and Portugal have developed a good system through collaboration between insurance companies and the Government. This followed on from a law on agricultural insurance in 1978. The government subsidises the premiums, at different levels ranging from 20-50% according to the crop (and differs between male and female farmers), and provides reinsurance to the insurance firms. This has proved to be

very effective at sharing risks and has avoided the need for the government to pay out emergency relief. Farmers who do not take out this insurance will not get any relief from the government in the event of any drought.

(6) Enhanced public awareness education

Public awareness of water-saving is essential, and this starts from a very young age and is comprehensive. Full details are provided and information is available to everyone. All forms of media are used.

I.2.3 Lessons for drought management in PRC

(1) Speed up the transformation of management mode

Although emergency management through relief aid projects, to drought-affected populations with bailout funds or other forms of support is very common, this kind of passive management is seriously flawed, because it does not help beneficiaries to change their behavior or resource management practices as a condition of receiving assistance. Reliance on Government aid can reduce the enthusiasm of the affected people to get involved drought prevention and mitigation, and it is not conducive for encouraging producers to invest in enhancing the ability to cope with drought and self-reliance. It is therefore recommended that drought risk management capacity is further strengthened.

(2) Promote institutional reform

In Spain and Portugal, all agencies associated with drought are subordinate to the Ministry of the Environment, which avoids the issues of redundancy or lack of coordination. This contrasts with the situation in PRC, where although State and local flood control and drought relief headquarters are the drought relief authorities, there are many businesses across different sectors, Ministry of Water Resources, Ministry of Agriculture, Weather Bureau, and The Ministry of Civil Affairs who are also involved. In times of drought emergency and drought relief organizations can be coordinated efficiently and orderly at all levels, but given the slow development characteristics of drought emergencies, this linkage does not meet the economic and social demands.

Therefore, in addition to emergency drought relief functions, functions of drought resistance need to be strengthened in routine times (Normal stage), breaking through systematic obstacles from top to bottom, establishing multi-sectorial integrated coordination mechanisms.

(3) Enhancing drought risk monitoring

At present, some work on drought risk monitoring had been carried out, but it is not comprehensive so there is a need to strengthen meteorological, hydrological, agricultural, industrial, water intake and water supply monitoring systems associated with drought, and to improve dynamic (real-time) monitoring capacity for drought- related information. This should have a complete national coverage and reasonable layout, with a good network of information and resource sharing.

In addition to the establishment of drought information monitoring system, even more important is the creation of information-sharing mechanisms among the various relevant departments. At present, various inter-departmental information sharing can be done more smoothly in times of drought emergency

communication, but this is difficult to achieve in ongoing drought management. Information resources are managed by the various administrative departments, with "islands of information." There are obstacles to receiving timely and relevant information from each sector to provide effective early warning for drought prediction, with objective and scientific assessment of drought risk. Therefore, the State should formulate as soon as possible and introduce drought-related information sharing arrangements and develop data-information-sharing networks. It is essential to break the departmental segmentation of information resources as well as geographic segmentation. Establishment of interagency information-sharing mechanisms is needed to achieve the transformation from information resources to shared use.

(4) Strengthening water-saving management.

The temporal and spatial distribution of water resources in China is extremely uneven, with insufficient water resources per capita at just 30% of the world average. With global climate change and increasing demand for water, the water resources shortage situation is increasingly dire. The traditional water management model has led to increasing water demand, which cannot be met on a sustainable basis. There now needs to be a paradigm shift to water demand management, recognizing water resources capacity constraints, optimizing the industrial structure, improving water use efficiency, strengthening soil and water conservation, paying attention to water conservation and water information. In determining the scale of economic development in many regions, water constraints have not been appreciated, and its consequences have seriously affected economic and social development.

(5) Improving emergency response capabilities

In Spain the core of the management plan is to identify and develop appropriate response measures in advance, so that when droughts occur, responses can be targeted, rapid and effective. Although China has carried out similar work in the form of a drought relief preparedness system, this has exposed a lot of problems, mainly reflected in the lack of scientific reasonableness and operability of the plan. At present, China has completed the planning for drought resistance in many places, but this is often a formal content without a specific, in-depth, clear plan for response measures and with poor operability. Different levels of emergency response, project scheduling, emergency engineering and non-engineering measures for water provision, responsibilities of related departments, must be clear and specific, highly targeted and operable.

(6) The system of drought insurance

The mode of interim relief in response to natural disasters in China has for long been to provide compensation for disaster losses to a certain extent, but this is a drop in the bucket compared with the true value of disaster losses. In Spain, and Portugal and elsewhere internationally, disaster risk insurance system is an important measure. Although agricultural insurance does cover drought risks in some provinces in China, but in most cases the damage caused by the drought risk cannot be compensated by agricultural insurance. It is difficult to provide insurance to transfer the risk of drought, especially in the case of severe droughts. There is an urgent need establish a system of drought insurance, suited to the characteristics and law of drought in China, in accordance with the principles of insurance, to attract community funding. This will sharing of disaster risk between policyholders, insurance companies and the Government.

Annex 1– Study Tour Results

Drought management strategies in Spain and Portugal

Centre for International Economic and Technological Cooperation and Exchange

Ministry of Water Resources

Introduction

Through the Office of the State flood control and drought relief headquarters, International Center for economic and technological cooperation and exchanges of the Ministry of water resources and the efforts of China Institute of water conservancy and hydropower, the Asian Development Bank technical assistance project "drought management strategies for the implementation of pilot studies in China" (TA8185-PRC) was officially launched in March 2013. This project builds on the "China drought management strategy research" (TA7261-PRC), with further in-depth research abroad into drought management concept and practices, combined with the actual situation in Gansu, Liaoning, and Sichuan where pilot work has been carried out, and drought risk management tools and management plans have been developed with international drought management assistance. This exchange training is an important part of the project work.

In December 2013, International Director of the Center for economic and technological cooperation and exchanges of the Ministry of Water Resources, the State Protection Office, the protection office in Liaoning province, China Institute of water conservancy and hydropower, seven People led by Yu Xingjun (list attached) went to Spain, and Portugal to learn about drought management in the two countries. In accordance with the schedule, the exchange mission visited Spain Ministry of Environment, Spain engineering consulting firm OFFITECH, and Spain Institute of Energy, Environment and Technology, Spain land for economic redevelopment, Madrid, water resource managers, Portugal water resources Association, Portugal Cascais municipal water departments and other departments, and visited drought-resistant engineering projects.

Main Results of Study Tour

Situation in Spain and Portugal

Spain and Portugal Iberian Peninsula is located in South-Western continental Europe where, overall, the climate is mild and humid. But due to the greater variability of rainfall in time and space, there is uneven distribution of water resources and Spain's drought risk is higher.

Spain

The national average precipitation is 685mm, but precipitation varies greatly between the North-west in the Pyrenees (1500mm) and the South-East Eastern Mediterranean coastal Almeria (250mm). More than half area has an annual precipitation of less than 500mm, and about 20% of the area has more than 1,000mm. National water resources total 1,112 billion m^3. The major rivers include the river Duero, Tagus, Guadiana, Guadalquivir, and the country is divided into 16 River basin. Per capita water resources is about 2,700m^3, but this varies greatly in different river basins - from 14,738m^3 to just 263m^3/capita.

Grain output has remained for years at 2,100 Million tons. Wheat is the most important food crop, and Spain is also rich in oranges and lemons - citrus production ranks third in the world. Spain is the first in the world for olive oil production and export. Therefore, agriculture is worst affected by the drought in Spain. There have been many droughts over the past decades, 1941~1944, 1979~1982 and 1990 ~1995. Among them, the 1990~1995 -year drought is the most severe, affecting Spain most of southern and central regions, affecting 12m people, with agricultural losses amounting to 10 million euros, Hydro-electric power loss 14.5%, fire incidence in the southern region increased by 63%. Several cities were affected, including Granada, Seville, and Málaga, Toledo. Water restrictions were particularly strict in the Costa del Sol region, with the usual daily supply was reduced for 30% of the population.

Portugal

Portugal is located in the West of the Iberian Peninsula, adjacent to the Atlantic Ocean. The average annual precipitation is 960mm, regional distribution decreasing from North to South, Northeast up to 1500mm or more, Central 800~1000mm, South is reduced to 600mm. The average annual evaporation is 500mm. It is dry in the Central and Southern parts for up to 4 months, and therefore agricultural production must rely on irrigation. There are 15 river basins, water resources amounted to 687 billion m^3, per capita water resources for 6,870m^3. Judging from the precipitation and water resources, Portugal belong to regions with abundant water resources, but it also often face the threat of drought in Central and southern areas. The highest drought risk is for non-irrigated agriculture, but with the development of tourism and irrigated agriculture, water demand has increased. Recently there was a drought in 2007. As a result of climate change it is expected that the Iberian Peninsula will have significantly increased chances of serious drought, especially in the spring and summer.

Spain and Portugal's drought risk management practice

(1) The national system for monitoring of drought risk

Spain and Portugal shifted some time ago from drought relief to drought risk management, with real time monitoring since 1985. A joint EU internet-based drought monitoring and prediction system for European drought has been set up and has evolved to offer timely and authoritative information. This provides real-time of monitoring and drought forecast information for each area and river basin, including drought monitoring indicators (SPI, soil moisture) and drought classification. It provides a platform and standard format for shared data, with an annual seminar for the exchange of knowledge.

Drought risk monitoring provides important information for support for drought relief and disaster reduction decision-making. The shift from crisis management to drought risk management is one of the central elements. Spain, and Portugal and other European countries in the area of disaster information monitoring and information-sharing are at the forefront of the world.

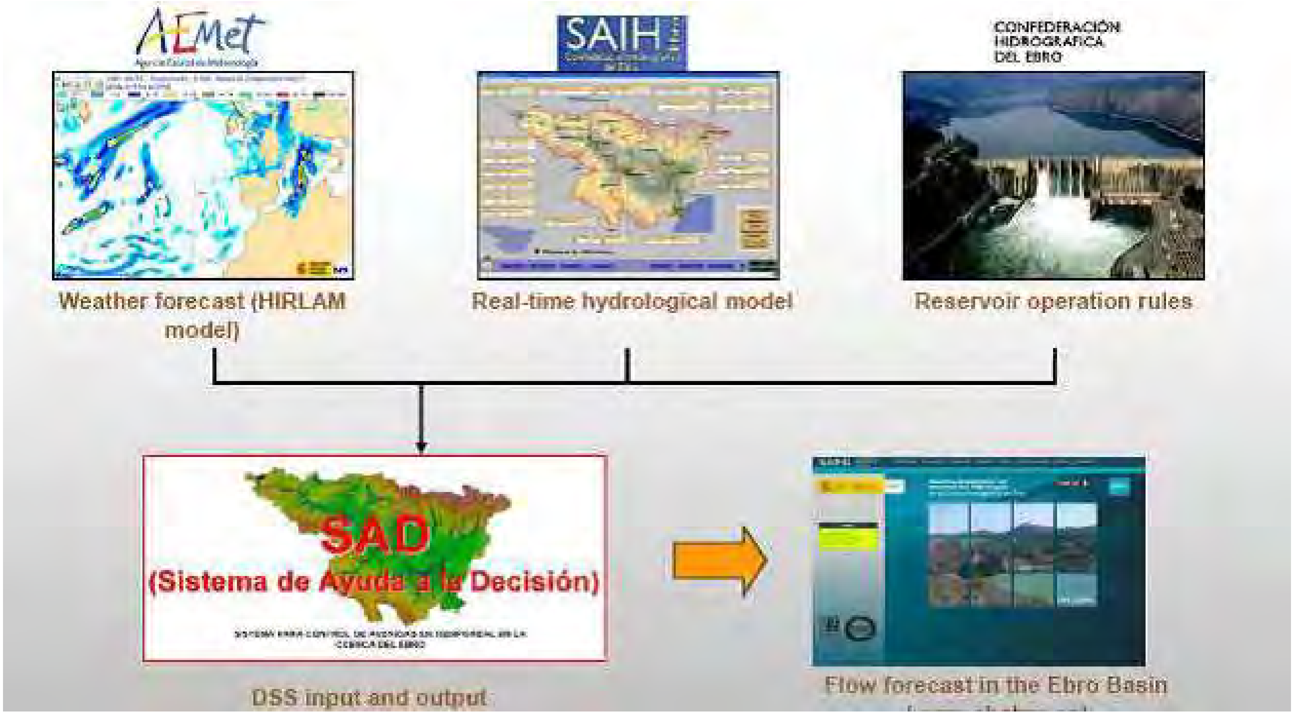
As the European regionalization of regional drought affecting the scope and severity at a European level in order to provide consistent and timely drought information for the European drought prediction, assessment and monitoring, implementation of decisions in the EU Joint Research Centre of the European Union " DESERT "The action on the basis of" the European drought watch "(European Drought Observatory) System development. "The European drought watch" the main objective of the project is to provide Europe with a platform of Internet-based drought monitoring and prediction for the European drought and evolve to offer timely and authoritative information. Specific target including: through multi-channel integration

European continental (EU level), and national (the members level), and area and river basin related information; for drought prepared and warning provides real-time of monitoring and forecast online information; on daily using of drought monitoring indicators, as standardization rainfall index, and soil humidity, reached consistent; dispersed data of shared and management, through general standard format achieved different level data and information of directly contact and Exchange; through different level continued of feedback, constantly comparison improved, Institutions for the annual user seminar provides a platform for the exchange of knowledge.

In Spain, engineering consulting firms OFFITECH developed a real-time automatic monitoring information system as early as 1985.

Figure I.2: Meeting with a Spain engineering consulting firm: OFFITECH

Figure I.3: Flood and drought management based on data sharing decision-making processes-to Ebro Basin



2001 Year of introduction of the Act requires the national hydrological plan, Spain has developed into specialized information and decision system of drought--national drought index system (National Drought Indicator System. The system includes the following items:

- All basin hydrological, meteorological and other basic information for each control in real-time monitoring, mainly includes the water levels in reservoirs, groundwater flow, precipitation, runoff, storage parameters reflecting drought in the basin.
- Watershed personalized integrated drought indicators. Each watershed based on different parameters are given different weights, and then integrated into a composite indicator of drought.
- Basin drought classification. In constructing an integrated drought indicators on the basis of historical data series, basin drought classification criteria established, in turn divided into normal situations, early warning, alert and emergency in four phases.
- Information sharing and disclosure. Watershed Management Committee to submit such data on a regular basis to the water resources division of the Department of the environment database, and then the Ministry of the Environment in the form of diagrams, tables and statistics monthly report form, posted on the Web site of the Department of the Environment, for inspection by the relevant stakeholders and the public.

Figure I.4: Spain Ministry of environment for exchanges on drought management issues

Figure I.5: National drought indicator system on the Ministry of the Environment Website, open to the public

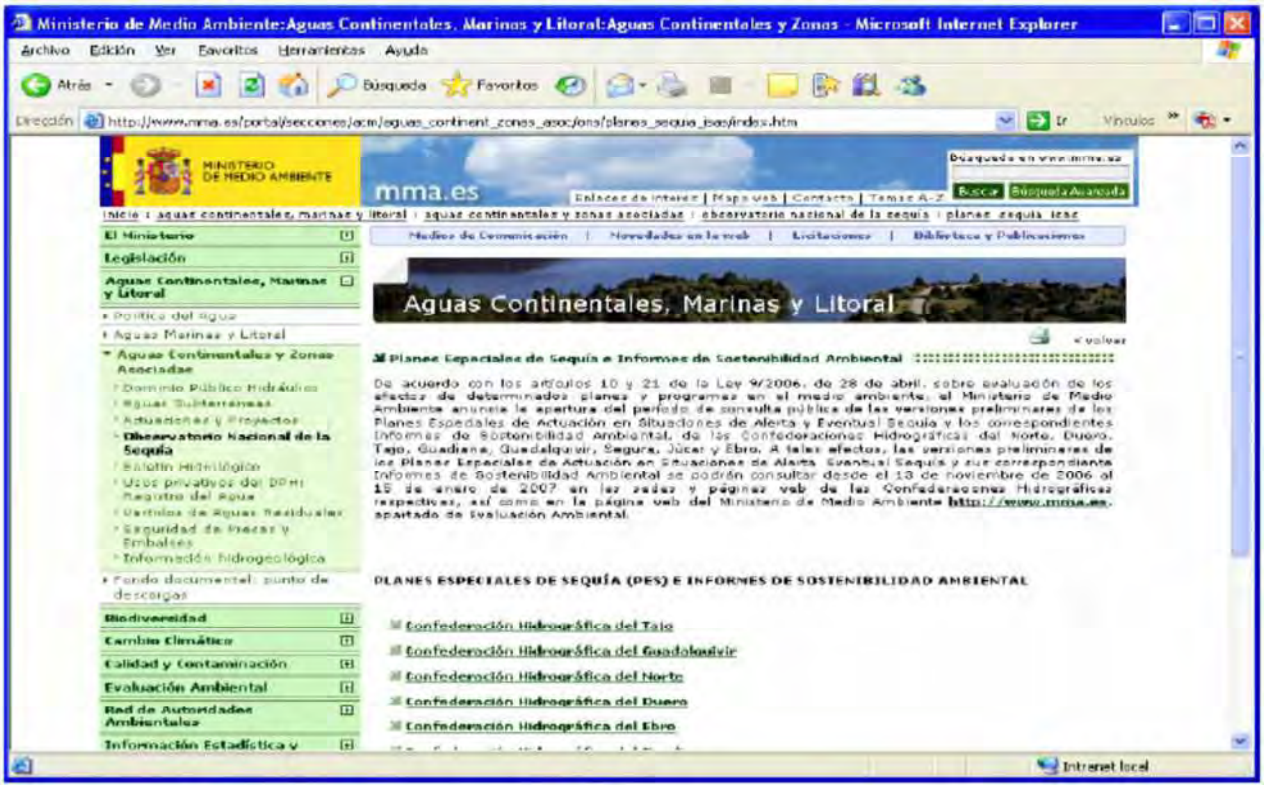


Figure I.6: Spain's national drought ratings - Ministry of Environment Web site 2007

In Portugal, the Water Research Institute coordinated national-level water (including surface and ground water) and water quality data and monitoring responsibilities, but there is no direct mandate. At present, this mission mainly consists of 5 Regional Director of environment and natural resources to complete. Portugal completed the construction of the country's water resources information system (SNIRH), storing all data in relation to water resources, including rainfall, water level, water level, water quality stations, the main characteristics of the determinants. At the same time, established a national environmental information system (SINAIA), gathering all the data. National water information system and the national environmental information systems Portugal provides information support for drought management and decision-making.

(2) The introduction of water saving management is needed to avoid the risk of drought

Drought restricts agricultural development which is critical for Spain's economy, so water-saving irrigation has been highly developed and promoted by the government. Modern techniques such as drip and spray irrigation are used on 90% of the land. Water distribution systems are automated, with accurate measuring and control equipment, and all data is compiled and managed efficiently. Farmer cooperatives are actively involved in management, thus reducing the management costs.

Spain in total land area, 37% Arable land 14% Plain and pasture. Main crops are wheat, barley, oats, maize, rice, sugar beets, cotton, sunflower, etc. Due to the climatic and geographic conditions, drought is

an important factor restricting the development of agriculture. Development of water-saving irrigation, water saving management is Spain an important task of agricultural development. At present, Spain is one of the largest country in the world of water-saving irrigation, water-saving irrigation, second only to United States.

Building on a long history of agriculture and water resource management, Spain Government has started to improve agricultural production efficiency; to develop water-saving irrigation engineering and irrigation district transformation plans with by government investment on original old irrigation district for saving transformation; to transform irrigation technology with high-tech irrigation technology, on field crops, all used irrigation technology, uses clockwise type, and pan type irrigation unit or fixed type irrigation for transformation, for vegetable, and fruit, cash crops, All using drip irrigation technology. Through more than 20 years of reform, the country's total irrigated area in the 90% has been used more than high standards of water-saving irrigation techniques such as drip irrigation and spray.

Spain most of the water projects, irrigation water transmission and distribution projects and the irrigated area are equipped with good performance automation measuring and control equipment, realization of automatic regulation of water distribution and irrigation. Established has irrigation database, storage year or several year of land, and farmers, and crop, and water, about irrigation data, uses system of automatic control features, achieved Remote Automation management, farmers according to irrigation Association provides of crop needed water information, through network, and irrigation card or directly applications, way to irrigation Association made irrigation requests, irrigation Association in in the controlled room through remote control for specifies schedule for irrigation.

Spain water saving in agricultural water demand management has achieved good results, has also benefited farmers ' cooperative organizations. Irrigation districts are managed by autonomous farmers ' cooperative organizations such as associations or unions of farmers for irrigation management. Irrigation district's main function is to represent the interests of farmers in irrigated area when the Government introduces a water rationing system, according to the national water resources allocated to this area to coordinate matters relating to water. Irrigation districts develop irrigation schemes of service, introduce and popularize advanced water-saving technology, implementation of efficient water management model. Due to the small management staff, there is high efficiency, with very low share of management and related costs.

(3) Water conservancy construction to regulate drought risk

Water storage dams have been built for thousands of years, and are very important for mitigating droughts. In addition, water transfers from the wet north to the dry south are very important for this purpose.

Drought is a natural phenomenon, humans are unable to control it or destroy it, so man can only try to get used to it and cope with it. Some droughts that outcome of the interaction between natural phenomena and human activities, closely related to human social activities, so to a certain extent human social activities can influence drought. In Spain, and Portugal the Government also realizes the importance of water conservancy infrastructure construction for regulating drought risks.

Spain's dam construction began in Roman times, and by the 19 century Spain had built 90 dams, of which 58 are still running, main purpose is irrigation. In the 20 century, greater development of dam construction, with 218dams built to form a total storage capacity of 60.34 billion m^3 (an average annual capacity increase is about 120 millions m^3. By 2000, there are 1196 dams in Spain (dam in operation of 1175, dam under

construction 21). The total storage capacity is 56.5 billion m^3,and the regulatory capacity is 45 billion m^3,which accounts for 40% of the total water availability. Spain higher levels of water resource development, is the result of Government's long-term emphasis on public investment. Use of reclaimed water in water areas to implement water-saving measures, increasing water use efficiency through inter-basin water diversion projects to facilitate rational allocation of regional water, ensuring balanced development; on the water quality through improved drinking water and wastewater facilities, reduction of reservoir eutrophication status. Currently, Spain national water resources integrated planning has change has traditional extensive of expansion type development policy, gradually reduced new large irrigation engineering investment, with policy priority transfer to repair of aging engineering and field support for engineering technology, public investment into water protection, improvement of water pipe network system, field irrigation system of technology, and channel anti-seepage saving technology.

Spain Government by carrying out water conservancy construction to regulate drought risks, worthy of special mention is the implementation of inter-basin water to control the uneven spatial and temporal distribution of water resources. The north of Spain has abundant water resources, but there is drought and water shortage in the South; through trans-basin water diversion project, the Government will be able to redeploy surplus water resources to the Eastern Mediterranean coastal areas, making reasonable arrangement of regulating reservoir, concentrated groundwater exploitation, settlement of industrial and agricultural production and water issues. Tajoe-Segura water transfer project was started in 1933 years, but only went into operation 1972~1979 year since there was no trans-basin water transfer law. South North water transfer project has built two reservoirs, with a total capacity of 2 billion m^3. The water transmission distance is 250km, in which 60km long are pipes. The maximum capacity is 1 billion m3 per year and it is mainly for irrigated agriculture in the South, a small part for the drinking water supply and for ecological protection. The project was invested by the government and the feinuosa Power is responsible for the operation and management. The government will not subsidize more on the O&M and all operational costs will be recovered by the incomes from water supply and power generation. Agricultural water price is set as 16 peseta (about RMB 1) per cubic meter and the irrigated area in Spain is important for fruit-production. The, fruit is sold throughout Europe and the economic benefit is very significant. This water price can be afforded by local farmers. Another water transfer project will be Ebro water diversion project. Ebro River is the largest river in Spain, rises in the Cordillera mountains in the North. By building up a canal between the Llotja in the North and the Murcia in the South of 362 km, the three rivers (Ebro river, Jucar river and Segura river) will be connected. This connection will be in parallel with the coastal line of Mediterranean Sea and is expected to mitigate the drought impacts in the future.

Figure I.7: A small-II type reservoir locates in Barcelona, Spain

Portugal 20 Century 30 Began construction of modern dams, according to the statistics, 20 Century 30 — 40 Dam 10 Seat, 50 Dam after speed 50 Dam 22 Seat, 80 90 Dam 21, As of 1998 Years, China had built and under construction height of more than 15m Dam 102 Seat with height of more than 100m Dam 5 Block. Cabril dam the highest double-curvature arch dam, high 136m, with a total capacity of 7 billion m3; reservoir dam was the largest concrete arch dam of aerkuiwa, high 96m, With a total capacity of 42 million m3, an effective capacity of 31.5 billion m3, the project's main goal is electricity generation, irrigation and water supply, on 2002 year in operation. These water projects in 2006 played an important role in years of drought, and effectively mitigate drought.

Figure I.8: A small-II type reservoir locates in Barcelona, Spain

(4) The development of drought management plans to address drought risks

The new Water Law in Spain in 2001 required each basin to prepare drought management plans and these have been approved at ministerial level. These ensure adequate water supply to guarantee the human life and health; minimize the ecological impact of low flows; and determine priorities for water allocation at time of drought on public water supply.

The drought management plans draw on

- *Diagnosis of the drought situation – basin characteristics, historical trends, drought indicators, thresholds and standards.*
- *Development of drought response measures. With the development and intensification of droughts, the response gradually rises from information management to water-saving measures, and finally to restrictive measures. Drought mitigation measures include new wells, canals, desalination plants, and non-engineering measures, such as changing priorities of water, and increased abstraction of groundwater. Conjunctive management of surface and groundwater has proved to be very effective*
- *Public consultation, stakeholder collaboration, and integration of local knowledge and practices into different levels of water management.*

Most countries and regions of the world are in a state of emergency for a long time after a drought, taking stop-gap measures, lack of systematic, continuous and overall work, with much repetition and inefficient

work and waste of resources. This has a serious impact on drought management and sustainable development. In recent years, Spain has been aware of the abuses in the short-term emergency actions and tried to advance through development of drought management plans and prepare to change the situation. This early intervention program and the preparation of effective plan is also an important part of drought risk management.

In 2001, the introduction of the Act requires the national hydrological plan; Spain is required for all watersheds development of drought management plans. By 2007 this was done in all river basin as one of the specialized plans of river basin management, and approved by Ministerial Decree. Drought management plan's main goals are:

- water supply to guarantee the maintenance of human life and health;
- minimizing the ecological impact of low flows, even avoiding impact
- determines priorities for water based on river basin management planning, drought on public water supply, Minimizing the impact of economic activity.

Drought management key elements of the plan are:

- diagnosis of the drought situation. Includes analysis, diagnosis of the basin drought factors such as topography, environment and partitioning; historical law of drought and drought characteristic analysis; identification of drought indicators, thresholds and grade standards.
- development of different drought response measures. Based on watershed characteristics of various different stages of, drought, according to local conditions to develop response measures. In order to achieve the above objectives, drought management plans according to the stage of drought mitigation measures to determine the best. In the normal phase, mainly considering general management measures. With the development and intensification of droughts, response to gradually rise from information management to water-saving measures, and finally to the restrictive measures. In General, the mitigation measures include the following: measures (digging new wells, new plumbing, new seawater desalination plants) and non-engineering measures (changing priorities of water, water effects, increased groundwater supplies, and so on). In Spain, through surface and groundwater joint regulation to ease the water shortage issue proved to be a very effective measure.
- management and follow-up. In order to ensure the effectiveness of drought management plans also require the participation of the public consultation, stakeholder collaboration, different levels of water management, as well as the integration of local knowledge and practices. In Spain, drought management plan has been proven to be effective tools to address water during a drought, provides the basis for more systematic response to drought.

Table I.1: Spain phasing and response measures of drought in a drought management plan

Drought threshold	1-0.5	0.5-0.4	0.4-0.3	0.3-0.2	0.2-0.15	0.15-0.1	0.1-0
Drought stages	Normal	Early warning		Warning		Emergency	
Response objective	Plan	Application information		Water-saving measures		Restrictive measures	
Measure types	Strategic			Tactical		Acute	

(5) Through the introduction of agricultural insurance systems to divert the drought risk

Drought risk insurance is high risk, low income in comparison with other types of insurance. However, Spain and Portugal have developed a good system through collaboration between insurance companies and the Government. This followed on from a law on agricultural insurance in 1978. The government subsidizes the premiums, at different levels ranging from 20-50% according to the crop (and differs between male and female farmers), and provides reinsurance to the insurance firms*. This has proved to be very effective at sharing risks and has avoided the need for the government to pay out emergency relief. Farmers who do not take out this insurance will not get any relief from the government in the event of any drought.*

Compared to other commercial insurance and agricultural insurance, there is a high risk, high cost, high-pay, low-income levels, low fees, low security features for drought insurance. However, Spain, and Portugal's agricultural insurance, insurance not only complete and perfect the management mechanism, the Government supports a strong, self-responsibility, healthy development, as farmers do benefit. It not only in the EU is relatively mature, even if you are successful examples in the world.

In Spain, 1978 Years ago, agricultural insurance is fully operated by the private company, did not participate in the Government, natural disasters such as disaster preparedness, early frosts are not covered. 1978 years later Spain has enacted the law on agricultural insurance, submitted voluntarily by farmers insurance, the Government against private insurers providing reinsurance and premiums granted subsidies to farmers; farmers that do not participate in agricultural insurance, after the misfortune does not give any assistance to the Government. Spain mainly economic management institutions of agricultural insurance with the Insurance Department, the Department of Agriculture's agricultural insurance Bureau of finance, agricultural insurance and agricultural insurance corporation of the four sectors, specific business 38 private agricultural insurance. If private insurance losses are being provided by the Government-supported agricultural reinsurance reinsurance, are paid by the Government Super fixed compensation claims. Thanks to the good operation of the system of agricultural insurance, Spain apart from the annual insurance premium subsidies, government finance, no other agricultural disaster relief spending has yet to create a huge claim reserve system, private insurance companies did not offer other aspects of financial and tax incentives. Agricultural subsidy policy of the Government is mainly reflected in three aspects:

- first, on the subsidy standard, insurance premiums subsidies which are different for different standards. Standard than full-time farmers subsidies than farmers and industry, women farmers ' subsidy

standards are higher than male farmers, collective farmers ' subsidy standards higher than insured individuals are insured.

- Second, the subject matter will be different for different insured premium rate. Lemon, potatoes, cereal crops, livestock and poultry, and crops for industrial use, such as a viable subject of insurance rates for 18%; about not filling conditions for cereal crops, sugar beets, grapes for wine, both 28% insurance rates.
- Third, Government subsidies and insurance premiums by adjusting standard rates to the adjustment of agricultural planting structure. As government subsidies for crop insurance premiums for 20%, to focus on crop subsidies for 50%. So far, Spain engaged in agricultural insurance business, has yet to appear poor financial position, claims the difficult conditions.

In Portugal, participate in agricultural insurance crop under State law, farmers ' voluntary participation in insurance, basic insurance cover disasters such as droughts, fires, lightning, and hail damage. Farmers to participate in agricultural insurance, the Government helped pay a premium, up to a maximum premium of 75%. Farmers insurance premium subsidies based on a reference rate of premiums of the Government. Under normal circumstances, commercial companies to develop rates being higher than the reference rate set by the Government, in this case, the reference rates is that the Government premium subsidies to farmers based on the part above the reference rate borne entirely by the farmers themselves, does not give the Government premium subsidies; when a commercial company to develop a rate lower than the reference rate for Government, Government subsidies for premiums low and not high. Reference rate published by the Government and differences from region to region.

If cooperative collective insurance, Government subsidies can also be higher rates. In addition, the Portugal Government agricultural risks catastrophe fund has also been established, led by the Department of Agriculture's agricultural and financial institutions responsible for the management of fisheries, refers to when there are policies other than the unexpected huge losses, compensation to the farmers by the insurance companies to apply for the catastrophe fund. Definition of catastrophe is that of accidents the insured crop disaster, resulting in 50% per cent of losses, causing large losses to farmers. Startup programs are, Ministry of agriculture and the Ministry of Finance announced that the Government of a catastrophic damage to the area, while identifying the affected crop. Those farmers voluntarily pay a fee to the catastrophe fund, is currently a basic premium of 0.2%, paid by insurance companies in the era of premium collection, accounts included in the catastrophe fund. The catastrophe fund is a complementary mechanism of commercial insurance, insurance companies have to apply for the catastrophe fund, must be the agriculture insurance business throughout the country not only operating in some areas of agricultural business or just running some crop insurance business. At present, Portugal all commercial insurance companies to participate in this mechanism, work well.

(6) Enhanced public awareness education

Public awareness of water-saving is essential, and this starts from a very young age and is comprehensive. Full details are provided and information is available to everyone. All forms of media are used.

Water saving is a lifestyle change, this change takes longer or shorter period of time, in order to shorten this process as much as possible, Spain, and Portugal developed European countries long committed to a variety of sources, such as water-saving awareness of the whole society, and popularity played a good role in drought risk awareness. Mainly includes the following aspects:

- water saving from an early age, a range of matters such as the need for water saving, water-saving importance, methods of propaganda education in primary schools.
- the use of all means water-saving awareness, including newspapers, radio, television and the Internet.
- water-saving awareness didn't omit any detail. Even if you're a foreign visitors, you may accept into water-saving awareness, which is accessible from each training mission hotel, hotel embodies. In each hotel's bedside Cabinet and bathroom vanity tops are stocked with water-saving awareness cards tell visitors clearly try to choose a shower instead of a tub (this can save 60 liters of water), please turn off the tap when you brush your teeth or shave, when you apply the lotion, please turn off the showers, towels can also continue to use the pending and so on.

I.A.3 Revelations and recommendations

Spain, and Portugal is located in the European continent, precipitation, water resources, economic conditions are far better than China, drought threat is far less severe. But, Spain, and Portugal between in should drought problem Shang is quite attention, efforts absorbed United States, and Australia, developed made of drought risk management concept, and active practice line risk management, including through national drought system construction to monitoring drought risk, and through introduced needed water saving management to circumvention drought risk, and through carried out hydraulic engineering construction to Regulation drought risk, and through developed drought management plans to should drought risk, and Through the introduction of agricultural insurance systems to divert the risk of drought, as well as pervasive drought risks through enhanced public awareness education and so on, are worthy of our many practices or learn from. Combined with the Spain, and Portugal training and investigation, on China's drought management makes the following recommendations:

1. Speed up the transformation of managing mode

In response to the drought in the course of events, the Government's intervention is the method most States currently. This kind of emergency management through emergency relief aid projects, to the drought-affected populations with bailout funds or other forms of support. From the perspective of disaster management, this kind of passive management is seriously flawed, because it does not aid beneficiaries to change their behavior, or resource management practices as a condition of receiving assistance. Dependency on Government aid to a certain extent reduce the enthusiasm of the affected subjects on disaster prevention and mitigation, is not conducive to encouraging producers to invest in enhancing the ability to cope with drought in order to achieve self-reliance. Project for disaster prevention and mitigation of drought, to reduce drought vulnerability, mitigate the effects of drought, from drought to drought emergency management disaster risk management is the development trend of disaster management. To that end, recommended further strengthening of drought risk management in our country.

2. Promote institutional reform

In Spain and Portugal, are subordinate to the Ministry of the environment associated with drought, which avoids the redundancy issue. At present in our country, State and local flood control and drought relief headquarters is drought relief authorities, but many businesses across different sectors, Ministry of water resources, Ministry of agriculture, Weather Bureau, the Ministry of civil affairs. In times of drought emergency and drought relief organizations can efficiently and orderly at all levels of command and

coordinate relevant Department joint response, but given the slow development characteristic of arid, drought emergency departments of this linkage does not meet economic and social demands on drought relief work. Therefore, in addition to emergency drought relief functions, functions of drought resistance in drought relief organizations at all levels need to strengthen routine, breaking through the system obstacles from top to bottom, and the organizational structure, get members more involved in the day-to-day drought relief work, establishing multisectorial integrated coordination mechanism, give full play to its organizational and coordinating role in day-to-day management of drought.

3. Enhancing drought risk monitoring

At present, China's work on drought risk monitoring had been carried out, but it is not as comprehensive drought preparedness and reduction and effective support. Therefore need to strengthen meteorological, hydrological, farming, industry, water intake and water supply monitoring system associated with drought, improve dynamic monitoring capacity to drought information, form a complete national coverage, reasonable layout, information, drought monitoring network of resource sharing. In addition to the establishment of drought information monitoring system and, more importantly, is the creation of information-sharing mechanisms among the various relevant departments. At present, various interdepartmental information sharing can be done more smoothly in times of drought emergency communication, but are difficult to achieve in the ongoing drought management. Information resources are managed by the various administrative departments, the "islands of information" seriously. Current drought relief commanding institutions drought information sources is also largely dependent on the escalation in drought-hit areas, receive timely and relevant information on sector there are certain obstacles, to be timely and effective early warning for drought prediction, objective and scientific assessment of drought disaster command and control to have a significant adverse impact. Therefore, States should formulate as soon as possible and introduce drought-related information sharing arrangements or requirements and develop data-information-sharing networks, breaking the information resources department segmentation, segmentation geographic segmentation and business, establishment of interagency information sharing mechanisms to achieve transformation from information resources used to shared use.

4. Strengthening water saving management

Temporal and spatial distribution of water resources in China is extremely uneven and insufficient water resources per capita in the world per capita 30%, Especially in the large-scale exploitation of global climate change and water resources under double factors, water resources shortage situation is increasingly dire. Traditional water management model led to increasing water demand, cannot meet the requirements of sustainable development of water resources, water demand management should be a paradigm shift, to reasonable regulation of water resources carrying capacity constraints to economic and social demands for water, optimize the industrial structure overall arrangement, to improve water use efficiency, strengthening soil and water conservation, pay attention to water conservation and water information. In determining the scale of economic development in many regions, economic structure, industrial layout, often a lack of drought and water shortage considerations, not been done due to the water system, water, and its consequences have seriously affected economic and social development. Therefore, must be based on the carrying capacity of water resources and water environment, adjustment and optimization of economic structure and industrial distribution, reduce vulnerability to disaster-pregnant environment and avoid the risk of drought.

5. Improving emergency response capabilities

Spain arid phase of core elements of the management plan is to identify and develop appropriate response measures in advance, so that when droughts occur, can be targeted, rapid and effective response. In fact, our country has carried out similar work, namely, drought preparedness system. Drought relief plan for droughts in recent years have played an important role in the work, but also exposes a lot of problems, mainly reflected in the plan of scientificity, reasonability and operability, and so on. At present, China has completed the planning for drought resistance in many parts, but often a formality, content without specific, in-depth, ambiguous, elusive plan to start conditions, response measures targeted is not strong, poor operability. Concern to different regions and different levels of drought, and grasp the boundaries vary, plans to launch conditions clearly defined and easy to grasp in order to ensure a prompt start emergency response. Different levels of emergency response measures, project scheduling, emergency engineering and non-engineering measures of water provision, follow up, responsibilities of related departments, must be clear and specific, highly targeted and operable.

6. The system of drought insurance

A long time, the mode of interim relief in response to natural disasters in China, paid compensation to disaster losses to a certain extent, but it is a drop in the bucket compared with the disaster losses. Including Spain, and Portugal the foreign practice shows that, for the random occurrence of natural disasters, and establish and improve the effectiveness of disaster risk insurance system is the transfer of important measures. Although some provinces in China's agricultural insurance will be drought as disaster-causing factors to be taken into account, provided that the more demanding, in fact very few risks due to drought in the agricultural insurance claim cases, most of the damage caused by the drought risk cannot be compensated by agricultural insurance, it is difficult to play insurance transfers risk of drought, and the severe drought situation does not fit. Urgently required depending on the characteristics and law of drought in China, in accordance with the principles of insurance, establish a system of drought insurance to attract Community funding involved in drought prevention and relief, disaster risk borne by policyholders, insurance companies and the Government losses, plays both the market and the role of government financial funds, spreading drought and transfer risk.

Table I.2: Members of the delegation

Serial number	The name	Sex	Unit	Post / Titles
1	Yu Xingjun	Male	Centre for international economic and technological cooperation and exchanges	Director / Teach high
2	Wang Xiang	Male	Office of the State flood control and drought relief headquarters	Deputy Director/ Teach high
3	Cheng Fuyun	Male	Office of the State flood control and drought relief headquarters	Director
4	Lv Juan	Female	China Water Conservancy and hydroelectric power research, IWHR	Deputy Director/ Teach high
5	Sun Chaoyu	Male	Liaoning Office of flood control and drought relief headquarters	Director / Teach high
6	Wu Zhe	Female	Centre for international economic and technological cooperation and exchanges	Engineer
7	Qu Yanping	Female	China Water Conservancy and hydroelectric power research, IWHR	Engineer

Spain, and Portugal the drought management training for heads of mission: Yu Xingjun

Appendix J. Approach to Public Education and Awareness-Raising

J.1 Approach to Public Education and Awareness Program

The public awareness program will promote the importance of conserving water and achieving water savings in both normal and drought years.

J.1.1 Objective

From a long-term perspective, children and students are an important target group. Because they are not only an essential part of the public, but also a majority of the public in the future, And after their water saving awareness was raised, it will influence and affect people around them.

Because they are not only an integral part of the public, but also the future of the public body and their water-saving awareness has been raised, it will influence and affect people around them.

In the perspective of development, it is necessary to improve urban water conservation awareness. Although the level of urbanization in China is still far below the level of the developed countries, China's urbanization process has shown to accelerate the trend. Over the next 20 years, more than 60% of the population will live in cities. Over the past decade, the use of urban domestic water has shown a rapidly increasing trend. In addition, the urban area has always been the key guaranteed objects that water supply covers, many urban residents have rarely suffered from water deficit, so that the public awareness of the water conservation is still weak.

From a practical point of view, the improvement to farmers' awareness of water conservation is very important. China is still a big agricultural country, currently more than 50% of the population lives in rural areas affected by various subjective and objective reasons. China has a large agricultural water saving potential, but whether this potential can truly be fulfilled, depends largely on the extent of farmers' awareness of water conservation.

J.1.2 Educational Content

Raising public awareness of water conservation can be achieved primarily through propaganda and education which mainly includes four aspects:

1. water-related scientific knowledge, including precious nature, limited nature, irreplaceable nature, and indispensable nature of water and soil and water conservation knowledge;
2. drought-related scientific knowledge, including temporary drought, severity, periodicity, inevitability and contingency, etc.;
3. water-saving knowledge and technology, including agricultural, domestic and industrial water-saving knowledge and technology and tips for water use in daily life;
4. policies and regulations.

J.1.3 Method

Publicity and education methods mainly include: television public service ads, online columns, newspapers and magazines that publish regularly water-saving related education content, propaganda and education activities related to water facing the public majorities; brochures about scientific knowledge related to drought and water resources, and water saving propaganda training courses, etc.

J.2 Current Awareness of Water Users on Water Saving

The current state of knowledge of water saving methods was based on the water user surveys. The following are general conclusions found from these surveys.

Awareness of water saving measures

Currently, the public awareness of water conservation is generally not high, including of farmers, urban residents, enterprises, and even water management departments also have not yet given enough attention so that many of the city's leakage rate is high. The agricultural irrigation efficiency and water utilization coefficient are far below international levels in countries with higher water conservation levels. The water consumption per unit of industrial value added is also high.

Awareness of water saving relevant policies

The regulations related to water savings are not feasible and not helpful in improving public awareness of water saving. Currently, the regulations about water savings are limited. In addition, the regulations are general, and lack of feasibility. Only a few areas and sectors have adapted the progressive water price policies.

Perceived limits and constraints to improve public awareness of water saving

The main two constraints to improve public awareness of water saving are i) the conception that there is not enough water saving publicity and education work, and ii) the lack of water related policies and regulations. Currently, most regional water conservation education is limited to number of thematic activities, and there are no long-term structured programs. Another constraint is the lack of regulatory incentives that could encourage the publics including farmers, urban residents, companies, and administrative institutions to save water.

Current water tariffs and willingness to pay for water use

Water costs can be divided into domestic water in rural and urban areas, agricultural (irrigation) water and industrial water. Rural domestic water expenses can be divided into two cases, one is the private water intake for domestic water use that is free of charge, and the other one is the water intake from water supply infrastructure that is charged on a price of water supply cost, which is less than 1% of the household income. Urban residents water price includes two aspects, on is the water supply cost and the other one is the wastewater treatment fee. The cost of water use normally takes 1% to 2% if total household income; agriculture cost for water use is mainly water supply cost. The water price for industrial water use makes minimal profits.

J.3 Implementation Of Public Awareness Program

A sound implementation plan is required to enhance the public awareness of water saving. This mainly includes the following aspects:

Preparedness of propaganda and education materials

For different social groups design audience-oriented water saving education materials would be effective in raising the public awareness of water saving. But this is still lacking. Therefore, compiling water saving education materials is needed as soon as possible.

Preparedness of propaganda and education plan

Raising the public awareness of water saving is a long term work, and it requires proper communications that fit the target audience in order to be effective. From the methods, communication methods other than World Water Day and China Water Week campaign including television, newspaper needs complete communication plans, specifically in following aspects:

- Develop propaganda and education channels. Developing water saving education channels needs to be led by the government and cooperated by related administrations. Including water saving knowledge in the text book of elementary through high school needs not only to identify proper contents, but also the approval from corresponding administrative agency and government. Therefore, developing water saving propaganda and education channels must be led by the government, and cooperated by related departments.
- Choose proper propaganda and education contents. Choose propaganda and education contents based on different target social groups. For agriculture water saving technical manual, the focus is to introduce water saving knowledge that closely related to the rural household production and domestic activities including water saving planting techniques, agriculture irrigation water saving techniques, and drought tolerated crop selections, etc. For water saving to be included in the school educations, the focus is to introduce the functions of water in biosphere, the hydrological cycle, the limited and precious nature of water, water preservation and basic water saving knowledge. For the water saving education on television and internet, the focus is domestic water saving tips and techniques. For the water saving education on the radio, the focus is to introduce international and national new industrial water saving technologies. For the water saving education on the newspaper, the target audience is urban residents; therefore the focus is water saving in urban living and water price policies. For different areas, choosing proper water saving education contents should incorporate local natural and geological conditions. Climates, as well as human social and economic activities, especially the agriculture farming characteristics.
- Determine proper propaganda and education frequency. For the schools, water saving knowledge could be included in the general text books or biological text books, educate students based on teaching schedules. For the water saving knowledge to be published on the newspaper, the information could be included in column. For the water saving education on the televisions, the information could be categorized as domestic and agriculture water saving techniques. The domestic water saving techniques and tips could be promoted in advertisements regularly or intermittently. The agriculture water saving techniques could be promoted with agriculture program shown on the televisions.

Funding for propaganda and educations

All of above whether it is water saving materials or preparedness, and water saving propaganda is implemented through proper media and methods. This needs both regulatory and financial support. Water saving education is a community program. Although the benefits are long lasting from both social and environmental perspectives, this is not profitable activity. Therefore, the government mush issue related policies and develop financial support means to guarantee the implementation of water saving propaganda and educations in order to improve the public awareness of water saving gradually and better react to the drought events.

According to the institutional and water user survey results and differing water use needs and knowledge in the general public, a drought risk awareness public education and awareness plan will be proposed. The work program mainly includes suggestions on different public awareness and education organizations, groups, and education and public education and awareness methods, education and public awareness contents, as well as budgeting for education and public awareness activities. And the contents outlines will be listed in tabular form with recommendations on ways to implement the program by others.

J.4 Contents of Public Awareness Program on Water Saving

J.4.1 Contents of public awareness program on water saving

The overall contents and methods for the programs for the various stakeholders are listed below, although not all components will be included in each case.

Focus Group		Methods/Media	Contents
Student	Elementary school (5-12 years)	• Class • Quiz • Posters • Excursions	• Basic functions of water • Basic knowledge of water cycle • Basic knowledge of water pollution • Basic knowledge of water uses
	Middle school (12-18 years)		• Basic functions of water • Basic knowledge of water cycle • Basic knowledge of water pollution • Basic knowledge of water uses and efficient ways of managing these uses • Basic knowledge of water and soil conservation • Basic knowledge of drought
Farmers		• TV program • Agriculture water saving techniques brochures • Technical manual	• Basic knowledge of water savings • Basic knowledge of drought risk management • Understanding of drought triggers and actions • Agricultural actions to be taken when a drought is forecast or occurring • Water demand for different crops, including knowledge of water demand during key growth periods and the impact of water stress at different growth stages • Agricultural techniques for water saving and water conservation • Irrigation techniques for water saving • Basic knowledge of irrigation system management and irrigation scheduling to maximize water use efficiency
Urban residents		• TV program • Campaign • news column • internet • social media • targeted emails • bill inserts from water companies	• Basic knowledge of water cycle and the limitation of total resources • National and local water resources situation • basic knowledge of water saving in an urban context • domestic water saving knowledge and tips • water saving equipment in kitchen and washroom • basic knowledge of water pollution • water saving regulations and policies
Managers in company		• Company brief • Journals • Internet • Related documents	• water price information • knowledge of water-saving techniques • wastewater treatment techniques • greywater reuse techniques • water reuse techniques • related innovation in water saving • national and international advanced water saving techniques • national and local water saving regulations and policies

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Contents

Appendix K. Current Plans and Prototype Provincial DMPs

K.1 Introduction

This appendix provides details of the current plans and recommendations for future drought management plans. It is structured as follows:

- K.1 Introduction
- K.2 Existing Drought Relief Plans
- K.3 A strategic approach for DMPs
- Annex 1 Proposed Structure of a Provincial DMP
- Annex 2 UK Drought Management Plans
- Annex 3 Liaoning DMP
- Annex 4 Gansu DMP
- Annex 5 Sichuan DMP

Drought Relief Regulations (DRR) at the national level were released in 2009, supported by Drought Classification Rules in 2009. However, these documents have yet to drive fully a risk management approach to drought response, and this project is designed to assist the FCDRH and MWR in their efforts to facilitate a more scientific and risk management approach to drought management in the provinces.

The IWHR guidance on drought relief plans (Compilation Guidelines for Drought Response Plan (SL 590-2013)) was issued by Ministry of Water Resources on 2013-01-22 and came into force in 2013-04-22. This guidance provides a blueprint for comprehensive planning and management of ongoing droughts. Since this guidance is relatively new, the earlier drought relief plans for the three pilot provinces have not yet been updated to comply with all the new guidelines.

The TA team has now proposed to overlay a drought risk planning approach on the front end of the existing drought management planning protocols, rather than propose a complete and immediate replacement of the existing systems. As the drought risk management processes mature, some of the triggered actions in these plans will focus on risk reduction, but this is a long term objective.

K.2 Summary of Current Drought Relief Plans in Pilot Provinces

The pilot provinces have not yet fully implemented the recent guidance and regulations on drought relief plans and this is evident for the three project pilot provinces, although Liaoning Province seems to have progressed more than the other two provinces.

The following sections provide brief summaries of the contents of the existing pilot province drought relief plans. The institutional framework and other aspects are fairly consistent, as described elsewhere in this report, and this review focuses on the different definitions of drought levels under relief. None of them provide much detail on activities to be triggered at various drought levels, and they simply summarize the work to be completed as each of the drought levels is reached.

K.2.1 Drought Severity Levels – Liaoning Province

Drought Level	Liaoning Definitions
Level I warning (extreme drought)	The Level I, drought grade color is red. A severe drought occurs when one of the following conditions has been met, and a Level I warning should be issued: ① More that 65% of the arable area in the province is affected by drought, and more than 30% of arable area severely affected ② More than 10% of rural population have difficulty with access to drinking water ③ More than 1/3 urban area facing water supply crisis, with water shortage rate higher than 30%
Level II warning (severe drought)	A level II severe drought grade color is orange. This occurs when one of the following conditions has been met, and a Level II warning should be issued: : ① More that 50% of the arable area in the province is affected by drought, and more than 20% of arable area severely affected. ② More than 7% of rural population have difficulty with access to drinking water ③ More than 1/3 urban area facing water supply crisis, with water shortage rate higher than 20%.
Level III warning (moderate drought)	A level III moderate drought grade color is yellow. This occurs when one of the following conditions is reached, and a Level III warning should be issued: ① More that 40% of the arable area in the province is affected by drought; ② More than 5% of rural population have difficulty with access to drinking water ③ More than 1/3 urban area facing water supply crisis, with water shortage rate higher than 10%
Level IV warning (mild drought)	A level IV mild drought grade color is blue. This occurs when one of the following conditions is reached and , a Level IV warning should be issued: ① More that 20% of the arable area in the province is affected by drought; ② more than 2% of rural population have difficulty with access to drinking water ③ More than 1/3 urban area facing water supply crisis, with a water shortage rate higher than 5%

K.2.2 Drought Severity Levels – Gansu Province

Stage of Drought	Irrigatedagriculture area			Rainfed agriculture area								Rural domestic water use	Urban water supply							
	area with inadequate irrigation resulting in significant damage to crop growth (%)			soil moisture (%)	Precipitation anomalies (%)			consecutive days without rain				water shortage (%)	Water shortage - For Lanzhou (%)				Water shortage - for other 13 municipalitie (%)			
	Mar - Jun	Jul - Oct	Nov - Jan		Jun - Aug *(in one month)*	Mar - May & Sep-Nov *(in two mths)*	Dec - Feb *(in three mths)*	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb		5%-10%	10%-20%	20%-30%	>30%	5%-10%	10%-20%	20%-30%	>30%
Extreme drought	>25	>35	>35	<40	< (-80)	<(-75)	<(-55)	>75	>50	>75	>90	>10	-		>40 d	>20 d				
Severe drought	10-25	20-35	20-35	45-40	(-60) - (-80)	(-65) - (-75)	(-45) - (-55)	51-75	36-50	51-75	61-90	7-10	>90 d	>60 d	20-40 d	10-20 d	>90 d	>60 d	>40 d	>20 d
Moderate drought	5-10	10-20	10-20	55-45	(-40) - (-60)	(-50) - (-65)	(-35) - (-45)	31-50	21-35	31-50	31-60	5-7	30-90 d	20-60 d	10-20 d	7-10 d	60-90 d	40-60 d	20-40 d	10-20 d
Slight drought	<5	<10	<10	60-55	(-20) - (-40)	(-30) - (-50)	(-25) - (-35)	15-30	10-20	15-30	20-30	3-5	10-30 d	10-20 d	7-10 d	3-7 d	30-60 d	10-20 d	10-20 d	7-10 d

Note Extreme Drought = Level 1 (Red); Severe Drought = Level 2 (Orange); Moderate Drought = Level 3 (Yellow); Mild Drought = Level 4 (Blue)

K.2.3 Drought Severity Levels – Sichuan Province

Table K.1: IV Grade Blue (mild drought)

Agricultural areas									Pastoral			Urban
		Meteorological index			Storage							
Drought Type	Period	Daily Precipitation (mm)	Precipitation Anomalies%	number of consecutive dry days	Water Storage anomalies %	Affected agricultural area (10,000mu)	Population with difficult water access (10,000)	number counties worse than slight drought	Precipitation	Pasture affected by drought	Number counties worse than slight drought	Water supply
Dry winter	Nov 21 - February 28	≤ 0.2	≤ -10	≥ 30	-3 To -8	80-450		≥ 82	30 consecutive days total precipitation less than 10 mm	Spring green grass area ≤ 85%, summer and autumn pasture relative yield ≤ 85%	≥ 27	15 consecutive days below the normal water supply rate ≥ 5%
Drought	March 1 - May 5	≤ 0.7	≤ -10	≥ 30		80-450	≥ 100					
Summer drought	April 26 - July 5	≤ 1.5	≤ -10	≥ 20		80-500	<200		20 days total rainfall is less than 20 mm			
Drought	June 26 - Sept 10	≤ 1.8	≤ -10	≥ 20		70-500						

Note: Alarm for agriculture area triggered by three compulsory indicators including affected crop area in the province, population with water access difficulty and number of counties worse than slight drought, meanwhile the meteorological and water storage indicators are optional and supplementary. The compulsory indicator conditions must be all met, and one of the supplementary conditions met to trigger the alarm. For pastoral area, all three indicators are compulsory. For urban area, there is only one compulsory indicator.

Table K.2: III Level Yellow (moderate drought)

Agricultural areas									Pastoral			Urban
		Meteorological index			Storage							
Drought Type	Period	Daily Precipitation (mm)	Precipitation Anomalies%	number of consecutive dry days	Water Storage anomalies %	Affected agricultural area (10,000mu)	Population with difficult water access (10,000)	number counties worse than modrate drought	Precipitation	Pasture affected by drought	Number counties worse than modrate drought	Water supply
Dry winter	Nov 21 - February 28	≤ 0.2	≤ -30	≥ 40	-8 To -15	450-950		≥ 65	30 consecutive days total precipitation less than 10 mm	Spring green grass area ≤ 80%, summer and autumn pasture relative yield ≤ 80%	≥ 20	15 consecutive days below the normal water supply rate ≥ 10%
Drought	March 1 - May 5	≤ 0.7	≤ -20	≥ 40		450-950	≥ 200					
Summer drought	April 26 - July 5	≤ 1.5	≤ -30	≥ 30		500-900	<400		20 days total rainfall is less than 20 mm			
Drought	June 26 - Sept 10	≤ 1.8	≤ -30	≥ 30		500-900						

Note: see above

Table K.3: II Level Orange (severe drought)

Drought Type	Agricultural areas									Pastoral			Urban
		Meteorological index				Storage							
	Period	Daily Precip-itation (mm)	Precip-itation Ano-malies%	number of cons-ecutive dry days	Number of days high temperature	Water Storage anomalies %	Affected agric-ultural area (10,000 mu)	Popu-lation with difficult water access (10,000)	number counties worse than serious drought	Precipitation	Pasture affected by drought	Number counties worse than serious drought	Water supply
Dry winter	Nov 21 - Feb 28	≤ 0.2	≤ -50	≥ 50	Daily average temperature of 30 ℃ or 35 ℃ daily maximum temperature ≥ 8 days	**-15 to -25**	**450-950**	950-1,500	≥ 45	30 consecutive days total precipitation less than 10 mm	Spring green grass area ≤ 80%, summer and autumn pasture relative yield ≤ 80%	≥ 15	15 consecutive days below the normal water supply rate ≥ 15% (municipal), ≥ 20 (county)
Drought	March 1 - May 5	≤ 0.7	≤ -40	≥ 50			**450-950**	950-1,500					
Summer drought	April 26 - July 5	≤ 1.5	≤ -50	≥ 40			**500-900**	900-1,800		20 days total rainfall is less than 20 mm			
Drought	June 26 - Sept 10	≤ 1.8	≤ -50	≥ 40			**500-900**	900-2,000					

Note: see above

Table K.4: I Grade Red (extreme drought)

Drought Type	Agricultural areas									Pastoral			Urban
		Meteorological index				Storage							
	Period	Daily Precip-itation (mm)	Precip-itation Ano-malies%	number of cons-ecutive dry days	Number of days high temperature	Water Storage anomalies %	Affected agric-ultural area (10,000 mu)	Popu-lation with difficult water access (10,000)	number counties worse than extreme drought	Precipitation	Pasture affected by drought	Number counties worse than extreme drought	Water supply
Dry winter	Nov 21 - Feb 28	≤ 0.2	≤ -70	≥ 60	Daily average temperature of 30 ℃ or 35 ℃ daily maximum temperature ≥ 15 days	<-25	> 1,500	≥ 500	≥ 30	30 consecutive days total precipitation less than 10 mm	Spring green grass area ≤ 40%, summer and autumn pasture relative yield ≤ 40%	≥ 10	15 consecutive days below the normal water supply rate ≥ 25% (municipal), ≥ 30 (county)
Drought	March 1 - May 5	≤ 0.7	≤ -60	≥ 60			> 1,500						
Summer drought	April 26 - July 5	≤ 1.5	≤ -70	≥ 50			> 1,800			20 days total rainfall is less than 20 mm			
Drought	June 26 - Sept 10	≤ 1.8	≤ -70	≥ 50			> 2,000						

Note: see above

K.3 Strategic Approach to DMPs at Provincial and Local Levels

The provincial drought management plan has been developed under a presumed future tiering of drought management responsibilities with linked and specific roles and responsibilities at each layer of the process: the provincial plan and local plans are part of an overall hierarchy of drought planning. IWRM requires that detailed water management decisions should be made at the lowest practical level, which in general would be water companies, industries and agricultural interests. Their drought management activities should be coordinated by county level and municipal level organizations in accordance with county and municipal drought plans, which in turn is managed and coordinated in accordance with provincial plans. The entire process follows the guidance and oversight from national level drought management organizations.

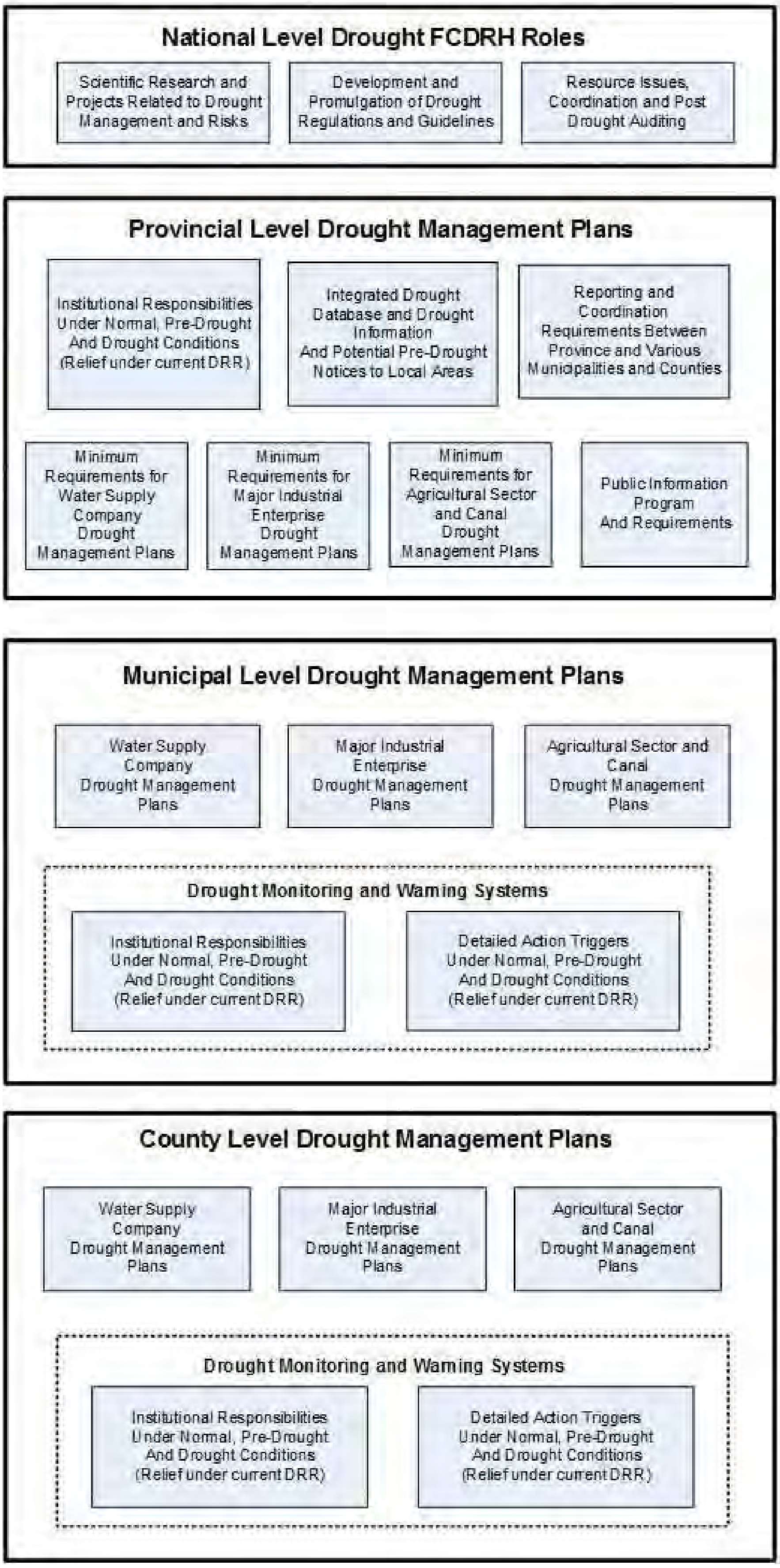
Since PRC practice has been to develop drought response or ***relief*** plans, it will take time to phase in the concept of drought ***management*** planning at all times, even during normal conditions. There may be an interim period where drought management and drought relief plans exist simultaneously, with the intention that the drought management plans will eventually supersede the need for separate drought relief plans.

There are many constraints to implementing tiered drought risk management activities during all times:

- Drought funding and budgets being tied to drought relief activities, with insufficient budget and motivation to perform drought management activities in Normal and Pre-Drought time periods. Although much of the required drought monitoring in these periods is already being performed, it is not put into a drought management system or context.
- Limited collaboration and cooperation amongst PRC water management agencies, especially when there is not a definitive drought requiring emergency relief.
- The need for additional capacity development and training to enable lower level water management staff (at levels below the provincial government) to adequately implement the municipal and county drought management plans. Once capacity is developed at lower levels, there is no reason to keep all drought management decisions and actions at the provincial level as IWRM demands that decisions be made at appropriate levels, by those most impacted.
- The time required for municipal and county level FCDRHs to develop adequate drought management plans. There needs to be a staged process for the provincial drought management offices to phase in shared roles and responsibilities with local jurisdictions as the local plans are developed.
- The time needed for municipal and county level officials to work with the various sector water management officials (urban water supply, industry, agriculture) on their sectorial drought management plans so that they can be connected to the municipal/county level DMPs.

As a result of these constraints, the provincial drought management plan may initially be a ‘command and control’ DMP for local areas using the integrated database until the municipalities and counties develop adequate local DMPs and improve their technical capacity to manage drought. The TA team has recommended both a long-term strategy of tiered drought management between the provinces and the local jurisdictions, and a short-term strategy of using the new integrated drought database for overall risk-based drought management at the provincial level. The short term scenario simply involves the provincial FCDRH assuming more of the work related to risk reduction and mitigation measures at local levels during interim period, until the municipal and county level DMPs are working effectively

The following figures illustrate the long-term hierarchy and the provincial plans have been developed under this assumed process..

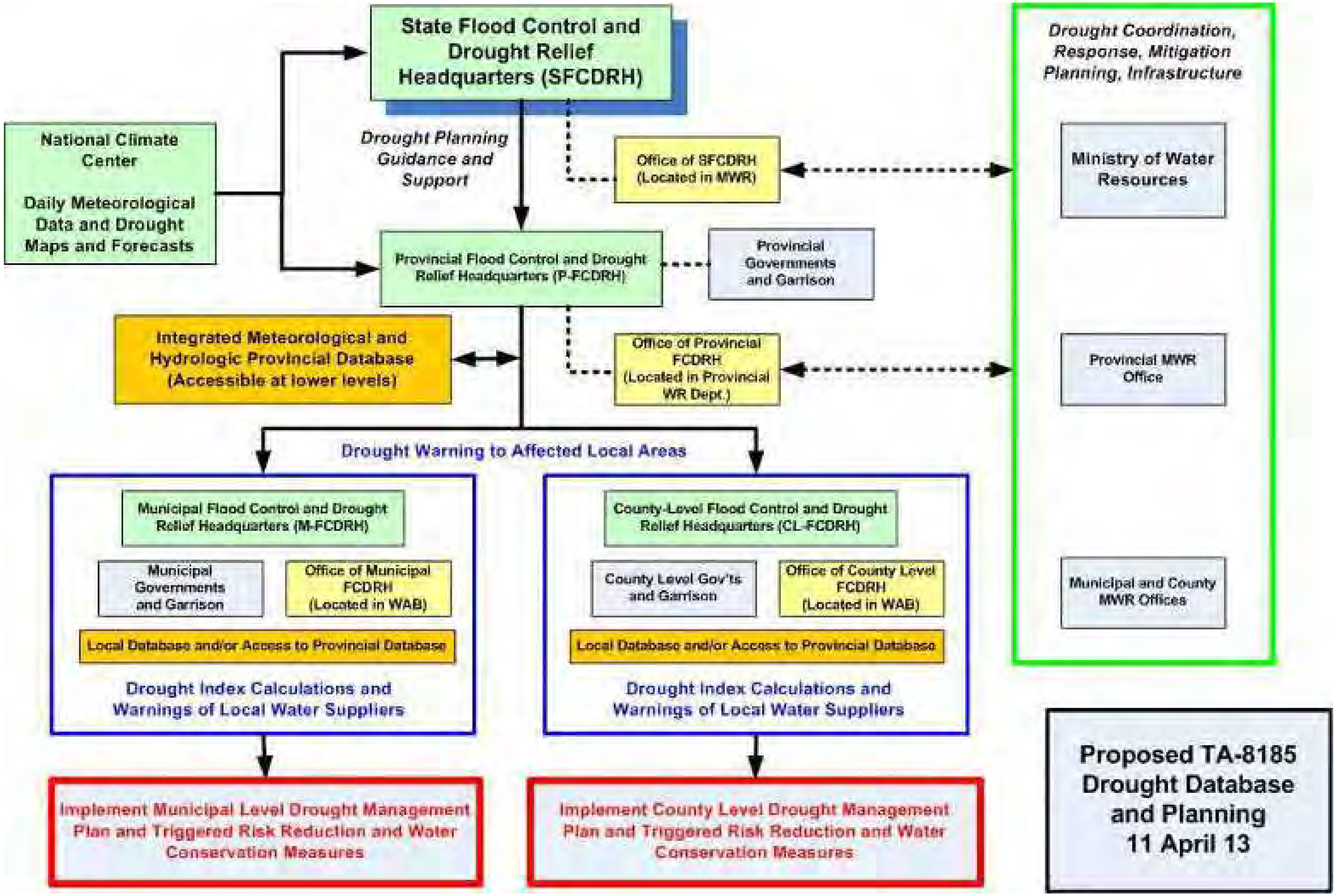


- Develop research, regulations and guidelines or drought risk reduction and management
- Coordinate planning and response levels on major multi-province or widespread concerns
- Determine resource needs with PRC State Council

- Send provincial meteorological information/ indices
- Review and coordinate area monitoring, triggers, and risk reduction and mitigation measures found in DMPs of all municipalities and counties
- Coordinate and report activities to province and public, as well as SFCDRH

- Receive provincial meteorological information/ indices
- Coordinate area monitoring, triggers, and risk reduction and mitigation measures found in detailed DMPs of major water user groups
- Coordinate and report activities to province and public
- Manage risk reduction activities for major water user groups under municipal level control
- Coordinate and oversee work of county level DMPs under their jurisdiction

- Receive provincial meteorological information/ indices
- Coordinate area monitoring, triggers, and risk reduction and mitigation measures found in detailed DMPs of major water user groups
- Coordinate and report activities to province and public
- Manage risk reduction activities for major water user groups under municipal level control


State Flood Control and Drought Relief Headquarters (SFCDRH)
National Climate Center
Daily Meteorological Data and Drought Maps and Forecasts
Drought Planning Guidance and Support
Office of SFCDRH (Located in MWR)
Drought Coordination, Response, Mitigation Planning, Infrastructure
Ministry of Water Resources
Provincial Flood Control and Drought Relief Headquarters (P-FCDRH)
Provincial Governments and Garrison
Integrated Meteorological and Hydrologic Provincial Database (Accessible at lower levels)
Office of Provincial FCDRH (Located in Provincial WR Dept.)
Provincial MWR Office
Drought Warning to Affected Local Areas
Municipal Flood Control and Drought Relief Headquarters (M-FCDRH)
Municipal Governments and Garrison
Office of Municipal FCDRH (Located in WAB)
Local Database and/or Access to Provincial Database
Drought Index Calculations and Warnings of Local Water Suppliers
County-Level Flood Control and Drought Relief Headquarters (CL-FCDRH)
County Level Gov'ts and Garrison
Office of County Level FCDRH (Located in WAB)
Local Database and/or Access to Provincial Database
Drought Index Calculations and Warnings of Local Water Suppliers
Municipal and County MWR Offices
Implement Municipal Level Drought Management Plan and Triggered Risk Reduction and Water Conservation Measures
Implement County Level Drought Management Plan and Triggered Risk Reduction and Water Conservation Measures
Proposed TA-8185 Drought Database and Planning 11 April 13

K.4 Provincial Drought Management Plans

The TA team has developed a prototype provincial drought risk management plan has been prepared using references from a US State Drought Management Plan and ideas from UK regional drought management plans, whilst recognizing the local context and institutional structure. The annotated outline of this prototype DMP is presented in Annex 1 to this Appendix K, and the relevant features of the UK DMPs are presented in Annex 2. The three specific provincial drought management plans prepared for the pilot provinces of Liaoning, Sichuan and Gansu in the subsequent three Annexes. The approaches used in the DMPs are explained in the DMPs themselves and summarized in the draft drought risk guidelines, and thus are not repeated here.

Annex 1 – Proposed Structure of a Provincial DMP

This outline is extracted from a US State Drought Management Plan and also uses ideas from UK regional drought management plans. It also recognizes the PRC institutional structure. It is a starting point and set of ideas on structure for our provincial DMPs of the pilot provinces in the TA. Some of the important suggested language is included in this appendix while the prototype DMP is much larger.

Executive Summary

1. Introduction

1.1 Plan objectives

Box 1. Typical US DMP Goals

- Preserve essential public services during any level of drought severity from mild to critical emergency conditions.
- Minimize the adverse drought-related impacts on public health and safety, economic activity, environmental resources, and individual lifestyles during a drought event.
- Provide a comprehensive yet flexible framework to guide **Municipality XX** staff on the drought risk reduction, mitigation and monitoring efforts at early stages of drought, followed by drought relief actions once drought has developed to serious levels.
- Effective communication of drought awareness and response information to water customers.
- Provide an efficient means to monitor and improve the effectiveness of the Plan over time.
- Closely coordinate the drought mitigation and response with **Municipality XX**'s water supply reliability planning efforts as well as with other **Municipality XX** and regional level policies and planning efforts. This includes Municipality and Provincial policy as well as **Municipality XX**'s Conservation Plan and multi-hazard mitigation and emergency operations plans.
- Provide sufficient contextual information in the Plan to convey the importance of drought preparedness and management to the public and how the actions set forth in this Plan are relevant to reducing future drought-related impacts.

Box 2. Goals for Chaoyang DMP (Example from WRDMAP Project)

- Reduce the impacts of drought disaster through building awareness of drought management and undertaking effective measures to deal with droughts;
- Structure framework of drought management organization for drought risk management, improve the cooperation and coordination between government drought management departments at all levels;
- System of monitoring and reporting to identify and track onset, progress and recovery from droughts;
- Provide more information for drought management by drought prediction with appropriate new methods;
- Set out specified drought management plan and measures targeted on different water users to make a sure of equal/effective/ sustainable water use in drought condition;
- Pay more attention to environment in drought condition;

1.2 Plan principles

1.3 Model of Drought Management Tiering for PRC

2. Drought risk assessment

2.1 Drought hazard analysis

2.1.1 From the perspective of precipitation

2.1.2 From the perspective of water resources

2.2 Drought exposure analysis

2.2.1 Agriculture production exposed to drought

2.2.2 Pasture production exposed to drought

2.2.3 Urban population exposed to drought and water shortage

2.2.4 Population served by rural drinking water systems exposed to drought

2.3 Drought vulnerability analysis

2.3.1 Socioeconomic capacity against drought

2.3.2 Water infrastructure capacity against drought

2.3.3 Other capacity against drought

Table 1: Selected generic factors affecting drought vulnerability

Factors reducing vulnerability	Factors increasing vulnerability
Not directly reliant on rainfall	Reliant on rainfall
Able to obtain water from more than one source	Limited scope to obtain water from elsewhere during drought
Reservoir source especially with over year storage capacity	No or limited storage
Use groundwater, especially from a large aquifer	
Require little water	Need a lot of water
	Need very high quality or very reliable supply
New water efficient technology	Old technology
Can substitute water requirement (thermal power generation, transport more road)	Unable to substitute water requirement (even at a price)
	Lack skills or finance to change crops
Strong balance sheet	Weak financial status limits options
Product of high value to local or wider economy	Product of low value to local or wider economy
Have legal title to abstract, permit has known conditions so can prepare contingency plans ahead	No water abstraction permit to protect use
Have prepared sector or enterprise drought contingency plan in advance	Have not developed sector or enterprise drought contingency plan in advance
Have stand-by facilities to activate in emergency situation (e.g., borehole only used in emergency, pumps available to take water from reservoir below normal drawoff level)	
Well informed about drought status and forecast risk	Poorly informed about drought status and forecast risk
Small number of large abstractors (often bulk suppliers to many small users)	Many small users, poor coordination/organisation
Bigger organisations have greater in-house capacity to prepare for drought contingency	
Well located (central, close to other resources) or if remote location has good access	Remote location with poor physical access
Good political connections	Little political influence (marginalised)
Sector, or parts of sector, are recognised as 'high priority' over other water users enshrined in Water Act and other legal instruments (e.g., "water for living")	Sector, or parts of sector, are identified as lower priority in terms of water supply as established in legal instruments (e.g., users deemed "non-essential" or "luxury")

2.4 Drought risk assessment

2.4.1 Drought history

2.4.2 Drought risk map

Table 2: Historical Dry and Wet Periods in Province XX EXAMPLE

Date	Dry	Wet	Duration (years)
1893-1905	X		12
1905-1931		X	26
1931-1941	X		10
1941-1951		X	10
1951-1957	X		6
1957-1959		X	2
1963-1965	X		2
1965-1975		X	10
1975-1978	X		3
1979-1999*		X	20
2000-2006*	X		6

3. Drought team and responsibility

3.1 Brief Description of DMP Structure and Connection to Provincial DMP

3.2 Drought Team, Responsibilities and Provincial Coordination

3.3 Final Responsibility for Decisions

Table 3: Responsibilities - Example from Chaoyang DMP (WRDMAP project),

Group Member	Role
Development and Reform Committee	Examining and approving long-term drought management plans, supervising the implementation of plans
Financial Bureau	Allocating budget for drought management and rehabilitation of damage after droughts
Water Affair Bureau	Working together with both the Meteorological Bureau and the Hydrological Bureau to undertake the monitoring, forecasting and assessment of meteorological/ hydrological/ socio-economic factors relating to drought condition assessments; Providing information of monthly drought intensity as well as drought forecasting and providing warnings to the Drought Management Headquarter and the general public; During droughts, the preparation of specific Drought Management Action Plan based on this Drought Management Plan. This is submitted to the Drought Management Execution of the Drought Management Action Plan together with the herein specified departments or organizations with specific attention to urban domestic water supply, conducting the management of wastewater treatment plants; Summarizing and evaluating the reports / Drought Logs (drought damage assessments) drafted by each water use category; Reviewing drought action plans and the Drought Management Plan together with relevant departments; Undertaking routine works as directed by the Drought Management Headquarter.
Meteorological Bureau	Undertaking weather monitoring and forecasting; Assessing the changes of climate and weather and providing continued forecasting to weather in real-time;

Group Member	Role
	Providing timely meteorological drought information to the Drought Management Headquarters and other organizations;
Hydrological Bureau	Undertaking hydrological monitoring and forecasting; Working together with WAB, undertaking the evaluation and forecasting of hydrological droughts and socio-economic droughts; Providing hydrological drought information to the Drought Management Headquarters and other organizations;
Economic Committee	Working with WAB to supervise and manage restrictions to industrial water use; Investigation and evaluation into the impact of restricted water availability on industry; Organizing drought mitigation interventions and relief within industrial sector.
Rural Affairs and Economic Committee	Providing technological information on drought-resistant crops to local farmers in accordance with the development or severity of the anticipated drought event and the season(s) affected; Working together with the WAB and the Poverty Alleviation Office assist people and livestock in remote mountain areas in securing assess to drinking water in accordance with the decisions made by the Drought Management Headquarters; Undertaking the supervision and management of agricultural water use; Undertaking the investigation and assessment of drought damage to agriculture; Working together with Civil Administrative Bureau and Poverty Alleviation Office assist local farmers though drought mitigation and relief interventions;
Environment Protection Bureau	Working together with WAB undertake urgent water pollution management;
Urban Construction Bureau	Working together with WAB, undertake the supervision of restricted water use in urban areas; Undertake management of water supply and use in urban areas under drought conditions;
Civil Administrative Bureau & Poverty Alleviation Office	Working together with specialized organizations, assess drought damage and provide drought mitigation and relief;
Food Administrative Bureau	Providing local farmers with information on agricultural production marketing.
Broadcasting and TV Administrative Bureau	Publishing information on drought conditions and management approaches being adopted to the general public through coordination with relevant organizations in the process of drought management;
Forest Administrative Bureau	Working together with WAB, undertake the supervision and management to water use by forestry activities; Investigate and evaluate the impact of drought damage on forests; Undertake drought mitigation and relief to forestry sector as agreed by the Drought Management Headquarters.

4. Drought monitoring and reporting

4.1 Meteorological monitoring

4.2 Hydrometric monitoring

4.3 Drought monitoring by water users and stakeholders

5. Stages, trigger points and response actions

5.1 Drought stages and trigger points

Table 4: US Example Drought Stages, Trigger Point Guidelines, and Response Targets

Drought Stage	Drought Trigger Point Guidelines			Response Targets[1]
	Measured Snowpack near the end of April	Projected Reservoir Storage on July[1]		
		Storage Level	Approximate Supply[2]	
Watch	90% of normal	Storage less than 90% of full	2 years of unrestricted total demand	10% water savings
Warning	75% of normal	Storage less than 80% of full	1 year of unrestricted total demand	25% water savings
Critical	50% of normal	Storage less than 65% of full	1 year of total demand with mandatory outdoor restrictions	40% water savings
Emergency	30% of normal	Storage less than 50% of full	1 year of unrestricted indoor demand	50% water savings

[1] % water savings is measured as annual total retail water sales divided by a 5 year running average of retail water sales.
[2] Based on 2020 projected demands. Unrestricted implies no drought response or water restrictions.

Table 5: Proposal of Drought Classification for Chaoyang of Upper Daling Basin

Potential Drought magnitude	Potential Drought intensity	Colour present drought intensity	Potential Negative Impacts	Drought indices
i	Extreme drought	Red	Socio-economic development in extreme water shortage, some of cities have a lot of stress to access to domestic water supply	Composite SPIs for the latest 12, 24 and 36-month periods < -1.0 Average depth to groundwater is increased to 7.6 m
ii	Severe drought	Orange	Water shortage to socio-economic development, it is difficult for people and livestock in remote rural areas to access to drinking water	-1.0 ≤ Composite SPIs for the latest 12, 24 and 36-month periods < -0.5; Average depth to groundwater is increased to 7.0 m
iii	Moderate drought	Yellow	Water shortage to some of irrigated agriculture, and rain-fed agriculture has a severe water shortage	During the crop growth period, the SPI for the latest 6-month period < -1.0; Relative soil moisture (R) that is 10cm to 20cm below the soil surface ≤ 50%
iv	Slight drought	Blue	Water shortage to rain-fed agriculture	During the crop growth period, -1.0 ≤ SPI for the latest 1-month period < -0.5; 50% < R that is 10cm to 20cm below the soil surface ≤ 60%

Notes:

1) *Composite SPI* $= SPI_{(12)} * 0.6 + SPI_{(24)} * 0.3 + SPI_{(36)} * 0.1$
2) Groundwater depth averaged over 19 observation boreholes
3) $R_{(10\text{-}20cm)}$ calculated following standard guidance 'Meteorological Drought Classification' GB/T20281-2006
4) Chaoyang DMP slightly modified to show potential drought levels, so as not to be confused with actual drought levels I-IV in PRC DRR.

5.2 Drought management under normal conditions

Table 6. Actions and Triggers during Normal Conditions

Actions	Schedule	Responsibility	Resp. for Follow-Up
Review and update the DMP and WAB Drought Management Team Membership			
Hold Annual Area Drought Management Team Meeting			
Review water resources situation			
Confirm links with key water users			
Update abstraction/discharge databases and scenario tables			
Routine monitoring of weather forecasts, rainfall, SMD, river flows, reservoir levels, groundwater levels			
Publish monthly situation reports			
Consider move to 'Potential Drought' conditions based on Effective Rainfall, Groundwater or river level			

Table 7. Examples of Possible Mitigation Measures To Reduce Drought Impacts By Sector

Short Term Actions	Sector	Long Term Actions	Sector
Demand management			
Mixing fresh and low quality waters	U,A,I,R	Increase water collection and storage opportunities	U,A,I,R
Exploiting high-cost waters	U,A,I	Desalination of brackish and saline water	U
Over-drafting aquifers	U,A,I	Treatment and reuse of wastewater	A,I
Diverting water from given uses	U,A,I	Water transfers	U,A,I,R
Decreasing transport and distribution losses	U,A,I	Artificial precipitation	U,A,I,R
Adjust legal and institutional framework	U,A,I,R	Locate new resources (standby supplies)	U,A,I
		Aqueducts and canals	U,A,I
		Groundwater recharge	U,A,I
		Monitoring and forecasting	U,A,I,R
		Adjust legal and institutional framework	U,A,I,R
Demand management			
Restricting agricultural uses (rationing, subjecting certain crops to stress, …)	A	supplementary and deficit-irrigation	A
		Water saving irrigation techniques (drip, sprinkler, …)	A
Restricting municipal uses (lawn irrigation)	U	Incentives to invest in water saving technology	U,A,I
Review operations of reservoirs	U,A,I	Water recycling	U,I
Water metering and pricing	U,A,I	Dual distribution networks for drinking water supply	U
Water rationing	U,A,I	Inventory private wells and negotiate their public use	U,I
Education and awareness creation	U,A,I	Assess vulnerability & advise water users	U,A,I
Provide permits to exploit additional resources	U	Elaborate alert procedures	U,A,I,R
Provide drilling equipment	U	Carry-over storage	U,A,I
Adjust legal and institutional framework	U,I,A,R	Conjunctive use	A,I
Negotiate transfer between sectors	U,A	Adjust legal and institutional framework	U,A,I,R
Impact Minimisation			
Temporary reallocation of water resources (on the basis of assigned use priority)	U,A,I	Development of early warning system	U,A,I
		Reallocation of water resources on the basis of water quality requirements	U,A,I
Restrict uses	U,A,I		
Emergency supplies	U	Use of drought resistant plants	A
Public aid to compensate loss of revenue	U,A,I	Development of a drought contingency plan	U,A,I,R
Tax relief (reduce or delay payment deadline)	U,A,I	Mitigation of economic and social impacts through voluntary insurance, pricing and economic incentives	U,A,I
Rehabilitation programmes	U,A,I		
Resolving conflicts	U,I,A,R	Education for improving preparedness to drought	U,A,I
Postpone payment of credits	U,I,A	Elaborate set-aside regulations	U,A,I,R
Implement set-aside regulations	U,I,A,R		

Note: A = Agriculture, I = Industry, R = Recreation, U = Urban
Source: Bazza, M (2002)

5.3 Risk reduction and mitigation actions under pre-drought conditions

Table 8 Actions and Triggers during Potential Drought Conditions

Actions	Schedule	Responsibility	Resp. for Follow-Up
Place Drought Team on standby	If triggered		
Identify budget required to manage potential drought	If triggered		
Check and update drought communications plan	If triggered		
Activate additional hydrometric monitoring by Hydrology Bureau	If triggered		
Nominate key specialists and confirm their TOR	If triggered		
Notify stakeholders of potential drought status	If triggered		
Coordinate meetings with Municipality and key water users	If triggered		
Draft abstraction and discharge permit variations for non-essential uses	If triggered		
Publish weekly situation reports	Weekly		
Consider move to 'Drought' conditions based on monitoring of effective rainfall, groundwater or river levels or reports from stakeholders of water stress	See triggers below		
Consider return to 'Normal' status	See triggers below		
Wash-up meetings after normal conditions have resumed to learn lessons	If drought is over		

Table 9 Typical USA Conservation Measures

Conservation Measures
Outdoor watering only allowed 6:00 pm to 9:00 am
Toilet rebate program
Washer rebate program
Dishwater rebate program
Loan program for installation of xeriscape
Historic water usage provided on water bills
Water wasting ordinance
Incentives for water efficient fixtures and/or appliances on house resale or remodeling
New landscape ordinances that promote wise water use
Xeriscape loans
Promote indoor water audits
Public education program promoting conservation
Provide acoustical meters to assist customers in identifying leaks
Provide instructional resources on developing a business/office specific conservation plan

5.4 Emergency response actions under drought conditions

Table10 Responsibilities for emergency response actions

Actions	Schedule	Responsibility	Resp. for Follow-Up
Place Drought Team in operational mode	If triggered		
Activate key specialists if necessary	If triggered		
Check and update drought communications plan	If triggered		
Activate additional hydrometric monitoring by Hydrology Bureau	If triggered		
Notify stakeholders of drought status	If triggered		
Coordinate meetings with Municipality and key water users	If triggered		
Implement abstraction and discharge permit variations for non-essential uses	If triggered		
Implement drought management plans/re-allocations of essential water users	If triggered		
Publish weekly situation reports	Weekly		
Intensify monitoring of effective rainfall, groundwater or river levels and incidents of water stress	See triggers below		
Consider return to 'Normal' status	See triggers		
Wash-up meetings to learn lessons	If drought over		

5.5 Relief and recovery under post-drought conditions

6. Plan revision and updates

6.1 Plan revision

6.2 Plan updates

Annex 2 – UK Drought Management Plans

Environment Agency

The Environment Agency (EA) is responsible for monitoring, reporting and acting to manage the impact of drought on the environment, business and people. The EA plans and manages how much water is taken from rivers and the ground through a system of abstraction licenses. Its aim is to make sure enough water is available for everyone without damaging the environment, both now and in the future.

The EA has drought plans for the whole of England and Wales. In addition to the national drought plan, the Head Office drought plan, there are another seven Environment Agency drought plans; one for Wales and one for each of the six Environment Agency regions in England. These plans set out how the EA will manage water resources during a drought and defines roles and responsibilities. They aim to reconcile the competing interests of the environment, the need for public water supply and other abstractions. This involves monitoring a range of environmental and hydrological indicators that determine what action the EA will take to achieve this aim. For example, the EA may increase environmental monitoring, liaise with abstractors, run public awareness campaigns and determine drought permits.

Water companies

Water companies are responsible for maintaining water supplies to meet the needs of customers, without damaging the environment whilst considering the needs of other water users. All water companies have drought plans, which is a requirement of the Water Act 2003. Water company plans cover a range of scenarios from high demand during short summer dry spells to more prolonged drought events. These plans set out the actions water companies will take during a drought to maintain public water supply, including temporary restrictions on water use, leakage control, drought permit applications and publicity campaigns encouraging water conservation. The EA provides guidelines for companies to follow when reviewing their drought plans on a three-year cycle.

Water companies can apply to the EA for drought permits to make more water available for abstraction than under normal conditions. When determining these permits, the EA needs to be satisfied that the water company is acting in line with its drought plan and that additional abstraction will not result in long term or significant damage to the environment. We work with water companies at every opportunity to ensure that the needs of the environment and the needs of consumers and businesses are balanced. However, it is the responsibility of water companies to implement temporary water use restrictions on their customers under their own powers in the Water Industry Act 1991 (as amended by the Flood and Water Management Act 2010). Water companies are now able to restrict a much wider range of water uses in a drought such as using a hosepipe to fill a domestic swimming or paddling pool. These decisions are taken by individual water companies in line with their drought plans, but the EA will tell water companies and advise Ministers if they believe companies are not acting quickly enough.

Irrigation

All irrigation abstraction is carried out under the terms of a license granted by the EA and is often subject to restrictive conditions specified in the license. Many agricultural licenses have conditions associated with them, which allows us to restrict abstraction when flows fall below a certain level.

However, some older licenses do not have these conditions. As a result, the EA can limit the amount of water used for spray irrigation by using Section 57 restrictions (of the Water Resources Act 1991). These allow the EA to restrict or ban the use of spray irrigation licenses “by reason of exceptional shortage of rain”. The EA, however, takes great care to ensure that it strikes the right balance between the needs of the

environment and those of abstractors. When considering the need to impose these extra controls, decisions will be based on a detailed assessment of the local water situation and will be informed by communications with license holders and relevant organizations. The EA will work with abstractors to agree voluntary restrictions first and will make every effort to avoid the imposition of complete bans whenever possible.

Navigation

During a drought it is important that river flows are maintained so as to reduce the impact on navigation and the communities who rely on this environment. The EA manages and maintains water levels to prescribed levels through a system of locks and weirs to enable navigation, manage flood risk and support water levels for public water supply abstraction. However, if this is not possible due to drought the EA would have to inform boaters that there is not enough water to allow navigation.

British Waterways own and run a number of waterways and have their own drought plans which detail drought management options for their canals and navigable waters. EA works in partnership with British Waterways when such circumstances arise as part of our drought management role.

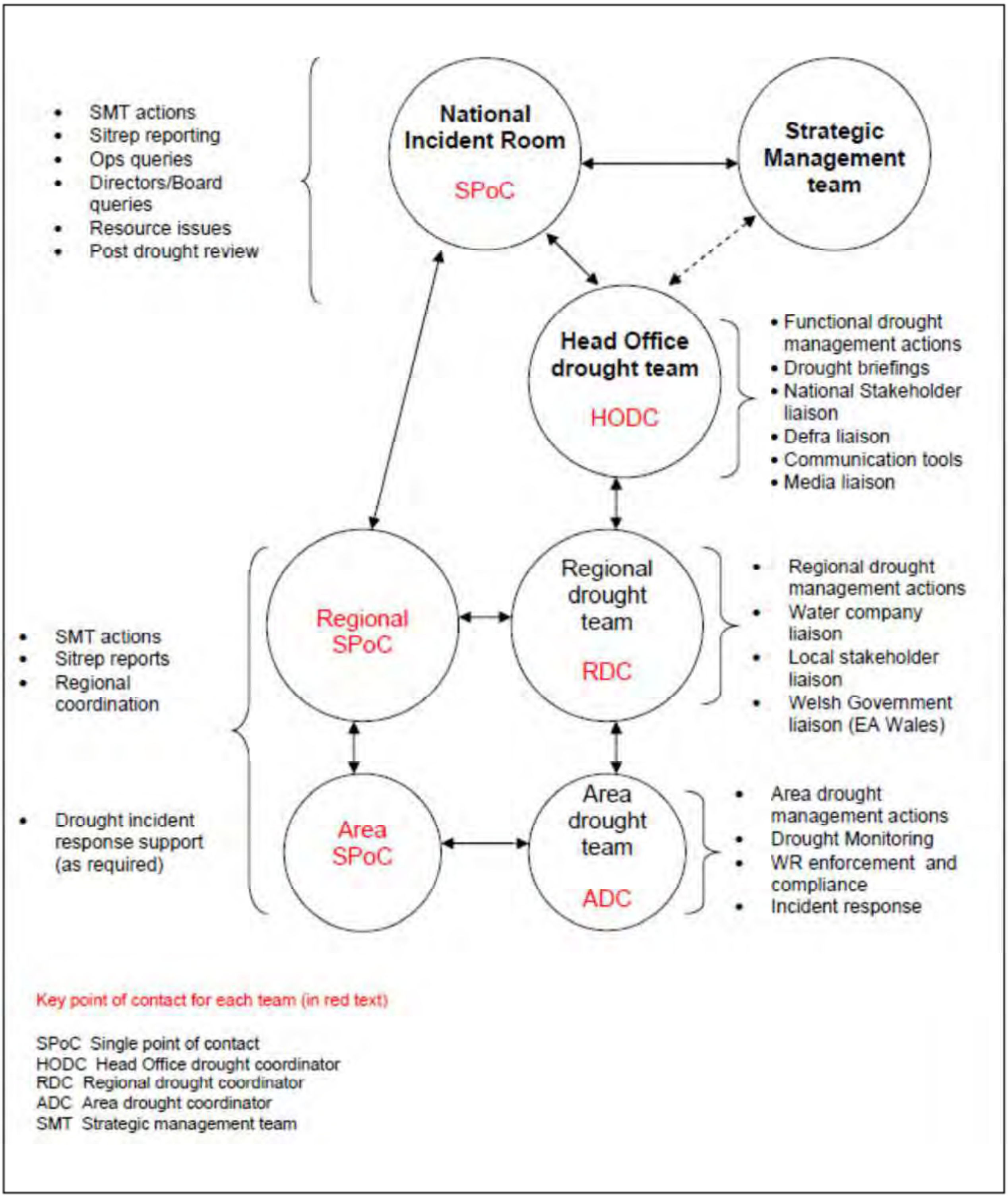
Local businesses and industry

Some businesses abstract water directly from rivers rather than use mains supplies. As such, EA needs to ensure that their needs are considered when making our decisions as to what actions we need to take during a drought. EA will endeavor to ensure that it carries out appropriate consultation and liaison with these water users to ensure that their businesses are not unnecessarily affected by the actions of others during a drought.

Different levels of drought management plans

Each of the areas, regions and national offices has identified drought teams who operate the day to day management of drought incident response. The EA convenes its strategic management team (SMT) during drought to provide strategic governance and direction.

Drought planning is principally led at a national level by water resources teams in Environment & Business and Operations Technical Services (OTS) in partnership with the National Incidents and Contingency Planning (ICP) team. In regions, it is led by Environment and Performance teams. There is no significant input from dedicated incident management staff. The organization of EA staff involved in drought management is shown in the figure below.


SMT actions
Sitrep reporting
Ops queries
Directors/Board queries
Resource issues
Post drought review
National Incident Room
SPoC
Strategic Management team
Head Office drought team
HODC
Functional drought management actions
Drought briefings
National Stakeholder liaison
Defra liaison
Communication tools
Media liaison
SMT actions
Sitrep reports
Regional coordination
Regional SPoC
Regional drought team
RDC
Regional drought management actions
Water company liaison
Local stakeholder liaison
Welsh Government liaison (EA Wales)
Drought incident response support (as required)
Area SPoC
Area drought team
ADC
Area drought management actions
Drought Monitoring
WR enforcement and compliance
Incident response
Key point of contact for each team (in red text)
SPoC Single point of contact
HODC Head Office drought coordinator
RDC Regional drought coordinator
ADC Area drought coordinator
SMT Strategic management team

Drought monitoring

The Head Office drought team is responsible for reporting, consistency of approach and co-ordination of information during a drought. The team collects various types and sources of information for monitoring a drought.

The EA undertakes routine drought monitoring as part of our national monitoring program to provide data for detecting the onset and end of drought and impacts during a drought. This normally includes data from:

- rain gauges;
- indicator flow gauging station network;
- groundwater level monitoring network;
- national ecological drought surveillance network;
- surface or ground water quality monitoring networks;
- water companies (e.g. reservoir storage data).

In addition, the EA may collect additional hydrometric, ecological or other data during a drought where it is appropriate for us to do so.

Within the regions, the operational environmental monitoring teams are responsible for collecting and analyzing the data. They use the information to decide how to manage the effects of drought and recovery. All monitoring plans and data are found in regional drought plans. The collection of hydrometric, ecological and water quality data is a routine activity of the Environment Agency, which is carried out at Area level.

Regions and areas routinely receive information from water companies as part of the EA water situation reporting. During a drought, they receive additional information from water companies to help them track the development of a drought and to monitor their actions.

Water companies must also keep the regional and area Drought Coordinators informed of the actions they are going to take as a drought progresses. These will include measures to reduce demand, such as publicity campaigns and temporary water use restrictions and measures to increase supply, such as reintroducing abandoned sources and upgrading water treatment works.

Drought permits and drought orders

The role of Head Office in dealing with drought permits and orders from water companies is largely advisory to ensure a consistent approach across regions.

The EA provides technical expertise and advice to operational staff assessing and determining drought permits and orders to ensure compliance with legislation and consistency across the organization. Regional water resource planners maintain contact with individual water companies.

Regional drought coordinators must inform the Head Office drought team as soon as it becomes apparent that a water company is planning to make a drought permit or drought order application, or where an Environment Agency drought order is being considered.

Annex 3 – Liaoning Drought Management Plan

Content

Tables

Figures

Abbreviations

ADB	Asian Development Bank
BP	Basin Plan
DID	Drought Information Dissemination Team
DMI	Drought Management Implementing and Drought Damage Assessment Team
DMP	Drought Management Plan
DRA	Drought Risk Assessment Team
DRM	Drought Risk Management
DRR	Drought Relief Regulation (2009)
DST	Drought Specialist Team
DWR	Department of Water Resources, Province Level
EA	Executing Agency
FCDRH	Flood Control and Drought Relief Headquarters (various levels)
IA	Implementing Agency
IWRM	Integrated Water Resources Management
O&M	Operation and Maintenance
M&E	Monitoring and Evaluation
MoA	Memorandum of Agreement
MoU	Memorandum of Understanding
MWR	Ministry of Water Resources
NCC	National Climate Center, PRC
POM	Program of Measures (Spain)
PRC	People's Republic of China
RRP	Report and Recommendations for the President
SFCDRH	State Flood Control and Drought Relief Headquarters
SPI	Standardized Precipitation Index
TA	Technical Assistance
TAO	TA Management Office
WAB	Water Affairs Bureau (local government MWR offices)
WB	World Bank
WMS	Water Management Station
WRDMAP	Water Resources Demand Management Assistance Project

1. Introduction

1.1 Plan Goals and Objectives

The knowledge of risk management approaches has historically been limited, and crisis management has dominated the management of disasters in the world. The drought crisis management mode is triggered only after a drought has already begun, with the development of emergency response and temporary measures to mitigate the effects of drought and losses. In this mode, the measures taken are often short-term and emergency nature, and drought management is often limited to relief of the actual occurrence of drought and mainly for the immediate and local issues. As a result, this often means piecemeal, stop-gap, and completely passive emergency actions and it is easy to fall into the "move from the one disaster to next disaster," the vicious cycle mode.

With the further deepening of understanding of the problem of drought, there is an emerging awareness that to achieve planned and effective drought management, drought relief management in a state of emergency has been unable to meet the requirements, and it is necessary to achieve unified management of Normal and emergency conditions, i.e. drought risk management.

The new drought risk management model involves the following steps:

- monitoring, analysis, forecasting of potential drought occurrence, and the pattern of development
- assessment of the potential damage and the effects of drought may cause and application of the optimal combination of various types of drought risk reduction and mitigation measures
- evaluation conducted after drought process

In this mode, the efficient risk reduction mechanism and rational control process integrates emergency management throughout the drought cycle and organizes the Normal drought management stage of their respective interests, to achieve the global optimum. Compared with the drought crisis management, drought risk management is active, well prepared, thorough and effective drought preparedness and mitigation management. Drought management is no longer limited to the actual drought stage, but throughout the whole process of the development of drought, with normalization of risk management with emergency management at all stages.

Specifically, the provincial plan goals included:

- Establish a scientifically sound risk analysis as the foundation of drought management. Obtain the distribution of values of the drought risk elements such as hazards, exposure, and vulnerability and their relative seriousness.
- Develop a coordinated institutional structure with clear responsibilities. Improve coordination between drought management agencies and different administration levels.
- Establish a scientific and practical platform for drought monitoring, assessment and prediction, improve the drought risk monitoring and early warning capacity.
- Establish a management mode that covers all stages of drought. Define the triggers, management measures for each stage of drought. Achieve proactive, organized risk management of drought.

1.2 Plan Principles

The following principles have been considered:

- Participation of supervision and management from top of the government, sound policies, clear responsibilities and effective management are crucial.

- The departments responsible for prevention, mitigation, relief and aid to the drought disaster need strengthened communication and coordination.
- Drought monitoring and early warning system is crucial in risk identification, assessment, and management.
- Prevention, mitigation and preparedness of drought disaster are the core tasks for drought risk reduction. This includes emergency measures but also a combination of pre-planned approaches from top-down and bottom-up are necessary to effectively implement the risk reduction, mitigation and preparedness measures.
- Improvements in the drought resistance capability for institutions, communities and individuals on different levels are necessary to lower the drought vulnerability.
- Drought risk reduction calls for long-term resource security, including manpower, funding, technical capacity and equipment etc.
- Drought risk reduction needs to consider various measures such as integrated environmental and natural resources management, coordination on social and economic development, land use planning and climate changes, etc.
- The high risk elements in society such as age distributions, disabilities, unfair social treatments and gender issues should be noted. The most vulnerable group are priority needs for protection and to minimize impacts of drought.
- In order to raise awareness on risk, education and training is very important for all people.

1.3 Components of Drought Risk Management

Drought should not be viewed as merely a physical phenomenon or natural event. Its impacts on society result from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand people place on water supply. Human beings often exacerbate the impact of drought. Recent droughts in both developing and developed countries and the resulting economic and environmental impacts and personal hardships have underscored the vulnerability of all societies to this “natural” hazard.

Vulnerability analysis provides a framework for identifying the social, economic, and environmental causes of drought impacts. It directs attention to the underlying causes of vulnerability rather than to its result, the negative impacts, which follow triggering events such as drought. For example, the direct impact of a lack of precipitation may be reduced crop yields. The underlying cause of this impact, however, may be that farmers did not use drought-resistant seeds because they did not believe them to be useful, the costs were too high, or because of some commitment to cultural beliefs.

Although drought is a natural hazard, society can reduce its vulnerability and therefore lessen the risks associated with drought episodes. The impacts of drought, like those of other natural hazards, can be reduced through mitigation and preparedness (risk management). Planning ahead to mitigate drought gives decision makers the chance to relieve the most suffering at the least expense. Reacting to drought in “crisis mode” decreases self-reliance and increases dependence on government and donors.

A new paradigm for drought management uses risk as the driving factor as follows:

RISK = HAZARD (Natural Event) X EXPOSURE X VULNERABILITY (Social Factors)

The hazard aspect of the risk could involve several factors including:
- Severity or magnitude - Intensity and Duration
- Frequency - probabilities

- Spatial extent
- Trends – Historical, Future projections, Impacts

The Exposure represents the probability of drought occurring and the number of people and resources affected. It is sometimes shown as a factor of the Hazard. The vulnerability side of the equation requires the production of drought risk maps and vulnerability assessments. Drought risk is based on a combination of the frequency, severity, and spatial extent of drought (the physical nature of drought) and the degree to which a population or activity is vulnerable to the effects of drought. The degree of a region's vulnerability depends on the environmental and social characteristics of the region and is measured by their ability to anticipate, cope with, resist, and recover from drought.

In principle, drought indices provide a measure of the difference between needed and available water resources and can be part of the "decision support systems" relating to drought. A local water company might use a drought index to trigger water use restrictions and to inform the public about the availability of water supplies. A river basin authority might use an index to inform about and coordinate the use of water throughout a basin. A province might use an index to measure the availability of water resources in entire province. At each of these levels indices can be used for reporting, research or management actions.

A key aspect of drought risk management is the setting of appropriate "triggers" for action based on monitoring of indices. The actions can include the application of pre-identified risk reduction and mitigation measures, including potential reallocation of available water supplies to higher value uses with compensation.

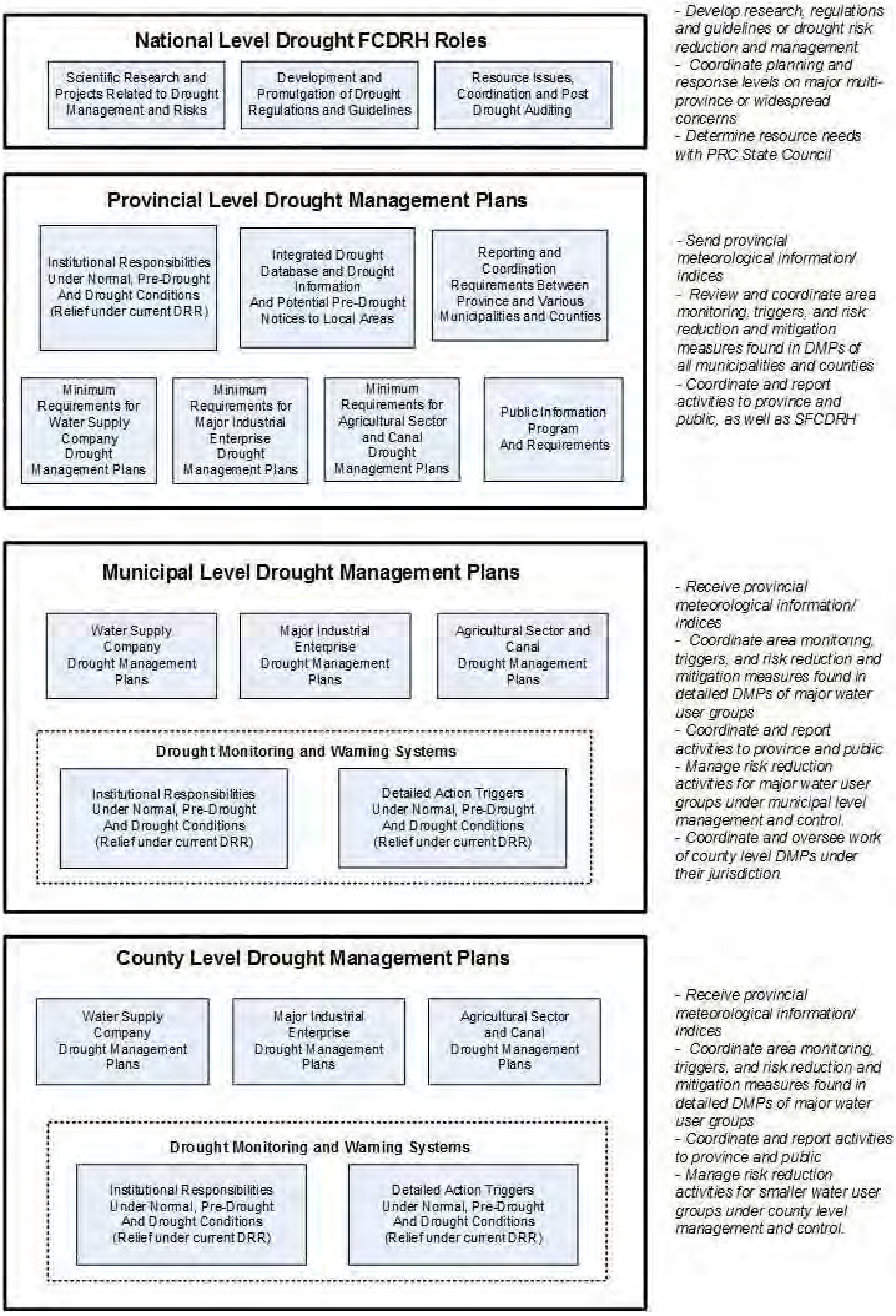
1.4 Model of Drought Management Tiering for PRC

Drought risk management theory (as well as IWRM generally) implies that water management decisions be performed at appropriate levels, usually more local than central. Given this background as well as the organizational structure of national, provincial and local FCDRHs in the PRC, the TA developed a strategic approach to drought risk management in the PRC. The TA pilot province drought management plans were developed under a presumed **future tiering of drought management responsibilities** with linked and specific roles and responsibilities at each layer of the process. Detailed water management decisions in IWRM are made at the lowest practical water management level.

Given this framework, the provincial plan and local municipal/county plans are part of an overall hierarchy of drought planning. The lowest level would be water companies, industries and agricultural interests. Their drought management activities are coordinated by county level and municipal level drought planning. The county and municipal level drought planning is managed and coordinated by these provincial plans, and the entire process has had guidance and oversight from the national level drought management process. Provincial plans need also to address the management and coordination of large scale droughts affecting multiple municipalities and/or counties.

Figure 1-1 on the following page illustrates this conceptual framework and tiered responsibilities at each level.

Figure 1.1: Suggested Tiered Drought Management Planning Responsibilities



The proposed framework for drought management in the PRC uses a set of standard protocols for drought management plans (DMPs) based on China law and international best practices. The provincial DMP has been developed to provide an effective and systematic means for the pilot provinces to reduce the impacts of water shortages over the short or long term. The DMP outlines a mechanism for coordinated drought monitoring, impact assessment, response to emergency drought problems, and mitigation of long term drought impacts. There are three major components of the DMP: mitigation, response and vulnerability assessment.

Since the PRC practice has been to develop drought response or relief plans at various levels, there will need to be some phasing in of the concept of drought management planning at all times, including Normal conditions. There may be an interim period where drought management and drought relief plans exist simultaneously for the local level, with the idea that the drought management plans should eventually supersede the need for separate drought relief plans. There are also a variety of potential constraints to implementing these tiered drought risk management activities during all times in the PRC including:

- Drought funding and budgets are tied to drought relief activities and there is insufficient budget and motivation to perform drought management activities in Normal and Pre-Drought time periods. It is noted that much of the required monitoring for drought during these periods is already being performed but not put into a drought management system or context.
- Collaboration and cooperation amongst PRC water management agencies remains problematic, and will be more of a problem when there is not a definite drought relief crisis.
- There is some concern that additional capacity development and training will be necessary to allow water management staff at levels below the provincial government to adequately manage the drought management plans at these municipal and county levels. If validated, this is no reason to keep all drought management decisions and actions at the provincial level as IWRM demands that decisions be made at appropriate levels by those most impacted.
- It will take significant time for municipal and county level FCDRHs to develop adequate drought management plans so there must be a planned time for the provincial drought management plan to phase in shared roles and responsibilities with local jurisdictions as these plans are developed.
- Local municipal and county level officials will also require time to work with the various sector water management officials (urban water supply, industry, agriculture) on their sectorial drought management plans so that they can be connected to the municipal/county level DMPs.

Based on these constraints, the Liaoning provincial drought management plan may be more of command and control DMP for local areas with the integrated database for the interim period until the municipalities and counties develop adequate local DMPs and improve their technical capacity to manage drought. Or, the provincial FCDRH and MWR could provide additional resources and technical assistance to the local levels in the interim period. As such, the Liaoning DMP recommends both a long-term strategy of tiered drought management between the provinces and the local jurisdictions and a short-term strategy of using the new integrated drought database for overall risk based drought management at the provincial level.

The approach for the provincial DMP includes the following:

- Establish goals and objectives for the plan;
- Prepare an integrated database for monitoring, using SPI, river flow and reservoir levels, with defined trigger points including data sharing with Meteorology Department;
- Organize a daily reporting/warning system from province to local jurisdictions using provincial indicators, to inform potentially affected municipalities/counties of potential or actual drought conditions;
- Prepare drought risk maps and vulnerability assessments of province to understand where and how drought impacts have occurred and where potential damages may happen;

- Implement standard protocols for pre-drought, drought(Levels IV to I) and post-drought stages including pre-identification of appropriate risk reduction, mitigation and water reallocation methods to be employed for each stage;
- Normal stage
  - Optimise water allocation and improve infrastructure
  - Monitoring and reporting on drought indices
  - Preparedness(risk reduction, mitigation and water reallocation methods developed for Pre-drought and all drought stages)
  - Education
- Pre-drought
  - Triggers
  - Preparation and application of risk reduction, mitigation and water reallocation methods;
  - Restrictions/ reallocation
- Drought
  - Triggers
  - Preparation and application of risk reduction, mitigation and water reallocation methods;
  - Essentially in accordance with current guidelines relative to drought relief requirements
- Post-drought Assessment and recovery

1.5 Planned Goals of Provincial DMPs Versus Local and Sectorial DMPs

As noted, the TA has proposed a layered decision support early warning framework that uses the NCC and MWR meteorological drought forecasting at the provincial level FCDRH (as well as available hydrologic and agricultural monitoring) to establish triggered notices to affected local areas (basins, municipalities, counties). Once the triggered notices of potential drought are received at the lower level FCDRHs, the use of the current hydrologic indices and other hydrologic data is expanded to evaluate the probability of drought based on the provincial warning. Depending on these combined meteorological and hydrological assessments and probability analyses, the local level DMPs are triggered for early action water reductions and water conservation measures.

Many of the local indicators can be found and used directly from SL424-2008, and complementary triggered risk reduction and mitigation measures are required. Depending on the severity of the potential drought, additional triggers for re-allocation of water abstractions may be considered with the Water Affairs Bureau based on the drought risk assessments and triggers outlined in the local DMPs. Although there appears to be somewhat comprehensive reporting during Normal operations, in the PRC little is actually triggered or done with this information unless the drought damages begin and an actual drought level declaration is declared (IV to I).

The FCDRHs at various levels are doing early action drought relief planning work but little in the way of monitoring drought indices, predicting droughts and taking early action risk reduction and mitigation measures based on the predictions. Given this background, the TA is not proposing improvements to an existing decision support framework for drought relief but proposing a completely new way of doing business with drought management activities at all stages of the drought cycle (Normal, Pre-Drought, Drought, and Post-Drought).

Drought is unlikely to occur equally over an entire province. At the provincial level, the three basic indicators monitored during Normal Conditions are the standardized precipitation index, runoff anomaly

index and reservoir level anomalies. These provincial early warning results will be provided promptly to the municipal level in Pre-Drought conditions. The local levels can adjust the indicators or add local indicators such as: 1) Adjusting the threshold interval of SPI; 2) Add more soil moisture monitoring stations for relative soil moisture computation; 3) Snowpack measurements, or other local indices.

Municipal levels both report the early warning result to the provincial level, and simultaneously convey the result to their county levels. Meanwhile, the municipal level can take actions according to the forecasting results. Similarly, the county level will make drought early warning and triggering on the basis of the municipal level. Key water use sectors should also be considered. Also, the result is reported to the municipal county and then conveyed to provincial level, and the actions can be triggered according to the forecasting results. With respect to the triggering action, the municipal and county levels should take appropriate measures according to their drought early warning results, including release of information, reduce water abstraction permits and allocate goods, and so on. All of the municipal, county and sectorial drought planning should be conducted using standardized methods and protocols developed by the provincial FCDRH.

For the proposed tiered provincial and local drought management plans, objectives that should be considered include the following:

- Collect and analyze drought-related information in a timely and systematic manner.
- Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.
- Provide an organizational structure and delivery system that assures information flow between and within levels of government.
- Define the duties and responsibilities of all agencies with respect to drought.
- Maintain a current inventory of government programs used in assessing and responding to drought emergencies.
- Identify drought-prone areas of the state/region/nation and vulnerable economic sectors, individuals, or environments.
- Identify mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.
- Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
- Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the World Wide Web).
- Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
- Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state or region.

In summary, the provincial drought management plan includes the following aspects:

- Integrated drought database to allow for continuous monitoring of MWR and NCC data on meteorology using SPI, river flows and reservoir levels.
- Vulnerability assessments in the province coordinated with local jurisdictions.
- Development of standard protocols and minimum requirements for municipal, county and sectorial DMPs prepared in the Province.
- Coordination of local DMP responses especially where drought affects multiple municipal areas or major sectors.
- Provide an organizational structure and delivery system that assures information flow between and within levels FCDRHs.

- Manage drought relief planning and implementation on provincial level according to existing PRC regulations.
- Report on activities upward to National FCDRH and downward to local FCDRHs.

The TA project is presenting a long-term vision for provincial DMPs in this draft document and has also suggested a template for local level municipal and county level DMPs. The proposed tiered approach to drought risk management assumes that the municipalities and counties are provided the funding and capacity building to both develop quality drought risk management plans as well as manage the process. In the short term until this occurs, the provincial drought management plans may be the most practical way to manage drought risk management using the integrated drought database, drought risk mapping, and the meteorological indices.

2. Drought Risk Assessment

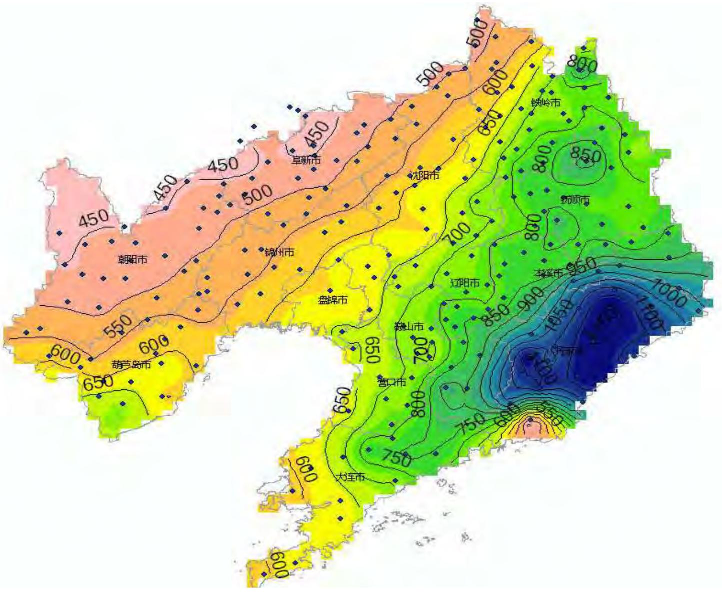
2.1 Drought Hazard Analysis

Risk analysis is the study of the drought-threatened areas likely to suffer the effects of drought intensity and probability. In general, when the intensity of meteorological droughts is greater, the frequency is higher, which means the greater the impacts of drought is, the risk is also greater.

2.1.1 Perspective of Meteorological Factors

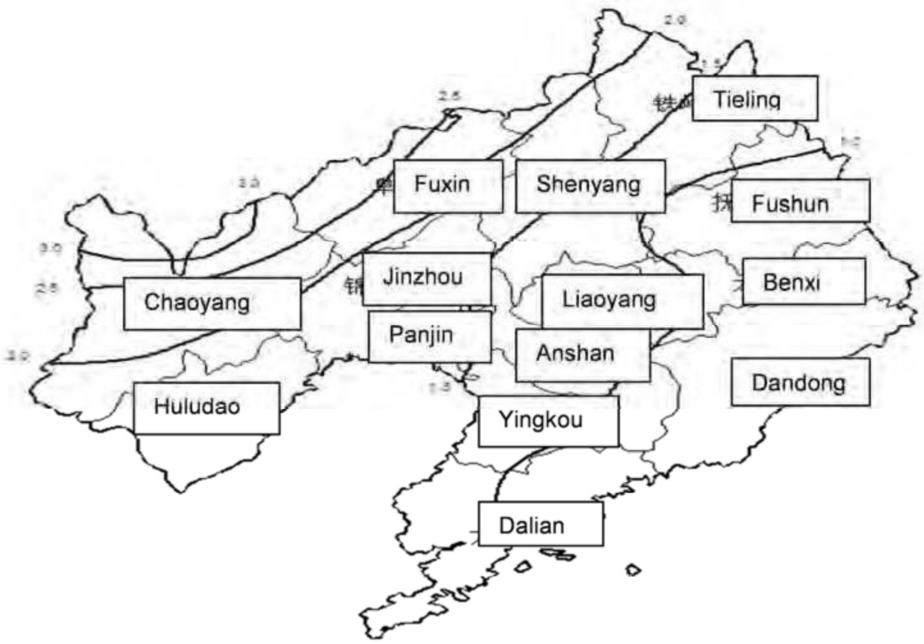
In Liaoning Province, the average annual precipitation is 680 mm, annual rainfall decreases from the southeast to the northwest, see Figure 2-1. Western mountains are connected with the Inner Mongolia Plateau, and the annual rainfall is about 400mm, area in the province with the least rainfall. The central plains have moderate rainfall, with the annual average of about 600mm. Annual rainfall in the eastern hilly area is above 1100mm. The water evaporation capacity, northwest up to 1000 ~ 1300mm, the middle is usually 800 ~ 900mm, eastern only 600 ~ 700mm.

Figure 2.1: Contour Map Of The Average Annual Precipitation In Liaoning Province



The Climate Drought Index (defined as Annual Evaporation divided by Annual Precipitation) increases 0.6 from southeast to northwest, to the northwest of up to 2.2, near Chaoyang. Fuxin region drought index above 2.0 which is the province’s most arid regions, and where drought has been also the most important over the years, see Figure 2-2.

Figure 2.2: Liaoning Province, The Many Years Average Drought Index Contour Map



In addition, according to the ‘10-day drought reports’ during 1972-2007, droughts occur in Chaoyang, Liaoning Jinzhou and Fuxin arid northwest most frequently. Huludao and Dalian, followed by the eastern region reported record drought rarely, see Figure 2-3. Visible, historical reporting and distribution of the province's drought situation is also consistent with precipitation, suggesting that the uneven distribution of precipitation in the region is the dominant factor in the risk of Liaoning spatial distribution of drought. Overall, the northwest is prone to more dangerous drought, but the risk of drought southeast is much smaller.

Uneven distribution of rainfall season in Liaoning Province is an important risk factor in drought time distribution. In crop growing season (May to September), there is generally concentrated more than 80% of annual precipitation. During this period the distribution of precipitation in the region is characterized by a gradual decrease from southeast to northwest. Around the eastern Liaodong the precipitation is 650mm or more, which is the highest, among which Dandong region is between 750 ~ 950mm, Kuandian with the largest precipitation of 955.6mm, Tieling, Shenyang, Liaoyang, Anshan, Yingkou, Jinzhou, and most areas in Dalian are at 400 ~ 650mm, while Fuxin, Chaoyang district only 400 ~ 450mm with the least precipitation in the Liaoning province.

In spring (March to May), the distribution of precipitation: the precipitation in Chaoyang, Fuxin, Jinzhou and Kangping are less than 80mm, among which the precipitation in Chaoyang, Jianping, LingRMB area are only 50 ~ 60mm, which generally does not meet the crop sowing, seedling growth and early spring crop growth requirements on watering. This is a spring Arid Area and said to be “nine spring drought in ten years." In eastern Liaoning Province, the spring precipitation is more than 120mm, and as much as 130-

140 mm in the Xinbin, Huanren, Kuandian, Donggang area. There is no spring drought, and some local areas sometimes have a wet spring phenomenon. Spring rainfall in most of other areas are 80 ~ 120mm, which meets the basic needs of planting and seedling growth requirements. But when the residual soil moisture is not sufficient or the rainfall is lacking or not distributed beneficially, there will still be different degrees of the drought and the hills and mountains area are affected significantly.

Summer (June to August) is strong and the main season crops during vegetative growth to reproductive growth. Most of the province's total annual precipitation in the region during this period of 60 to 70% of precipitation, while western Liaoning Province accounts for 70 to 75%. A time when high temperatures, the formation of hot rainy season, is very favorable for crop growth. Annual distribution of rainfall throughout June to August is; Chaoyang, Fuxin and Shenyang in northern region of 350 ~ 400mm, 500mm or more of Liaodong, where Dandong is 600 ~ 700mm, other regions of 400 ~ 500mm. But in drier years, Liaoning Province varying degrees of drought in some areas also occur.

In September most crops have matured into the season, the relative reduction in rainfall. Annual rainfall is around September 40 ~ 100mm, its distribution is still decreasing from east to west.

2.1.2 Perspective of Hydrological Factors

Surface water resources in Liaoning Province amounts to 30.25 billion m^3, groundwater resources are 12.468 billion m^3, with water resources total 34.179 billion m^3 (Liaoning Province, according to the results of the provincial second evaluation of water resources completed in 2004). In 2000, Liaoning province's population 4,135.35 million, per capita water resources 827 m^3. According to the standards defined by the United Nations, this implies the case of severe water shortages. From the distribution of water resources in the province, due to water resources and population, land resources, the combination is not well matched, resulting in water issues become more prominent. Bohai Sea along the western Liaoning Province, the West Liaohe River, the East Liaohe River Basin District Luan rivers and mountains, cannot reach the mean annual total production of the depth of 150mm minimum to maintain the original ecosystem water resources. Measured by per capita water resources along the Bohai Sea in the west of Liaoning Province, the West Liaohe River Basin is extremely muddy water, with a total area of 63,884 km^2, accounting for 44% of the total area; Liaohe River, east along the Yellow Sea, Luan River to severe water shortages, with a total area of 64,050 km^2, also accounted for 44% of the province's area. Accounting for 11.4% of the province's total area is wet Yalu River Valley.

From the distribution of water resources around the city level point of view, the distribution of water resources in Liaoning Province is very uneven, with similar trends in the distribution of precipitation, decreasing from southeast to northwest, the total water resources of the eastern city of Dandong is 8.594 billion m^3, accounting for 25.1 % of province, while the total northwestern Liaoning Jinzhou, Fuxin, Chaoyang, Huludao City, four water resources 5.69 billion m^3, accounting for 16.7% of the province (Figure 2-4). Per capita water resources in Fushun, Benxi, Dandong three cities is greater than 1000 m^3, Anshan, Tieling cities slightly higher than the provincial average per capita water resources, other cities are below the provincial average of 820 m^3. Per capita water in the northwestern Liaoning is extremely low, and therefore presents the greatest risk of drought (Figure 2-5).

Figure 2.3: Number Of Quarterly Reported Drought In Liaoning Province from 1972 to 2007

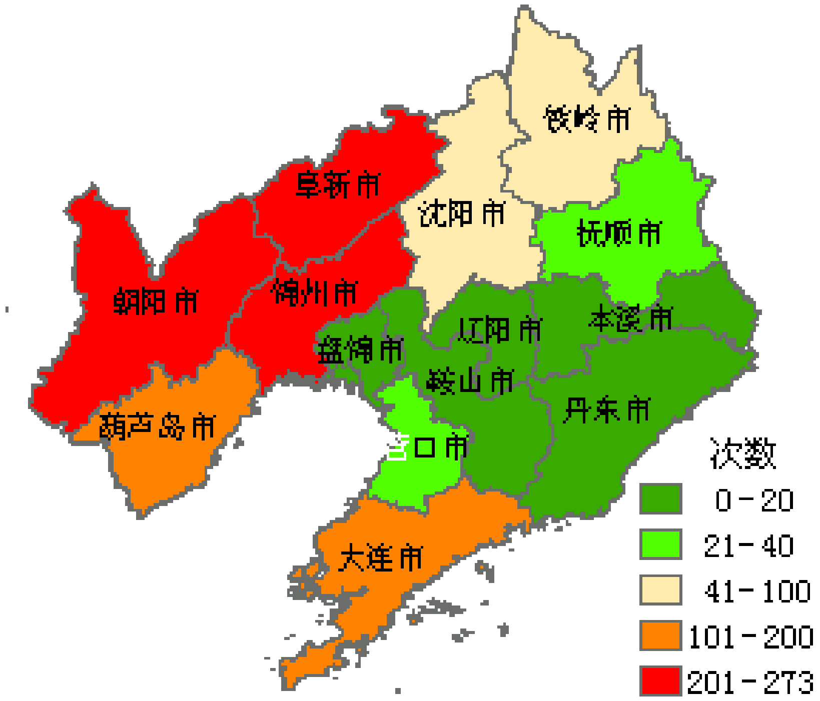


Figure 2.4: Distribution Of Total Water Resources In Liaoning

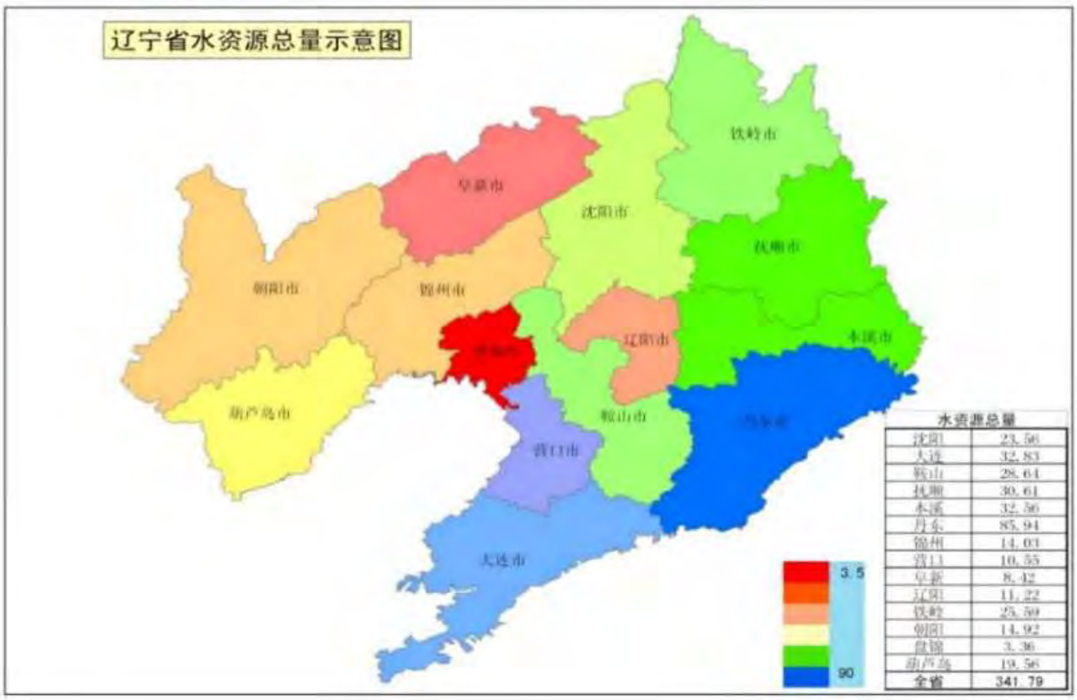
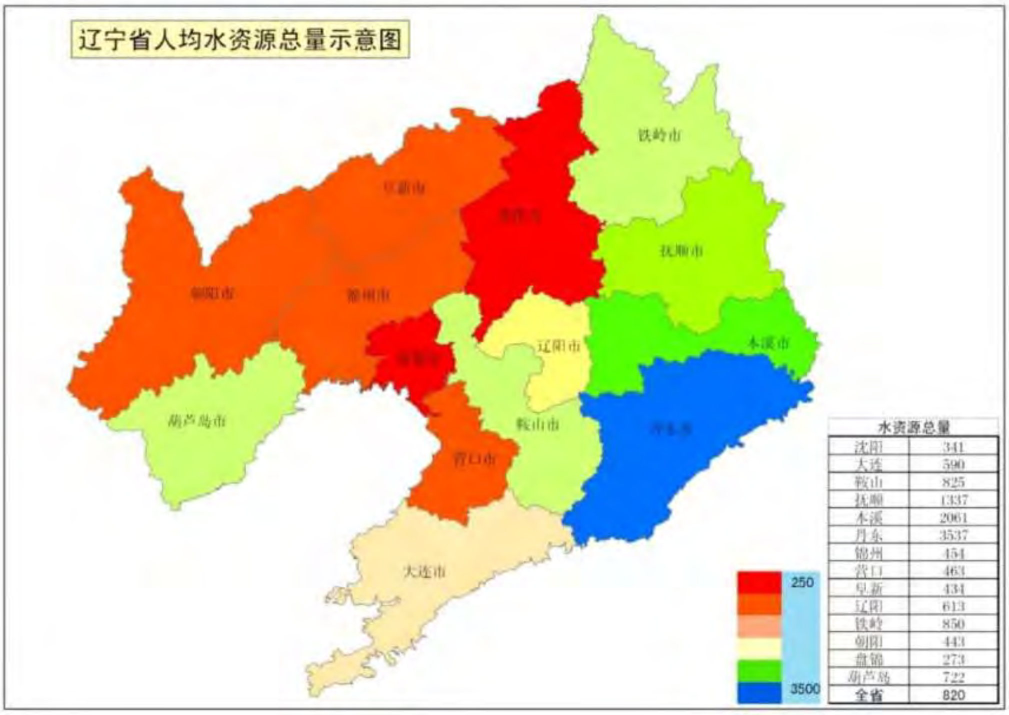


Figure 2.5: Distribution Per Capita Water Resources in Liaoning



2.1.3 Hazard Analysis

Based on the analysis of drought hazard's elements and current situation, with given data and information, the next step was to choose the main elements to establish 'drought hazard fuzzy evaluation indices' system, utilizing unification methods to create non-dimensional indices, interval of 0 to 1. The meant an analytic hierarchy process to determine the contributing weight of each index to corresponding drought risk elements.

Regional drought hazard is the description of characteristics such as time and location, intensity, variation, etc., which reflects comprehensively on drought indices such as meteorology and hydrology. For the drought hazard, taking county as a unit, selecting annual precipitation, variation coefficient of annual precipitation, and amount of water resources per capita as elements, with empirical score and calculated weight as listed in the following table:

Table 2.1: Liaoning Drought Risk Elements and Weight

	Elements	Directions	Weight
Hazard(H)	Precipitation	-	0.429
	Variation coefficient of Annual Precipitation	+	0.429
	Amount of Water Resources Per Capita	-	0.143

Note: In the table the "+" means when the value increases, the hazard increases, "-" means when the value increases, the hazard decreases.

Use the flowing equation to calculate the drought hazard

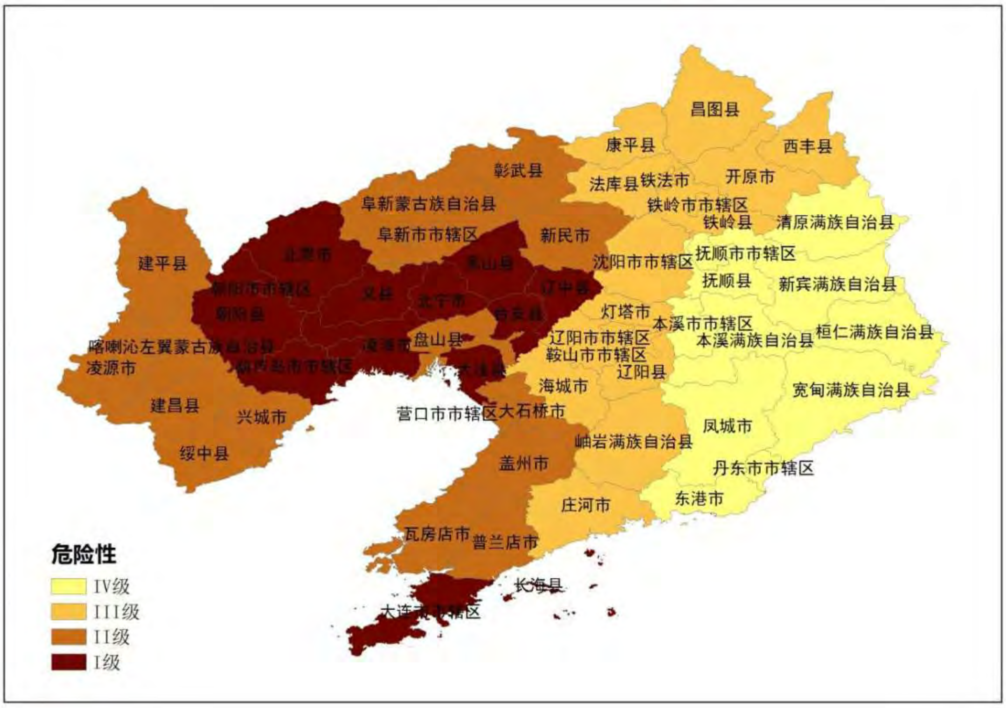
$$H = \sum_{1}^{n} \omega_i y_i$$

Where:

H is the drought hazard,
y_i is the hazard elements,
x_i is the dimensionalized value,
ω_i is the hazard element,
x_j is the weight obtained through analytical hierarchy process.

As illustrated on the drought hazard graph for each county in Figure 2.6, the drought hazard is higher in the northwestern of Liaoning than the southeastern, among which, the Chaoyang, Jinzhou, and Panjin has less amount or water resources per capita with the highest hazard in the province. In Dandong and Benxi, hazard is the lowest.

Figure 2.6: Distribution of Hazard in Liaoning

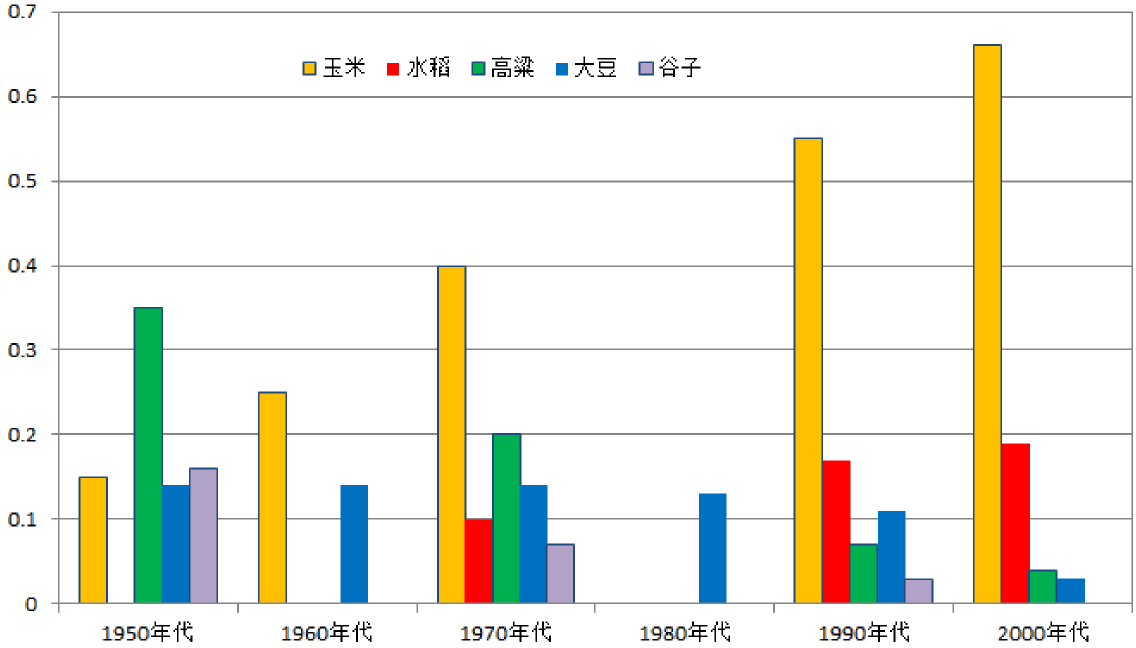


2.2 Drought Exposure Analysis

2.2.1 Agriculture Production Exposed To Drought

Since the 1950s, crop planting structure in Liaoning Province has undergone tremendous changes, the risk of being exposed to drought crop types corresponding changes have taken place. In the 1950s, sorghum was the main crop, sown area accounted for 35% of all food crops, millet 16%, 14% soybeans, and corn accounted for 15%. However, major changes occurred after planting structure. The main traditional crops of sorghum, millet and soybean acreage continued to decline, while maize and rice acreage rising. As of 2010, corn accounted for 69% of the total sown area of grain, rice accounted for 18 percent, accounting for 5% of the soybeans, wheat for less than 1%, showing that the current drought risk exposure is relatively focused large on corn.

Figure 2.7: Changes in agricultural planting structure in Liaoning Province



According to Liaoning Provincial Statistical Yearbook shows that in Liaoning the total arable land area in 2012 is 5.03121 million hectare, with effective irrigation area of 1.69882 million hectare. The total cropping area is 4.3613 million hectare, of which 3.2173 million hectare for grain crops and 0.77013 million hectare for cash crops. The total production is 20.705 million ton. Affected by natural conditions, crops grown in different parts of the province display certain differences, the western region (Chaoyang, Jinzhou, Huludao, Fuxin) due to the drought, mostly planting drought-resistant crops, mainly maize, sorghum, potatoes, soybeans other crops ; annual precipitation is centered in the central and northern regions (Shenyang, Liaoyang, Anshan, Tieling, Fushun), mainly maize, sorghum, rice and other parts of a small amount of crops ; eastern and southern regions (Benxi, Dandong, Panjin, Yingkou, Dalian) precipitation in Liaoning Province where most crops are mostly rice, also planted corn, fruit trees and oil crops. Overall, though mostly in western Liaoning planting drought-resistant crops based, but because of the higher risk areas of drought, agricultural drought risk exposure as well. Typical year following the selection of drought validates this conclusion.

According to the second assessment of water resources, for 1956 to 2000 including 45 years of natural frequency analysis of annual runoff, Liaoning province is divided into three regions including the Liao-Hun-Tai area, western area and southeast coastal area. Based on the analysis of monitoring data from representative stations for each area separately, the year 2000 was identified as the extreme drought year (97%) and the year 1993 was the moderate drought (75%). Drought planning from 'Liaoning province heavier drought disaster area loss rate analysis' (results obtained in 2001 disaster), the loss rate is larger, second only to 2000, so as to determine the severe drought in 2001 (95%).

Liaoning Province, three years from the typical agricultural drought area ratio grade distribution (Figure 2.8 - 2.10) found that drought expanded exhibit the characteristics of western Liaoning Province from 1993 to part of urban sprawl 2001 northwest Liaoning, and then in 2000 and spread to the northwest of Liaoning and middle south of Liaoning. Whether it is serious or moderate drought, severe drought, basically northwestern areas affected by drought, while as a percentage of the province's largest agricultural drought area, so the degree of exposure of agricultural drought is also larger. According to statistics of the severe drought in 2000 in Liaoning province, it covered 14 municipalities affecting 59 counties (cities, districts) 1103 towns, and 641 townships. This included a drought-stricken population of 1559 people, of which severely affected population of 4,030,000 people. The most severe losses appeared in four cities in western Liaoning, Wa Fangdian county in Dalian municipality, Yingkou municipality, Kangping County and Faku County in Shenyang municipality and Changtu Couty in Tieling municipality. In 2000 the province's GDP was 466.9 billion RMB, due to the drought, so that grain, fruit, vegetables, crops, forestry and aquaculture and other agricultural direct economic losses of 9.05 billion RMB.

Figure 2.8: 1993 Agricultural drought area of moderate drought level distribution ratio

Figure 2.9: 2001 Severe drought in Agricultural drought area ratio level distribution

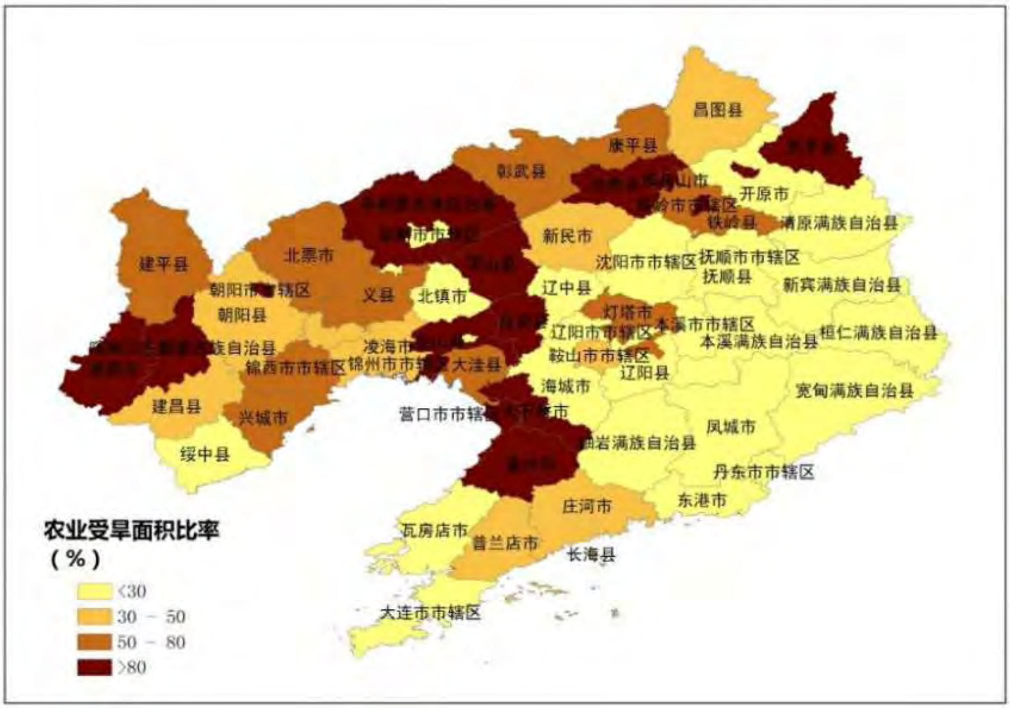
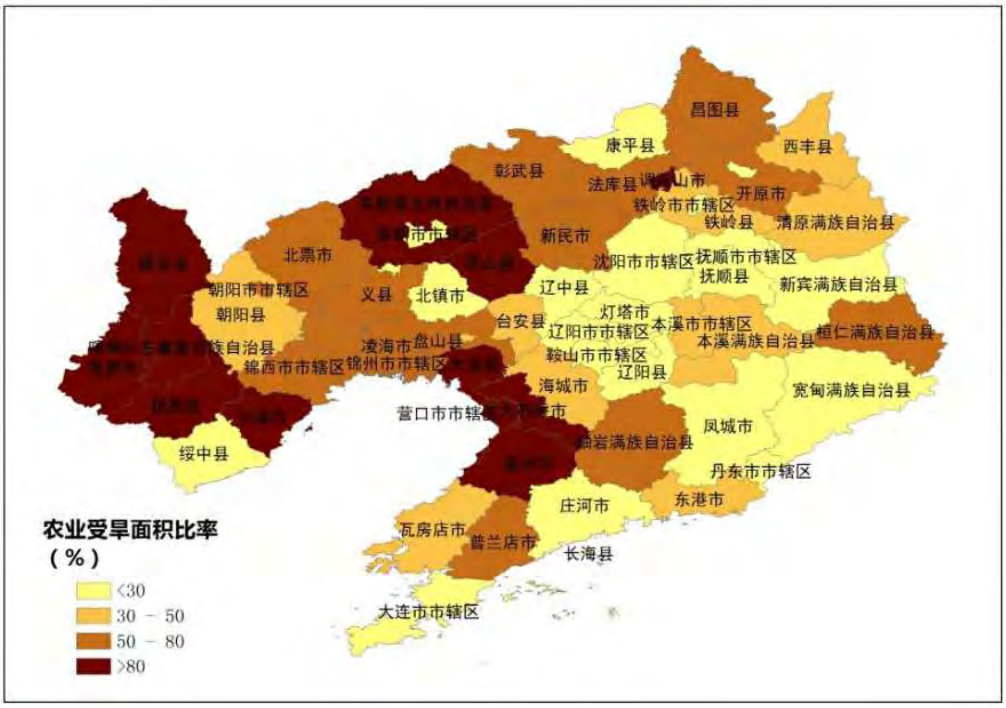


Figure 2.10: 2000 Extreme drought in Agricultural drought area ratio level distribution



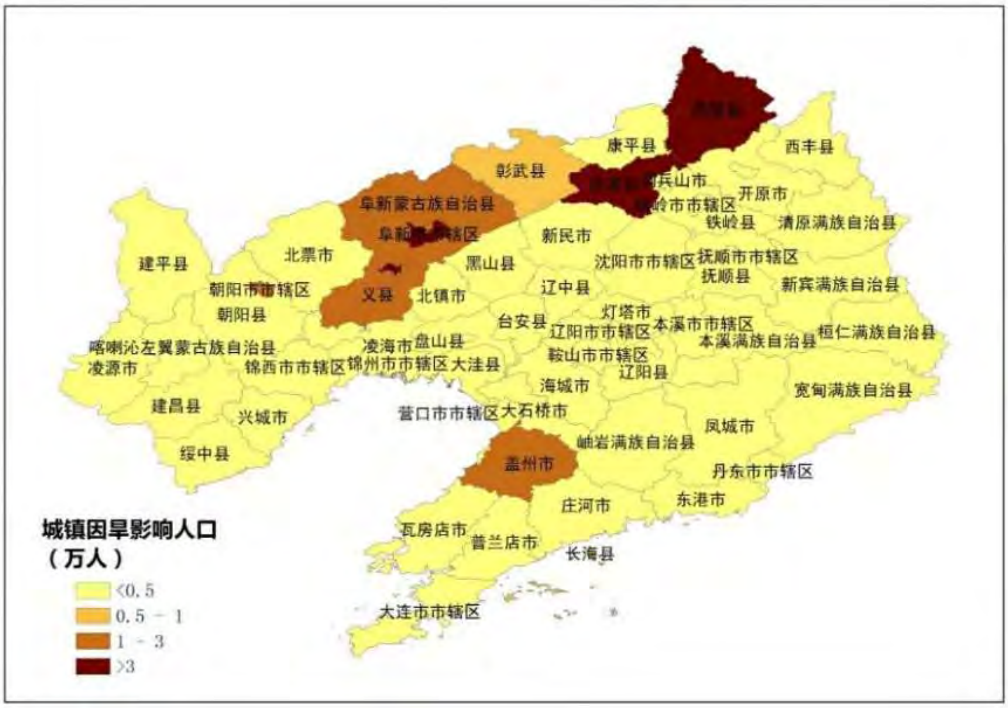
2.2.2 Urban Population Exposed To Drought

Urban areas are economically developed, densely populated areas and once the drought water crisis will have serious consequences for the stability and economic development of society. Due to drought, less per capita water resources, urban water consumption continues to increase, the risk and difficulty of solving the problem of the city also will increase the occurrence of droughts.

From statistics in 2000 to 2007, the drought-affected areas in Liaoning Province were: Wafangdian area in Dalian municipality; Jinzhou municipality; Gaizhou area in Yingkou municipality; Fuxin municipality; Beipiao area in Chaoyang municipality; and Xingcheng area in Huludao municipality. When facing severe drought, the water supply in the whole Liaoning Province was reduced by 20 million m^3, with the affected population of about 440 thousand and affected industrial added value of 1.16 billion RMB.

When moderate droughts occur (in 1993 as a typical year), urban drought affected population is 25.64 million in Liaoning Province, affecting more populous cities of Shenyang Faku County, Changtu County Tieling City and some areas of Fuxin County (Figure 2.11). This reduces the water supply by 4.73 million m^3 in the drought, affecting industrial added value of 978 million RMB, of which the Changtu County in Tieling Municipality was affected the most in terms of the water supply reduction and the industrial added value be affected.

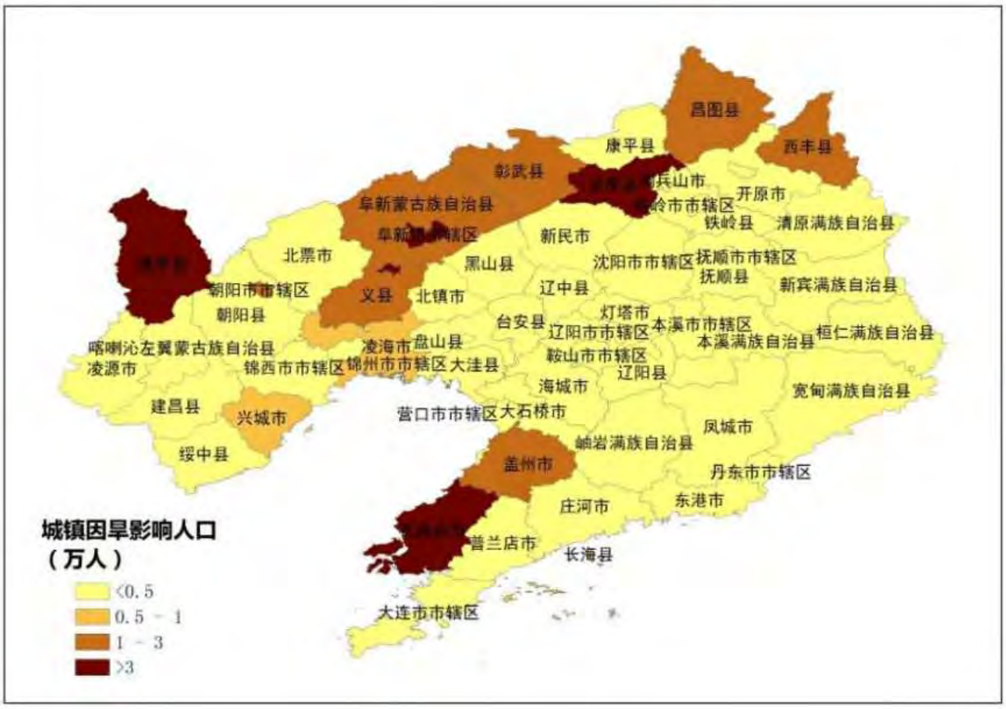
Figure 2.11: 1993 Moderate Drought Affected Population Level Distribution



When Liaoning experiences severe drought years (2001 is a typical year), 390 thousands population were affected, water supply was reduced by 15 million m^3 and the industrial added value was reduced by 3.2 billion RMB, of which the Changtu County in Tieling Municipality, Faku County in Shenyang Municipality,

Yixian County in Jinzhou Municipality and Jianping County in Chaoyang Municipality were affected the most (Figure 2.12).

Figure 2.12: 2001 Severe Drought Affected Population Level Distribution Of Drought



In an extreme Liaoning drought year (2000 is a typical year), the urban population of more than 45 million people are affected, reduces water supply 15 million m^3, and affects the industrial added value of 3.2 billion RMB, mainly affected areas of Faku County, Shenyang City, Jinzhou and Dalian Wafangdian Jianping (**Figure 2.13**). Typical year drought affected towns are shown in following table.

Table 2.2: Liaoning Province Town Typical Drought Impact Analysis Table

p(%)	Year	Actual Water Supply (100 million m3)	Water Supply Reduced due to Drought (10 thousand m3)	Populations under impact (10 thousand capita)	Industrial value added affected (RMB 100 million)
75	1993	30.66	473	25.64	9.78
≥97	2000	38.29	1568	45.07	31.87
90～95	2001	38.38	1495	39.01	31.67

Liaoning Province towns close to the big and medium-sized reservoir water level city and part of county-level cities, although when droughts occur naturally lead to reduced runoff and reduce reservoir levels. Because of the reservoir are regulating reservoir, the case of a serious and large meets the basic requirements of urban water supply during drought. According to county statistics, in 2000 some counties (cities) city water shortages, but to take time quantitative water supply, causing difficulties in urban drinking water, industrial development is limited, affecting industrial production and so on.

By selecting three typical years (1993, 2000, 2001) on the urban population of drought, the reduction in the amount of water, drought affecting the distribution of industrial added value was found in Liaoning Province: Changtu County, Tieling City, Shenyang Faku County, Jinzhou Jianping, Fuxin County and other counties Zhangwu city are vulnerable to the effects of drought and drought affect more urban population, and its impact on industrial production and a corresponding decrease in the amount of water is also relatively more. Therefore, the risk of drought in this region of the city of greater exposure.

Figure 2.13: 2000 Extreme drought affected population level distribution of drought

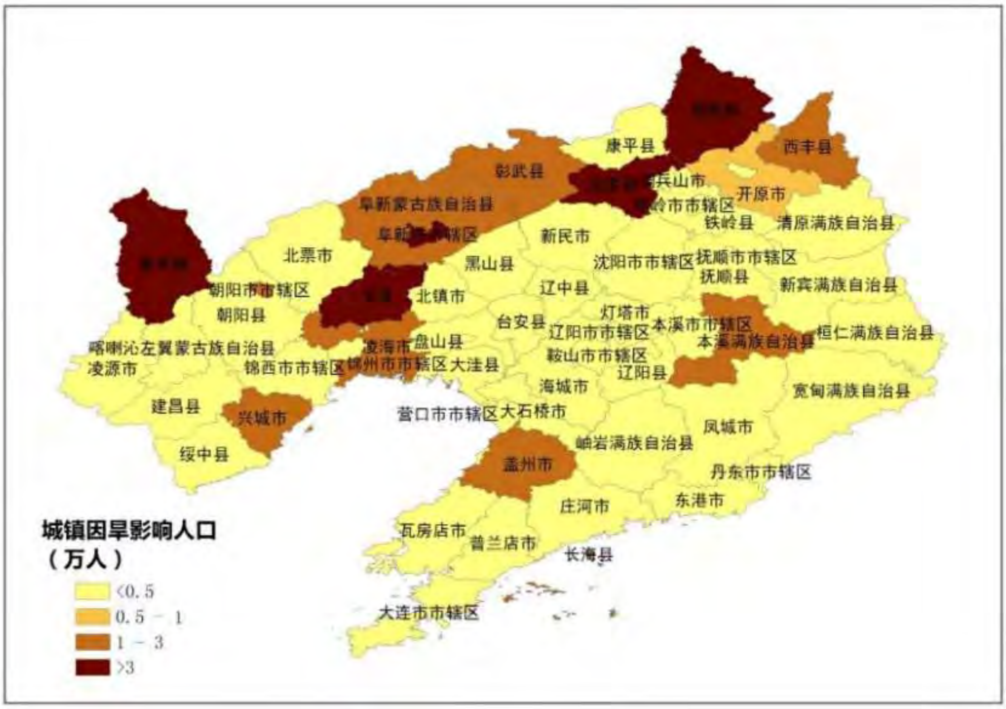


Figure 2.14: Liaoning Severe Drought Reduce Urban Water Supply Level Distribution

Figure 2.15: 2000 Liaoning Extreme Drought Reduce Urban Water Supply Level Distribution

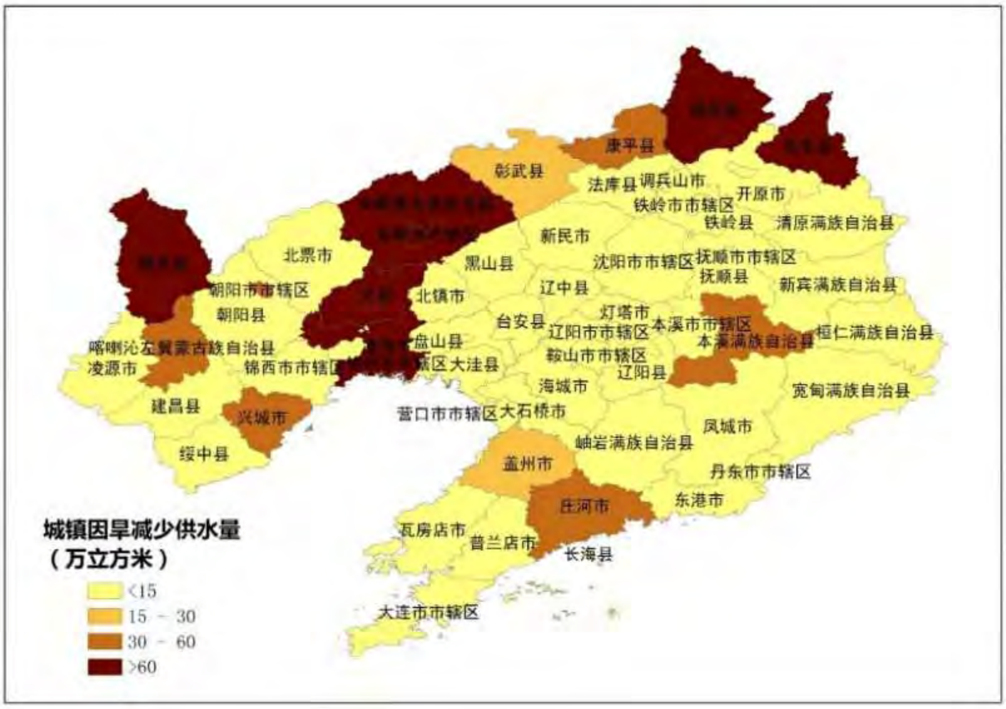


Figure 2.16: 1993 Liaoning Moderate Drought Affecting Urban Industrial Value-Added Distribution Level

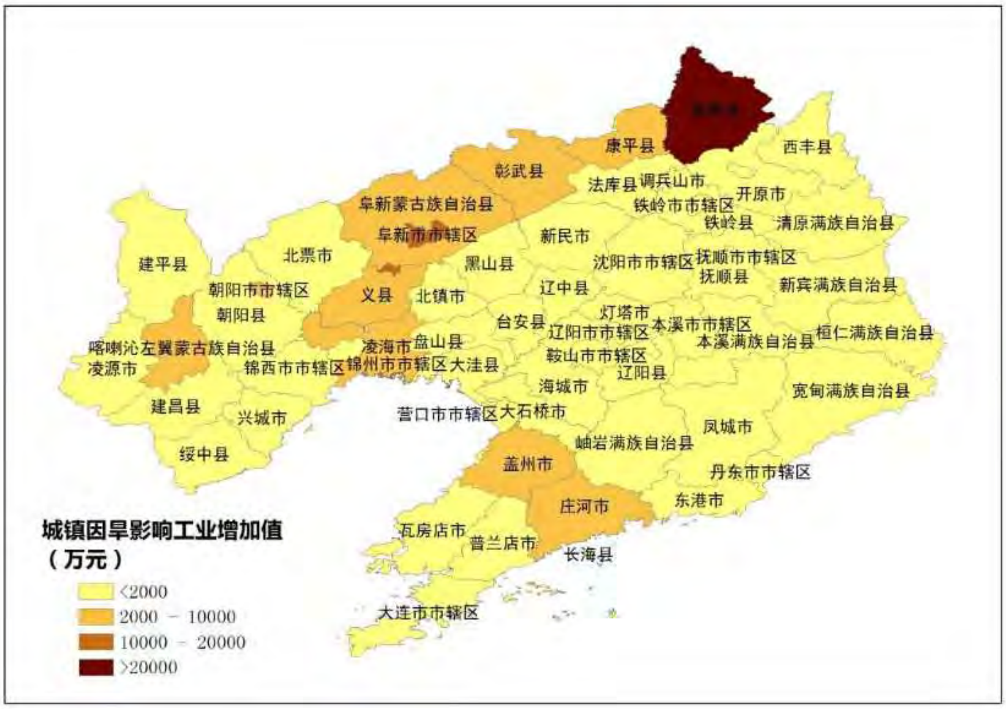


Figure 2.17: 2001 Drought, Liaoning Province, The Severe Drought Affecting Urban Industrial Value-Added Distribution Level

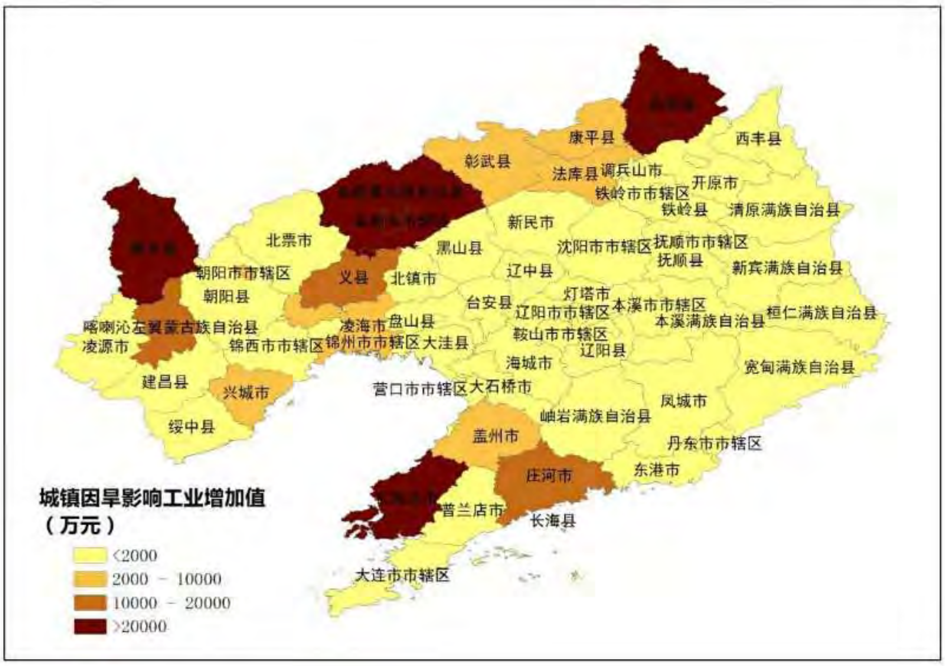
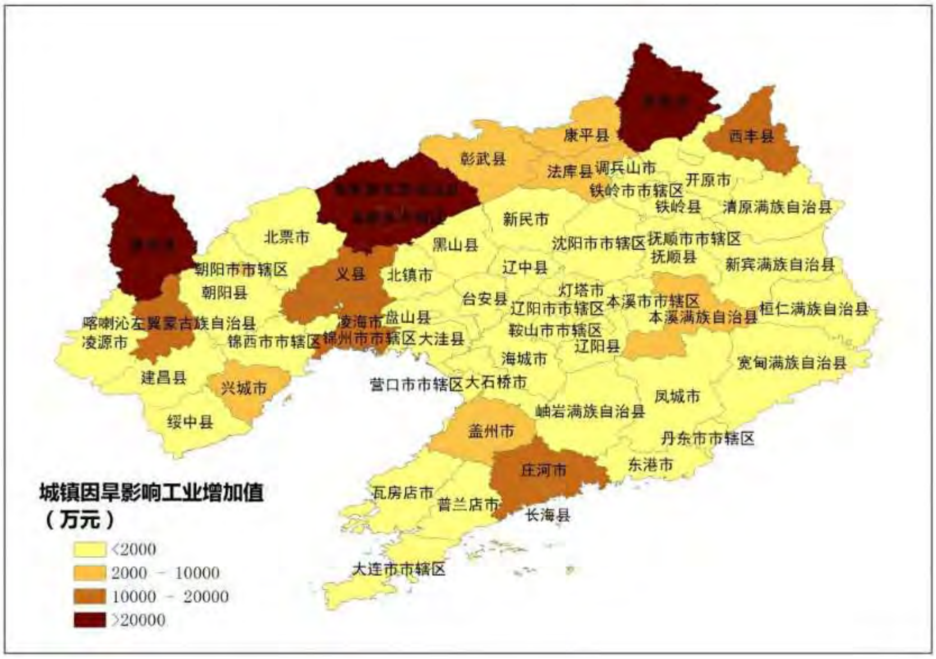


Figure 2.18: 2000 Liaoning Extreme Drought Affecting Urban Industrial Value-Added Distribution Level



2.2.3 Population Served By Rural Drinking Water Systems Exposed To Drought

Water shortages result in arid crop production, the impact of agricultural activities, causing soil erosion and a series of disasters, but also the impact of drought on rural drinking water is important. According to the statistical analysis in following table, Liaoning Province when the drought occurs when moderate (1993 is a typical year) grain loss rate of 3.4%, severe drought years (2001 is a typical year) while 16.8% experienced severe drought years (drought in 2000 was a typical year) rate of 35.1% when food losses, seriously affected the socio-economic development of rural areas. The case of severe drought in the countryside of grain, vegetables, cash crops and aquatic and other economic losses of 7.34 billion RMB. While droughts and severe difficulties caused by the drought on rural residents and livestock drinking water, in case of serious and severe drought years, drinking water is affected in the rural population of one million people, as well as livestock water supply.

Table 2.3: Typical Liaoning Drought Affected Rural Drinking Water Main Indicators

p(%)	Year	Grain Production (10000 ton)	Rural population stressed for drinking water (10000 capita)	Livestock stressed for drinking water (10000)	Grain production lost due to drought (10000 ton)	Rural economy lost (100 million RMB)	Rate of grain lost(%)
75	1993	1696	37.6	26.3	57.5	8.0	3.4
⩾97	2000	1140	165.3	93.0	400.3	73.4	35.1
90～95	2001	1408.4	165.8	89.8	237.1	42.3	16.8

It is typical of rural drought years' grade distribution analysis for drinking water problems of population and livestock (along with improved levels of drought,) drought in rural drinking water and livestock population has gradually increased. The 1993 moderate drought severely affected areas are mainly in Shenyang Faku

County, western and northern parts. During the severe drought in 2001, the population having drinking water crisis exceeded 100 thousand, including population in Changtu County, Xifeng County and Faku County in Jinzhou Municipality, Beipiao Municipality and Fuxin County. In western/northern/southern Liaoning, most cities have suffered temporary problems in water. In 2000 severe drought in the central part of the region in addition to little effect, other areas have serious difficulty in drinking water. In summary, drinking water in arid western and northern Liaoning has a higher exposure and greater drought risk.

Figure 2.19: 1993 Drought Moderate Drought Drinking Water Problems Of Rural Population Level Distribution

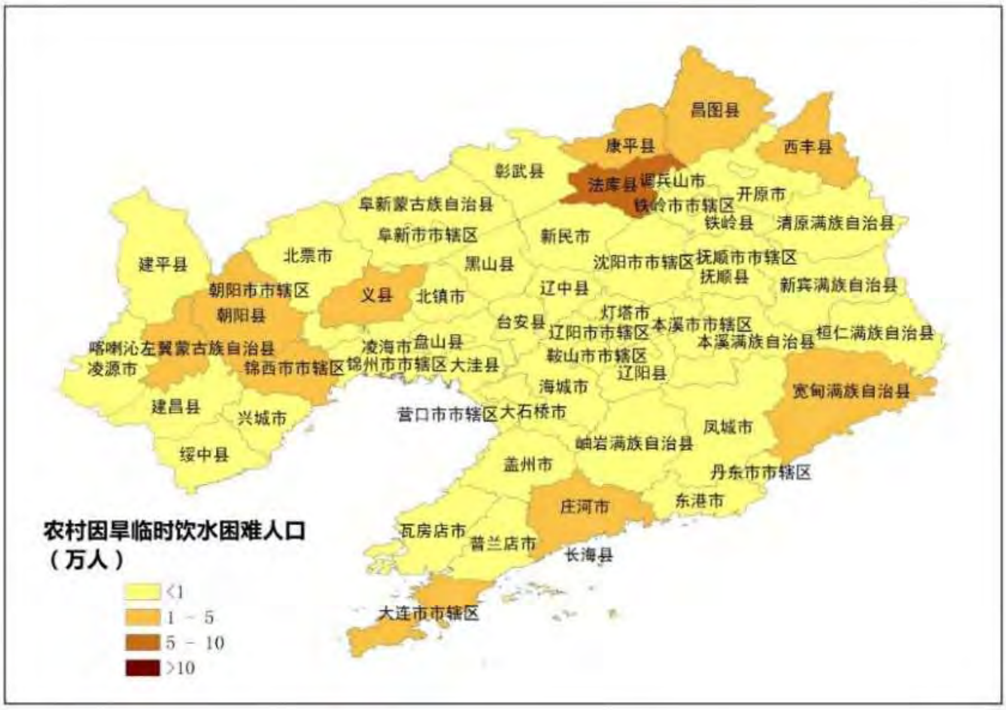


Figure 2.20: 2001 Severe Drought Drinking Water Problems Of Rural Population Level Distribution

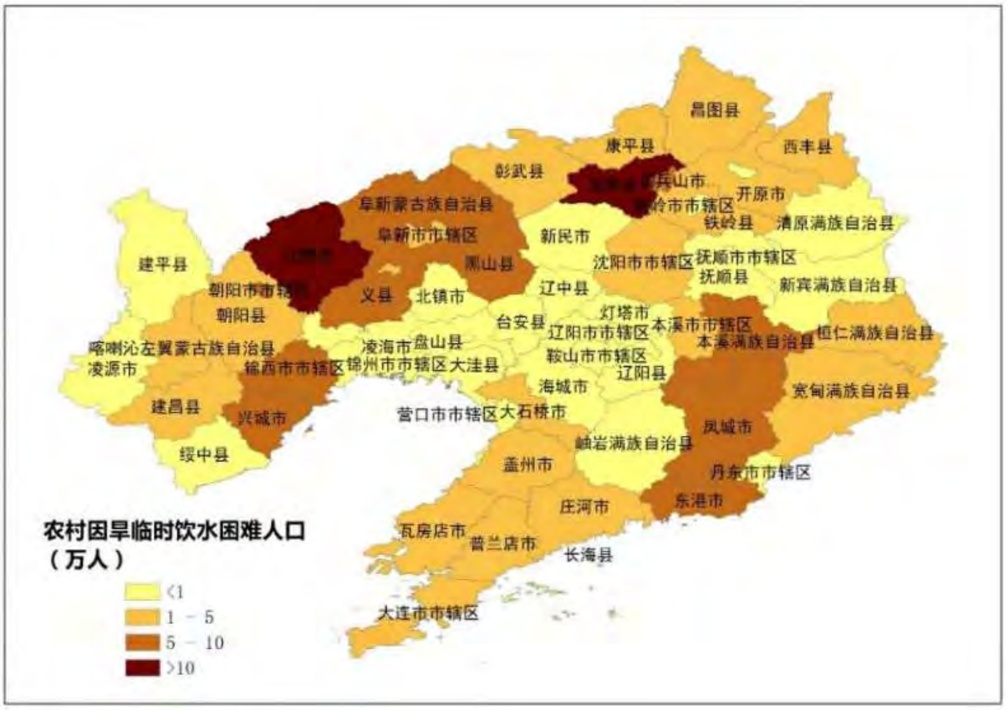


Figure 2.21: 2000 Extreme Drought Drinking Water Problems Of Rural Population Level Distribution

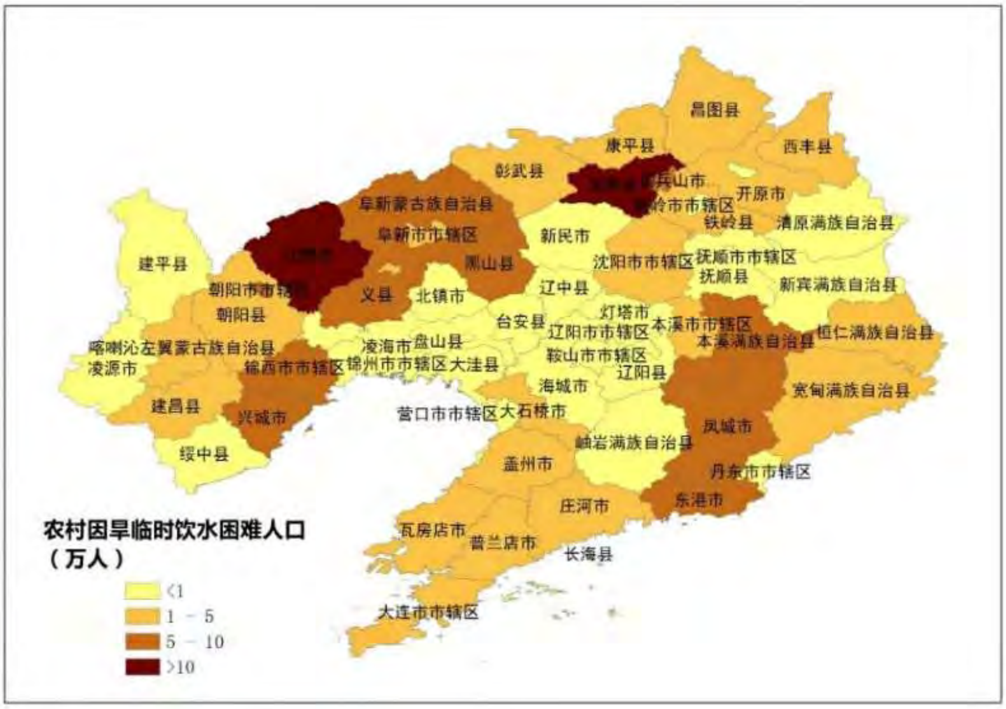


Figure 2.22: 1993 Drought Moderate Drought In Rural Drinking Water Problems Of Livestock Grade Distribution

Figure 2.23: 2001 Severe Drought In Rural Drinking Water Problems Of Livestock Drought Level Distribution

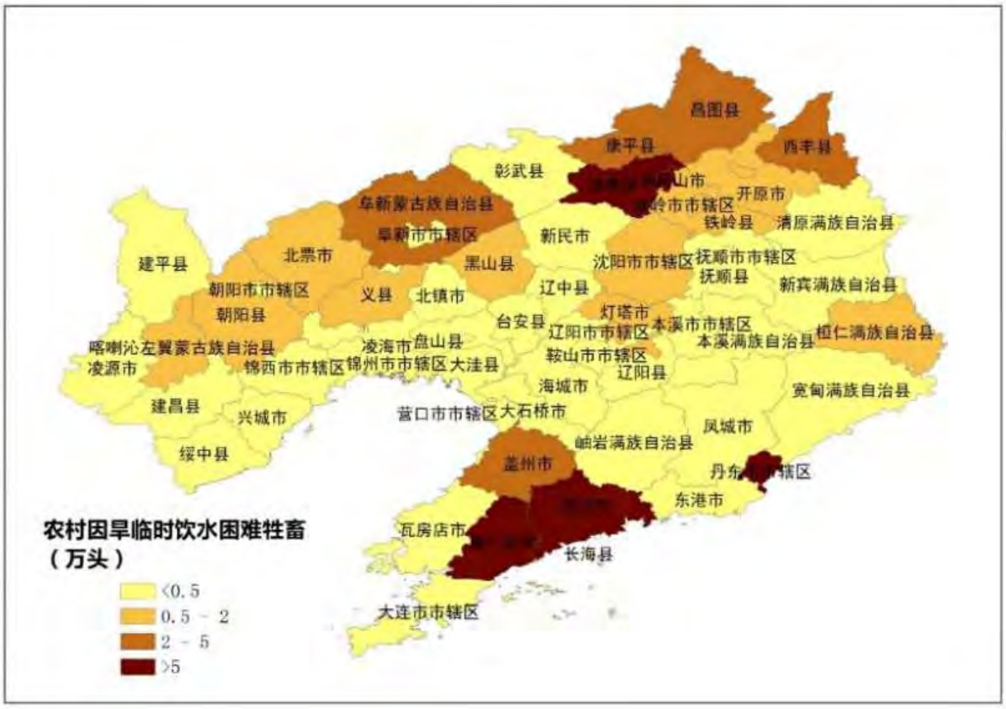
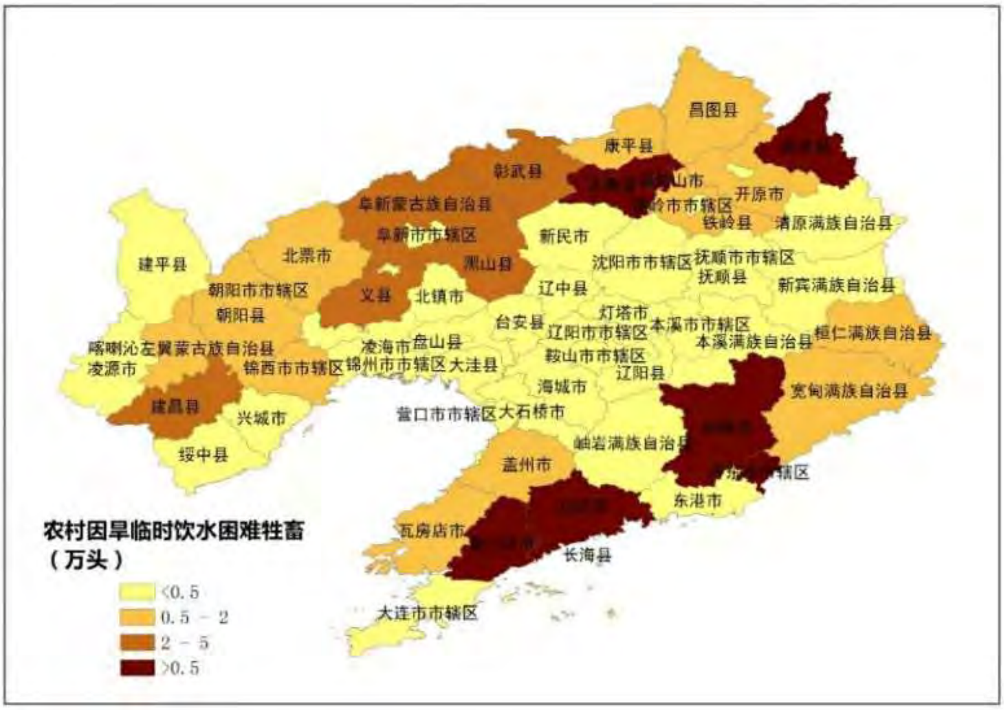


Figure 2.24: 2000 Extreme Drought In Rural Drinking Water Problems Of Livestock Drought Level Distribution



2.2.4 Exposure Analysis

Based on the analysis to different impacts in different typical years, a method that could reflect drought risk exposure comprehensively was searched. In the regional risk analysis, the elements affecting exposure are: population, resources, socioeconomic etc., based on the quantity and spatial distribution of these elements, the value of exposure could be determined. Considering the representativeness and availability of drought data, selecting GDP per capita, population density, and livestock density, as well as grain production per area as the elements to calculate the weight as following:

Table 2.4: Liaoning Exposure Elements and Weight

	Elements	Directions	Weight
Exposure(E)	GDP per capita	+	0.091
	Area of land per capita	+	0.273
	Number of livestock per area of land	+	0.091
	Grain production per area of land	+	0.273
	Are of land planted	+	0.273

Note: In the table the “+” means the higher the value is, the larger the exposure is,”-“ means the higher the value is, the smaller the exposure is

The equation of calculating drought exposure is as following:

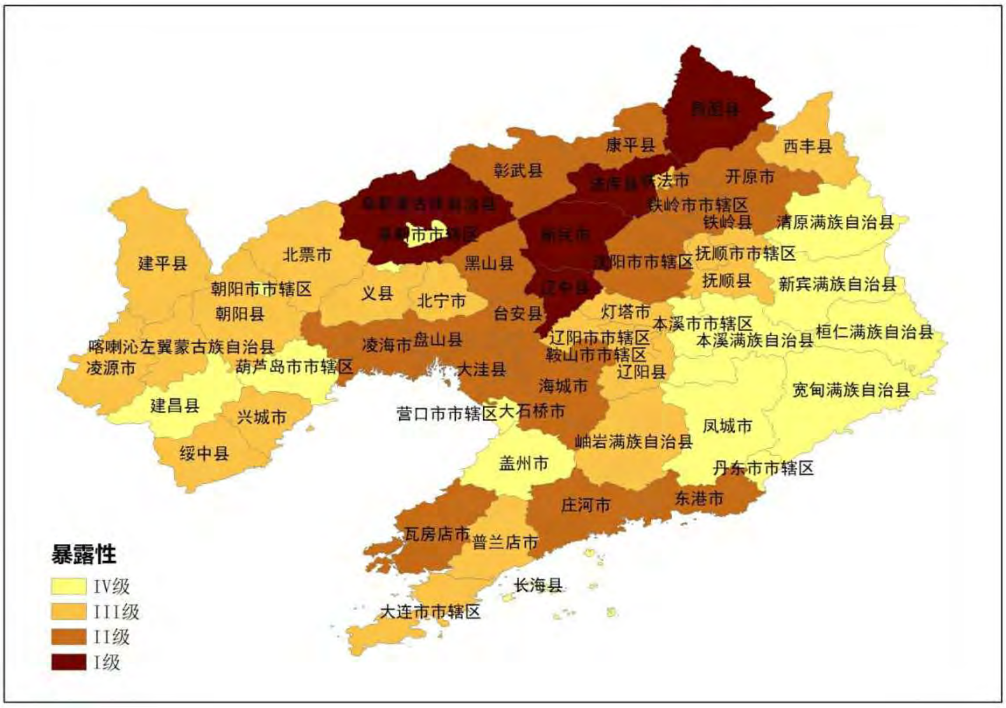
$$E = \sum_{1}^{n} \omega_i y_i$$

Where:

E is the value of drought exposure,
y_i is the hazard elements,
x_i is the dimensionalized value,
ω_i is the hazard element,
x_j is the weight obtained through analytical hierarchy process.

The value of exposure in different areas of Liaoning was illustrated in the following figure. The exposure is high in Tieling, Fuxin, Shenyang where the population density is high and agriculture production is developed. Bensi, Dandong and Huludao's exposures are the lowest.

Figure 2.25: Distribution of Exposure in Liaoning



2.3 Drought Vulnerability Analysis

Vulnerability as "a group, system or asset vulnerable to droughts caused by the nature of the threat and impact of loss" vulnerability analysis is focused on drought risk analysis, mainly from the natural environment and the socio-economic environment in the analysis of the threat of drought ability to resist drought in the region. The level of vulnerability to drought have a "enhance" or "attenuate" effect of the

disaster, and can objectively reflect differences in drought response, cushioning and resilience. In general, when the vulnerability of potential impact area is larger, the risk of disaster is higher.

2.3.1 Socioeconomic Capacity against Drought

In 2007, the total population of Liaoning Province was 42.317 million, in which 22.973 million was urban population and 19.344 million was the rural. The urbanization rate was 54.3%. At current price statistics, the province's GDP was 1.10235 trillion RMB, the primary sectorial value added was 113.34 billion RMB production, secondary sectorial value added was 585.31 billion RMB, tertiary sectorial value added was 403.7 billion RMB. Industry accounts for each percentage of their GDP, respectively, 10.3%, 53.1% and 36.6%. The average GDP per capita of the province was 26,050 RMB, the provincial average per capita income of urban households was 12,000 RMB, of which up to 17,000 RMB in Dalian, Shenyang 1.6 million; provincial average per capita income of rural households was 5,400 RMB, Municipal socioeconomic statistical indicators are shown in Table 2-5.

Table 2.5: Statistics of 2007, Liaoning Province, Socio-Economic Indicators

Municipality	Population(10000 capita)			Gross area product(10000 RMB)			
	Total	Urban	Rural	Primary Sector	Secondary Sector	Tertiary Sector	Total
Shenyang	709.77	464.72	245.05	165.3	1395.0	1205.3	2765.6
Dalian	578.18	377.61	200.57	248.0	1376.9	1082.0	2706.9
Anshan	350.25	219.09	131.15	60.9	672.2	428.3	1161.3
Fushun	223.73	155.62	68.10	36.4	274.6	164.4	475.3
Benxi	155.98	116.28	39.69	28.7	269.0	125.5	423.2
Dandong	242.90	113.73	129.17	66.0	187.7	151.4	405.1
Jinzhou	309.41	126.12	183.29	103.0	214.3	167.6	485.0
Yingkou	232.49	147.79	84.70	53.0	285.7	159.3	498.1
Fuxin	193.07	97.69	95.38	41.5	67.5	61.6	170.5
Liaoyang	183.38	92.11	91.27	29.8	267.5	112.1	409.4
Panjin	128.24	83.96	44.27	60.2	360.9	80.3	501.4
Tieling	305.45	110.31	195.14	101.8	163.6	97.2	362.6
Chaoyang	340.17	99.41	240.76	81.4	133.3	78.5	293.2
Huludao	278.70	92.87	185.83	57.2	185.1	123.5	365.8
Total	4231.70	2297.34	1934.36	1133.4	5853.1	4037.0	11023.5

According to statistics, rural per capita income distribution in the southern city of Dalian Wafangdian, Linghai is the highest, followed by the central, western and northeastern lowest incomes (Figure 2-26), so the higher vulnerability to drought is in this region.

Figure 2.26: Rural Per Capita Income Distribution In Liaoning Province

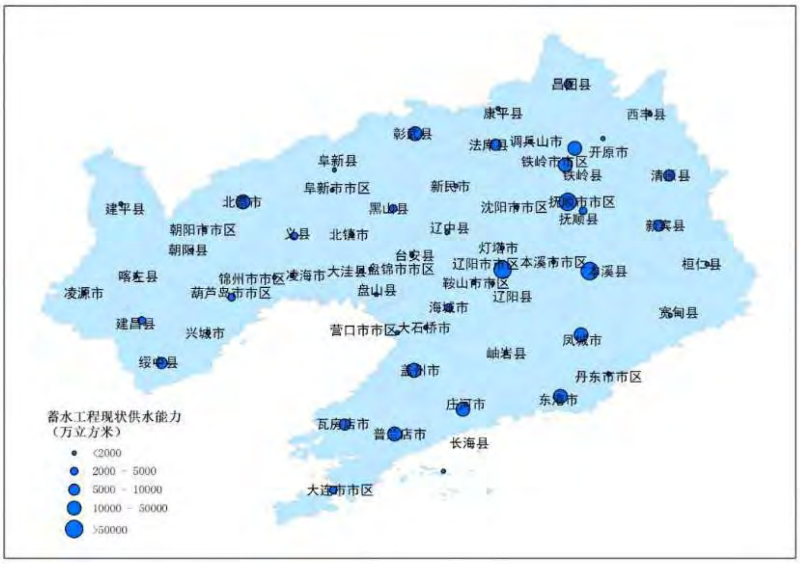
Economic and social development level drought vulnerability impact is very significant, mainly at the level of regional economic development, industrial structure and layout of the population urbanization rate, population density, population quality and living standards. Although higher than the national average of 47.5%, compared with the developed areas there is a great gap. The province's GDP ranked eighth in the country, and certainly the gap with the top few provinces still widening. Income level increase significantly lags behind the level of economic development, urban residents' income levels listed fifteenth of income urban residents in the provinces. In addition, since the province's cities and counties are quite different natural and geographical conditions, and other factors, the level of regional economic and social development displays imbalances. Especially for some of the lower level of economic and social development of the region, the lack of sustained and stable investment, drought mitigation capacity is relatively weak, which increases the vulnerability to droughts in large part.

2.3.2 Water Infrastructure Capacity Against Drought

2.3.2.1 Surface Water Projects

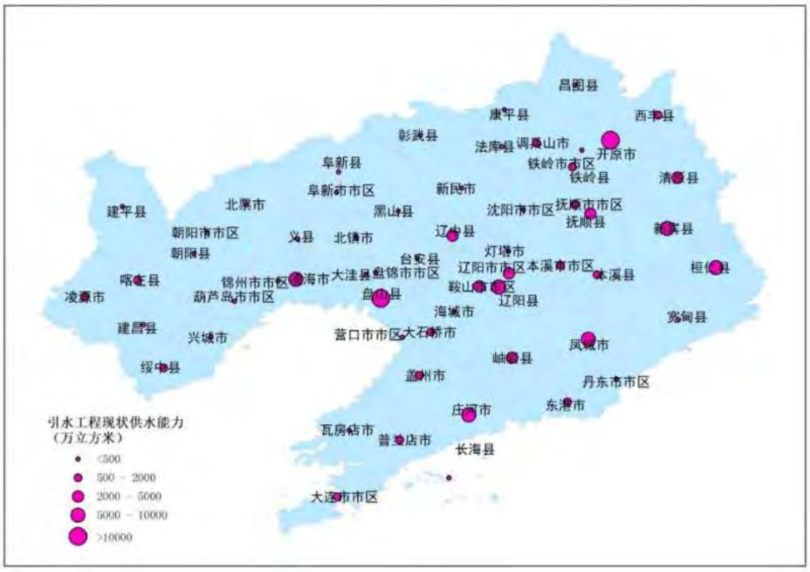
There are 871 existing reservoirs in Liaoning, including 27 large reservoirs, 74 medium-sized reservoirs, and 770 small reservoirs. The total reservoir capacity 16.76 billion m^3, including large of 13.67 billion m^3, medium of 2.08 billion m^3, and small of 1.01 billion m^3. Active reservoir storage capacity is 9.35 billion m^3, and large reservoirs comprise 7.75 billion m^3, medium reservoirs comprise 1.07 billion m^3, and small reservoirs comprise 530 million m^3. Figure 2-27 shows status of engineering distribution, indicating western, northern water storage projects are obviously weak, the basic 50 million cubic meters or less, while the central region of the strongest water storage projects, followed by Southern which in Fushun city, downtown Liaoyang, Benxi supply capacity more than 500 million cubic meters.

Figure 2.27: Status Of Water Supply Capacity Province Engineering Distribution



In Liaoning Province, there are 5412 existing embankments, 5429 square ponds. 2309 water transfer projects, in which eight large, 13 medium-sized and small 1317. Eastern and central regions where water diversion project ability, western and northern areas of water supply capacity is weak (Figure 2-28).

Figure 2.28: Status Water Diversion Project In Liaoning Province Ability Distribution



In Liaoning Province, there are 1898 existing water projects, where two large, 129 medium-sized and 1767 small. Which the central region, the city of Dandong, Donggang's water projects supply capacity, weak in other regions (Figure 2-29).

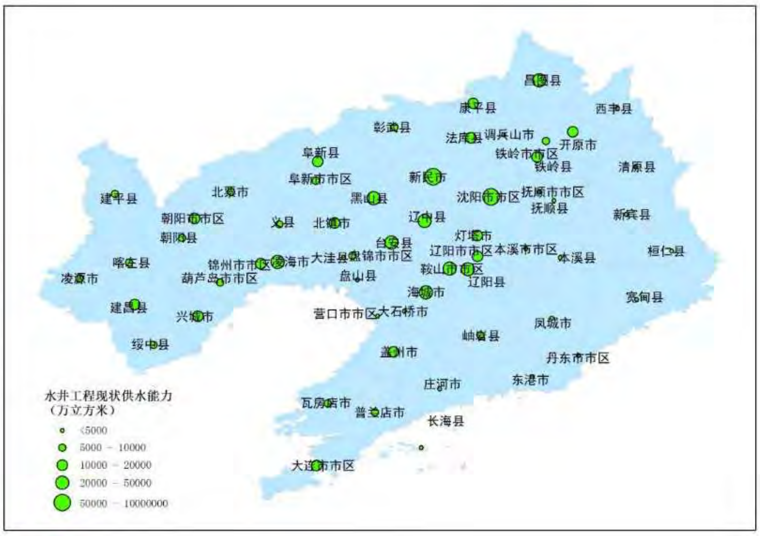
Figure 2.29: Status Of Province For Water Supply Capacity Of Distribution Engineering

Works from the entire surface water supply capacity to see, western and northern Liaoning supply capacity is weak, so the higher vulnerability to drought, and greater drought risk.

2.3.2.2 Groundwater Engineering

Liaoning has 306,340 existing shallow groundwater wells engineering, of which 173,000 supporting electromechanical well. Existing water wells include deep confined engineering are 340, of which 326 supporting electromechanical well. Central and northern wells which supply engineering ability, while the western, eastern and southern relatively weak (Figure 2-30).

Figure 2.30: Status Of Province For Water Supply Capacity Of Distribution Engineering



2.3.2.3 Other Water Projects

In Liaoning Province, other water projects refers to wastewater reuse projects, mine use, water use and rainwater harvesting projects. In Liaoning Province, the status of other water supply capacity is 114.7 million m^3, of which wastewater reuse comprises 33.66.million m^3, mine use comprises 21.74 million m^3, water use 58.32 million m^3, and rainwater harvesting projects 1.03 million m^3.

2.3.2.4 The Total Water Supply Capacity

Water supply projects in Liaoning Province-based total supply capacity is 17.12 billion m^3, of which: water engineering 6.32 billion m^3, water diversion project 1.197 billion m^3, water projects 2.236 billion m^3, shallow groundwater engineering 7.186 billion m^3, 69 million deep confined water project m^3, other water projects 115 million m^3. The city level total water supply capacity shown in Figure 2-31. Among them, the total water supply capacity of the north-central region of the strongest, while the western, northern and eastern border regions water supply capacity of the weakest, so the risk of drought in this region is large.

Figure 2.31: Status Of Water Supply Wells Distribution Capabilities

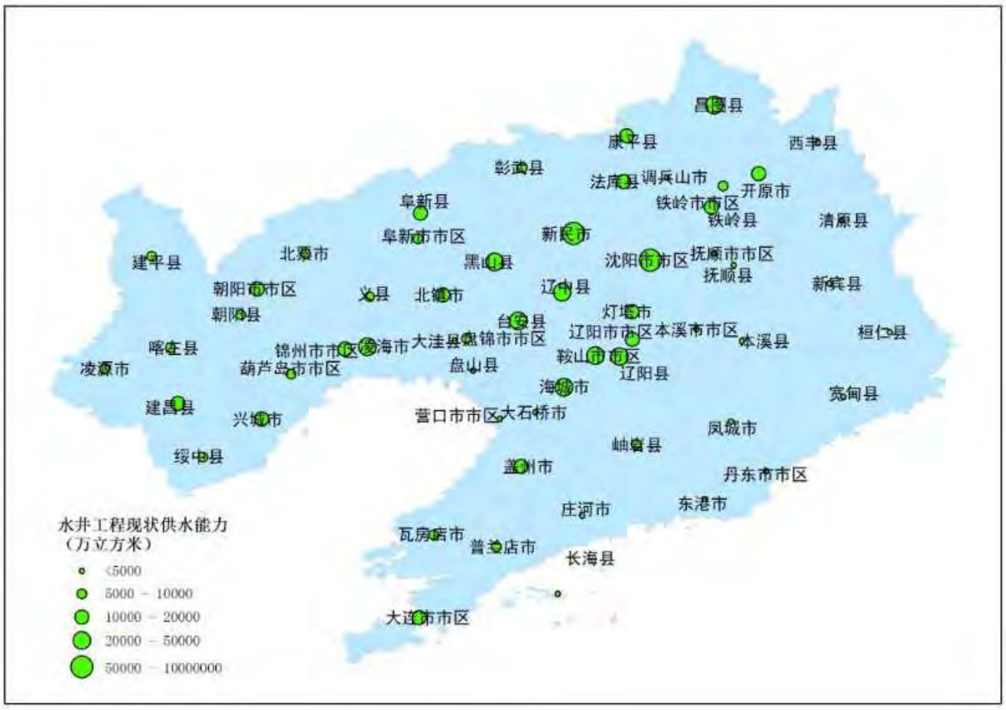
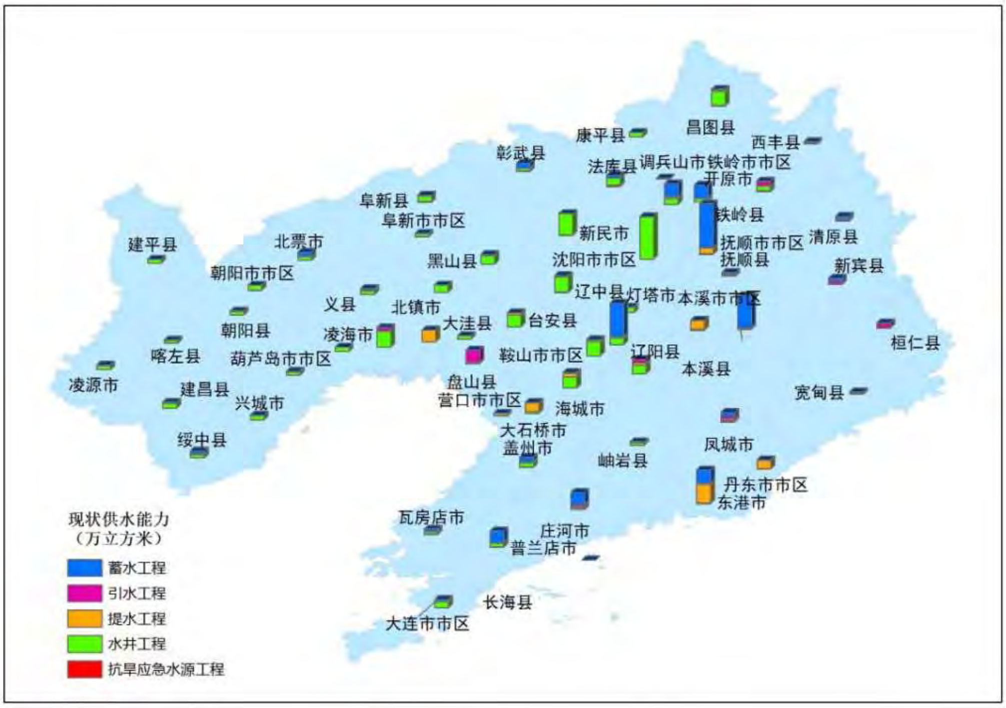


Figure 2.32: Status of Total Water Supply Capacities



2.3.2.5 Drought Emergency Backup Status of Water Projects

In Liaoning Province, the existing drought emergency water projects are mainly in the more serious water shortage in northwestern Liaoning and Dalian, Yingkou region. Drought emergency water projects for rural drinking water and agricultural irrigation projects, with a total water capacity of 260 million m^3, of which: rural people drinking water supply capacity of 25 million project m^3, agricultural irrigation water supply capacity of 186 million engineering m^3, regional drought emergency water supply capacity of project distribution shown in Figure 2-32, the main emergency water project in the northern and southern parts of the region, while the western and eastern regions of relatively less.

Figure 2.33: Liaoning Province Drought Emergency Water Supply Capacity Of The Project Status Quo Distribution

In summary, the vulnerability of potential impact area in western Liaoning displays higher environmental disaster, followed by the north, but the north has provided emergency water supply, so you can say that the problem has been somewhat mitigated in the north.

2.3.3 Other Capacity Against Drought

2.3.3.1 Drought Monitoring Analysis

In general, the drought monitoring system in Liaoning Province, has not been fully established. There are still many outstanding issues, such as drought information collection infrastructure, inadequate station network deployment, and low degree of automation. Data processing means relatively backward methods of inquiry for drought information, analysis and processing applications less. There is not real-time analysis of drought, drought trends is difficult to carry out scientific analysis and forecasts, there is a certain degree of blindness to drought measures. Outstanding problems are the following:

1. **Drought monitoring sites are not enough**, drought monitoring system is imperfect. Over the years, the hydrology department has established a rainfall, water, groundwater, water and other basic hydrological monitoring network and in drought relief it has played an important role. However, the current drought directly to the drought monitoring sites rarely, cannot constitute a province-wide drought information monitoring network. For the province, due to the scarcity of sites, the province still cannot meet the actual need for a comprehensive drought, and the current monitoring network was carried out in rainfed agricultural areas. Facilities for irrigated agriculture or other agricultural areas have not been monitored in the distribution stations.

2. Existing drought **monitoring information content cannot meet the need**. Drought is affected by many factors and collecting data is difficult. Since most hydrological stations are mainly dominated by flood, drought task not reported, so relying on the existing hydrological monitoring network is difficult to achieve real-time monitoring of drought. Although some key station has been gradually carried out in non-flood submitted regimen (drought) information, but a longer time interval, the drought means the information submitted, the information content and frequency of drought cannot meet the needs of the work.
3. Existing **drought information timeliness cannot meet the requirements**. Currently, the province systems include flood of information and communication, computer networks, but soil moisture important water sources, groundwater, water quality is closely related to drought and drought information mostly rely on water conservancy departments at all levels and drought management department by mail, telephone, fax and other traditional methods. This means no real time monitoring and delay in action. And the lack of uniform standards of digital information, the collection of data takes up a lot of work for processing, low efficiency, high error rate, it is difficult to meet the requirements of the emergency drought timeliness of information.
4. **Information processing** means drought cannot meet the existing requirements of the drought. Due to the development of drought affected by many factors, requires a combination of rainfall, soil moisture, groundwater comprehensive evaluation of hydro meteorological information in order to fully reflect the real drought. Currently, the foundation associated with drought is also a lack of historical data collation and collection system, has not fully completed the full range of information, information covered by the province's drought information database, the lack of mature technology, full-featured drought information processing and decision support software, drought is difficult to provide accurate and timely information and analysis of the results of scientific evaluation of drought and drought relief headquarters departments.

2.3.3.2 Drought Mitigation Management System Status

Currently, Liaoning Province drought relief management system could be improved. In City and County FCDRHs and other city and county agencies the drought management system requires improvement. The following issues should be highlighted:

- Lack of policies and regulations, and there are no independent drought policies and regulations;
- Fewer special drought relief plans;
- Drought monitoring technology with a low degree of automation, and poor timeliness;
- Drought database has not been established;
- Drought service organizations developmental delay;
- Variety of poor management capacity;
- Drought disaster risk management research is not deep enough, the drought has not been established with a scientific theoretical system

Overall, drought relief management system is not perfect, low drought tolerance, which increases vulnerability to drought in Liaoning Province to some extent.

1. Organization and Policies

In Liaoning Province, the work covers a wide range of drought. Establishing an effective drought management office is necessary to ensure that the basic conditions of drought relief works smoothly. Currently, there are no specific drought management divisions or sub-divisions for all municipalities in

Liaoning Province. Within the 14 municipalities in Liaoning, the drought relief offices of two municipalities were subordinate to the rural water division and were shared people with the flood control offices for the remaining eight municipalities. In the county level drought management team, full time staff are only 29, part-time staff are 230 people, causing much inconvenience to the drought relief work.

Currently, Liaoning has no specific terms of drought policies and regulations. We must be practical, accelerate the construction of local drought and regulations, such as the "Liaoning drought ordinance," and so on. Clear all localities and departments to work in drought responsibilities and norms of behavior, according to the law to ensure the orderly conduct of drought.

2. Drought Service Organizations

Drought relief services group is a specialized emergency drought relief response team organized by MWR, providing services of water hauling, mobile irrigation, equipment maintenance, and technical guidance, etc. for the local people. Drought services group is a major supplement to strengthen the capacity of drought resilience with advantages of flexibility and quick response, becoming a major force in drought relief and disaster mitigation. Agricultural drought service organizations as social service system and an important component of drought tolerance and means an important complement to play an important role during the emergency drought. Liaoning Province, the existing township -level service organization 46 drought, accounting for 5% of the province's total (942) of the township ; 43 county service organization representing the province's agricultural total(76) of the counties 56% ; municipal drought service organization 3, accounting for 21 % of the total number of provincial cities above prefecture-levels (14 in total). Drought service organizations, career series, corporate permanent staff and temporary total 1262 people, 113 million RMB in fixed assets drought device, drought emergency capacity of 20,000 irrigated acres, no drought emergency water supply capacity, because drought service organization do not possess water carts owned by the government. Although, in recent years, Liaoning Province, the drought has increased the investment in service organizations, service organizations drought has made great progress in building the organization continue to build the whole system, and constantly improve the service functions, service capabilities continue to improve, but because of Liaoning Province, drought-prone region mostly underdeveloped regions, local government service organization into a limited drought, poor self-management ability drought service organizations, service organizations in most developing drought situation is not good, the loss of fixed assets, equipment aging damage is serious, the service capacity is weak for drought.

3. Drought relief materials reserve

In recent years, Liaoning Province purchased a large number of drought supplies, mostly to farmers under partly stored in a temporary drought supplies county district warehouse. Due to lack of funds under management, drought and aging equipment are quite serious disrepair, according to statistics, the province's drought inventory of materials and equipment intact rate of about 70 percent in some areas, less than 40% of the equipment in good condition. There is no warehouse for the provincial or county level drought relief materials reserve. The drought relief materials were stored in one or two rented or borrowed offices, which is too small for large amount of materials reserve. If a large area of drought occurs, it is hard to meet the work needs.

4. Drought relief research

Drought basic research and application of new technologies is necessary to improve drought premise and foundation. In recent years, governments at all levels in Liaoning province, especially drought preparedness and drought departments attach great importance to the work. However, the province's overall drought basic research is still relatively weak, it cannot meet the current needs of drought. It is necessary to strengthen the Liaoning Province theoretical research of drought relief and to improve the province's drought management and integrated drought mitigation capabilities to minimize the impact of drought losses and provide technical support for drought relief work, according to "the State Council on Strengthening the Work of drought "requirement. In 2008, Liaoning Province took the lead in the country and launched the" Liaoning Province rural drought plan" preparation. Meanwhile, Liaoning Province also commissioned by China Institute of Water Research Institute to carry out flood control and drought relief agricultural drought risk assessment and management decision support system research support.

2.3.4 Composite Vulnerability Analysis

Society's vulnerability to drought is affected by (among other things) population growth and shifts, urbanization, demographic characteristics, technology, water use trends, government policy, social behaviour, and environmental awareness. These factors are continually changing, and society's vulnerability to drought may rise or fall in response to these changes. For example, increasing and shifting populations put increasing pressure on water and other natural resources - more people need more water.

People's vulnerability to drought is complex. Drought results in substantial effects in both developing and developed countries, but the characteristics of these effects differ considerably. The ability to cope with drought also varies considerably from country to country and from one region, community, or group to another. Therefore, a vulnerability profile, including analysis of vulnerability factors, is an invaluable tool in assessing local risk. The vulnerability profile is a cornerstone of drought risk reduction planning. "Vulnerability" consists of a variety of social factors such as:

- Population growth
- Population shifts
- Urbanization
- Technology
- Land use practices
- Environmental degradation
- Water use trends
- Government policies
- Environment awareness

The pilot province DMPs first employed drought risk analysis which is the study of potential effects on the drought-threatened areas based on likely drought probabilities and drought intensity. In general, when the intensity of meteorological droughts is greater, the frequency is higher, which means the greater hazard, the risk is also greater.

As the "characteristics of a group, system or assets that are vulnerable to drought and damaged or affected by drought", vulnerability analysis is the key of drought risk analysis, from the perspective of both natural environment and socioeconomics, analyzing the capacity of areas under potential drought impacts to resist drought. Drought risk vulnerability could have function to "amplify" of "mitigate" drought, and reflect differences on drought resistance and recovery capacity. In general, the vulnerability is higher, the drought risk is higher. For Liaoning province, the composite uses 10 indices as the elements of drought vulnerabilities including the significance of the primary industry (agriculture), ratio of effective irrigation area,

ratio of water land, ratio of rural population, degree of water resources development, average income, available water supply per area, number of drought service teams, number of drought monitoring systems and emergency water source. The following table lists the weight and direction of each index.

	Elements	Directions	Weight
Vulnerability(V)	Significance of agriculture	+	0.197
	Area of land irrigated	-	0.197
	Ratio of water land	+	0.079
	Ratio of rural population	+	0.197
	Development on water resources exploration	+	0.079
	Income per capita	-	0.031
	Water supply available per area of land	-	0.079
	Number of drought teams	-	0.079
	Number of drought monitoring systems	-	0.031
	Number of backup water supply sources	-	0.031

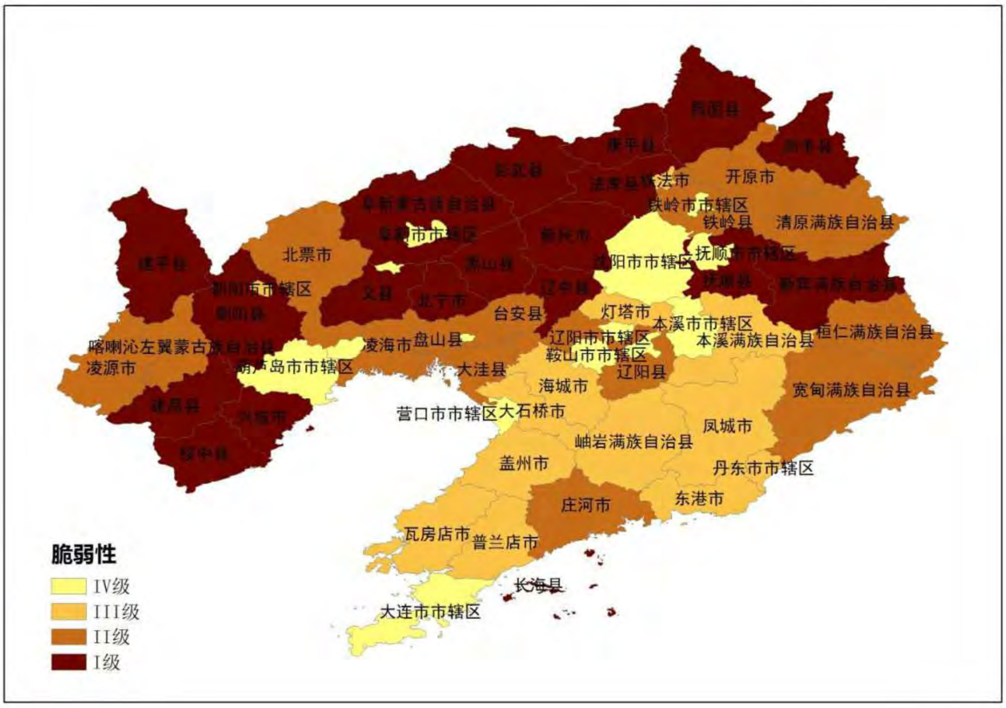
Note: In the table the "+" means the higher the value is, the larger the vulnerability is,"-" means the higher the value is, the smaller the vulnerability is

The drought vulnerability could be calculated using following equation:

$$V = \sum_{1}^{n} \omega_i y_i$$

The distribution of vulnerability is illustrated in following figure. The vulnerability of western Liaoning including Chaoyang, Fuxin, Jinzhou etc. are high, secondly higher is northern Liaoning including Tieling and Fushun. Since the northern area has the emergency water supply, the drought could be mitigated to some extent. The southern area including Dalian, Dandong, Yingkou, and Anshan's vulnerability is low.

Figure 2.34: Distribution of Exposure in Liaoning



2.4 Drought Risk Assessment

2.4.1 Drought History

There are droughts every year occurring in different places in Liaoning and in different seasons. For example, the extreme drought in 1989 and 2000, the severe drought in 2001 and 2002 in spring, the extreme drought in 2006 in middle summer, the severe drought in 2007 in summer and the most severe drought in 2009 in middle summer in the last 60 years. Those droughts affected urban and rural residents and agricultural production to varying degrees, severely restricting the normal development of the province's social and economic development. In previous disasters, Chaoyang and Fuxin cities had the most severe drought in the Midwest, especially since 2000, showing drought increased frequency and scale, duration and characteristics of disaster losses increased. Drought impacts had expanded from agriculture to industry, urban and the ecosystem. Water conflicts between agriculture and industry, between rural and urban, between economic development and ecosystem reservation are increasingly sharp.

Between 60 - year period of 1949 - 2009, there were 48 occurrences of drought. In Liaoning Province, basically droughts occur every year. The larger dry year number 16 (1957, 1968, 1972, 1982, 1988, 1989, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2006, 2007, 2009), an average of four years. In 2000, Liaoning Province, catastrophic drought, drought-hit population of 15.59 million, of which severely affected population of 403 million people, mainly in the northwestern areas. Area of 3,262 hectares of crops affected by drought, drought was 60.07%, inundated area of 2100 acres, the disaster was 38.67%; crops area of 1018 acres; grain production 6.3 million tons. In 2009, Liaoning Northwest severe summer drought,

affecting affected 909 million people in the population. Area of 3126 hectares of crops affected, of which 931 acres of crops; 5.6 million tons of grain losses, loss of 3.6 billion RMB of cash crops.

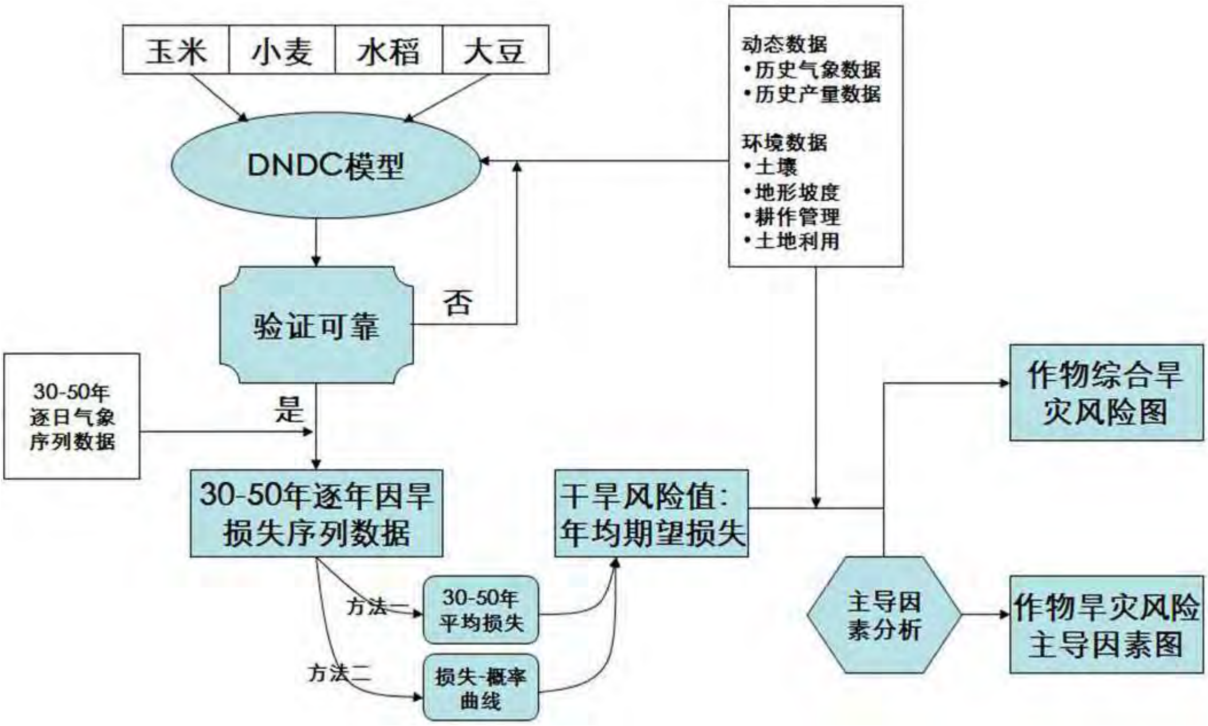
Throughout history, drought in Liaoning Province displays four characteristics:

1. **Alternating**. Inter-annual and seasonal precipitation differences, were abundant, flat, alternating dry, wet and dry seasons show a certain periodicity.
2. **Culture**. According to statistics, the probability of occurrence of drought, the western 70%, north, south to 50 percent, the central less than 20%. Summer drought occurrence probability, west of 30%, 10% to 20% in other regions. The number and extent of droughts, reduced from northwest to southeast. Western and southern drought highest frequency, occur every 1.5 years on average once a drought occurs once every 10 years drought.
3. **Seasonality**. Rainfall concentrated in the June to September, more than 60% of annual rainfall. In 60 years since 1949 between, drought accounted for about 40 percent, accounted for 20% of late summer, autumn drought accounted for about 10%. Which accounted for 9% of the spring and summer drought, spring and autumn drought accounted for 5%.
4. **Continuity**. In 60 years since 1949 between the province's three-year drought three times (1970 ~ 1972, 1980 ~ 1982, 1987 ~ 1989); drought 5 years 3 times(from 1951 to 1955, 1991 to 1995, and 1999-2003); 6-year drought once (1968 ~ 1973); drought nine years (1957 to 1965) and drought for 10 years (1975 to 1984), the 1st. Due to the uneven distribution of rainfall, "East West drought floods" have occurred "after the first flood drought" situation.

2.4.2 Agriculture drought risk mapping

As illustrated in Figure 2.35, the drought risk analysis approach brought up by the IWHR simulates different growth conditions of different crops through DNDC models. Based on the historical data, the models parameters are calibrated. Then assuming rainless in future N days, taking county administrative as basic analyzing unit, on the basis of comprehensive evaluation of agriculture drought risk elements including crops, meteorology, soil, topography, farming (including fertilization and irrigation), according to daily meteorological data in past 30 to 50 years, the grain loss was estimated with DNDC model. And the drought risk was quantified by the grain loss. The drought risk value for different crops on different ground was calculated. With the combination of dynamic data (meteorology, grain production, etc.) and environmental background data (soil, topography, etc.), the crop comprehensive drought risk map was developed. And the main elements that affect drought risk value were analyzed to develop a drought risk main elements map.

Figure 2.35: Drought Risk Analysis Approach



The following several aspects should be noted in use of DNDC model:

1. **DNDC model validation**: Select corn, wheat, rice and soybeans and other four kinds of food staples in Liaoning Province as an object, a receipt dynamic data analysis within the region (including the 30-50 year-old food historical meteorological data and production data) and Environmental Data (information, such as soil, terrain slope, tillage management change and land use change), the use of four kinds of DNDC model to simulate the growth process as, and select a strong representation of the analog data analysis unit comparison with historical data of the model parameters were validated to ensure that the scientific simulation.
2. **Drought losses sequence data**: the use of proven, reliable DNDC model, based on sequence data daily meteorological 30-50 years, the annual growth of four crops each unit of analysis within the simulation, each drawn an analysis unit 30-50 loss in year drought sequence data.
3. The value of drought disaster risk measure, the use of sequence data loss, select the value of drought disaster risk quantification method to calculate the amount of the annual grain losses drought expectations for that drought risk value.
4. **Drought risk map**: according to the value range of the drought disaster risk, drought risk level proposed standard, dynamic overlay data and environmental data to draw a comprehensive drought risk maps crops and crop drought risk factors leading figure.

2.4.2.1 Grain Loss Classification Due to Drought

According to the calculations for the crop production loss risks by drought for each county, four levels were identified to assess the drought impacts. The classification can be made based on different time scales

including 5 years, 10 years, 20 years, 50 years, 100 years and long term average. The classification of grain loss risks for Liaoning is shown as below.

Table 2.6: Classification Standards of Risk for Grain Loss in Liaoning

Drought Classification	Risk Classification(r)			
	Level 1	Level 2	Level 3	Level 4
5 years	r＞650	650⩾r＞450	450⩾r＞250	250⩾r
10 years	r＞650	650⩾r＞500	500⩾r＞350	350⩾r
20 years	r＞700	700⩾r＞550	550⩾r＞400	400⩾r
50 years	r＞750	750⩾r＞600	600⩾r＞450	450⩾r
100 years	r＞900	900⩾r＞700	700⩾r＞500	500⩾r
Many years average	r＞420	420⩾r＞320	320⩾r＞200	200⩾r

2.4.2.2 Drought Risk Mapping Based on Grain Loss

According to the results of the above analysis, the risk of loss in the value of drought food, overlay geographic information, remote sensing, earth-based access to information and other related information, the formation of different grades of drought risk of loss of food distribution in Liaoning Province.

Liaoning drought once in five years, most of the western and northern regions is a risk or two, east and south in two or three risk, middle risk is 3 or 4. As the drought worsens, the development of a case from five years to 10 years, 20 years, 50 years of a severe drought, the western and northern Liaoning risk level increases, most of the region in a risk; east and southern region risk strength changed little, still in two or three, but spread expanded; drought in the central region of the level of risk is relatively low. Looking at the chart above on risks, the highest risk of drought is located in western and northern Liaoning, followed by the drought risk in eastern and southern, with the central region the minimum.

Figure 2.36: Distribution of Risk for Grain Loss in Liaoning(5 years)

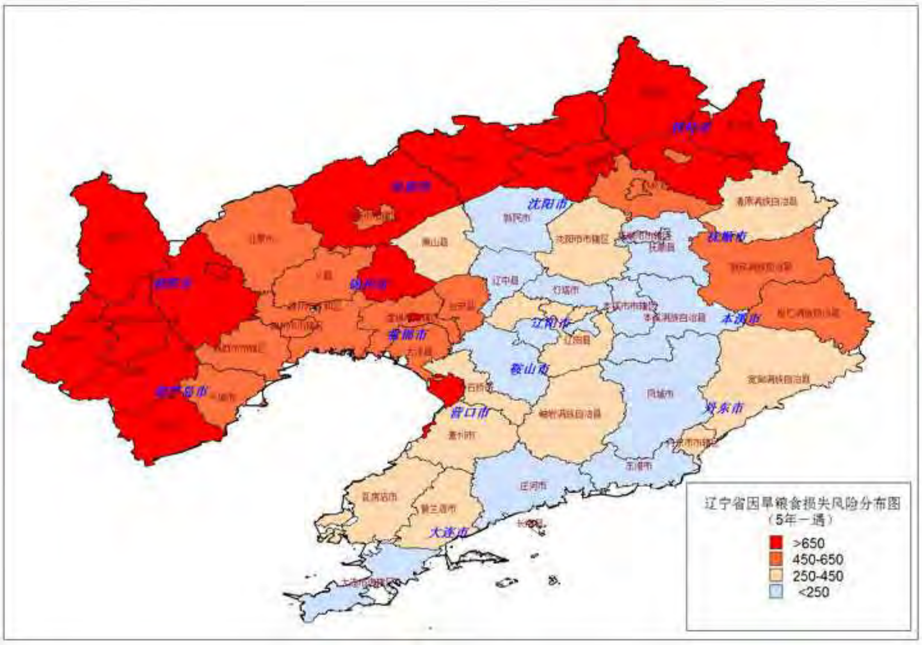


Figure 2.37: Distribution of Risk for Grain Loss in Liaoning(10 years)

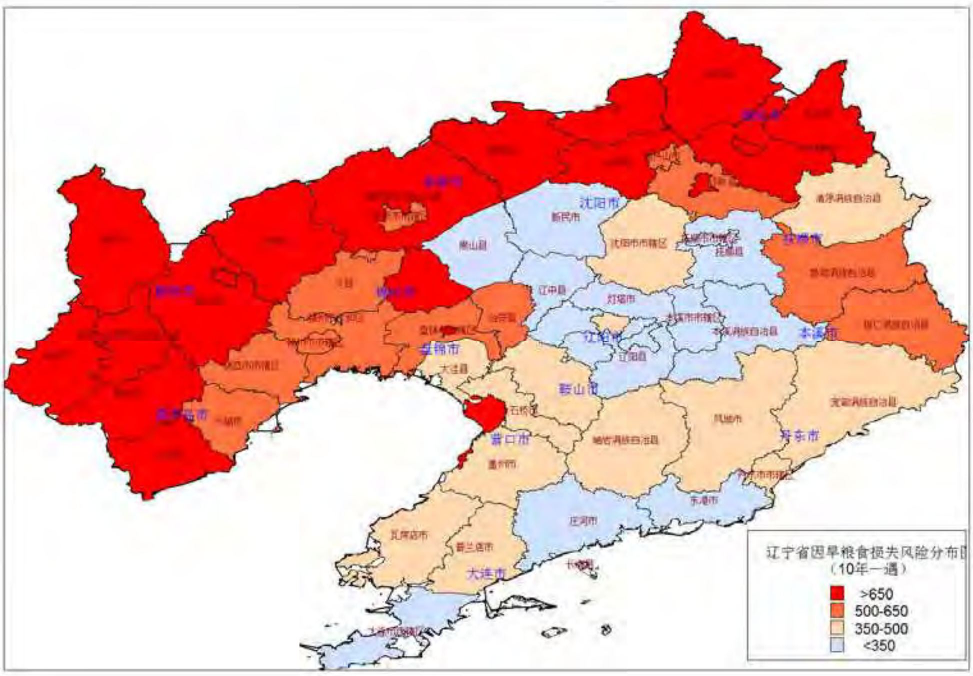


Figure 2.38: Distribution of Risk for Grain Loss in Liaoning(20 years)

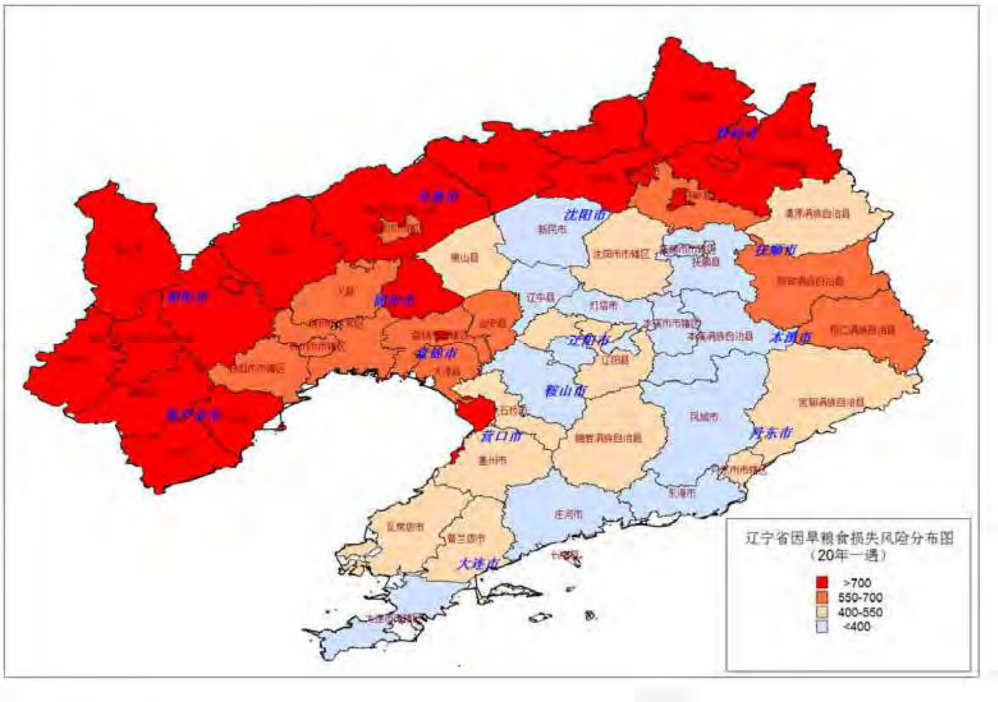


Figure 2.39: Distribution of Risk for Grain Loss in Liaoning(50 years)

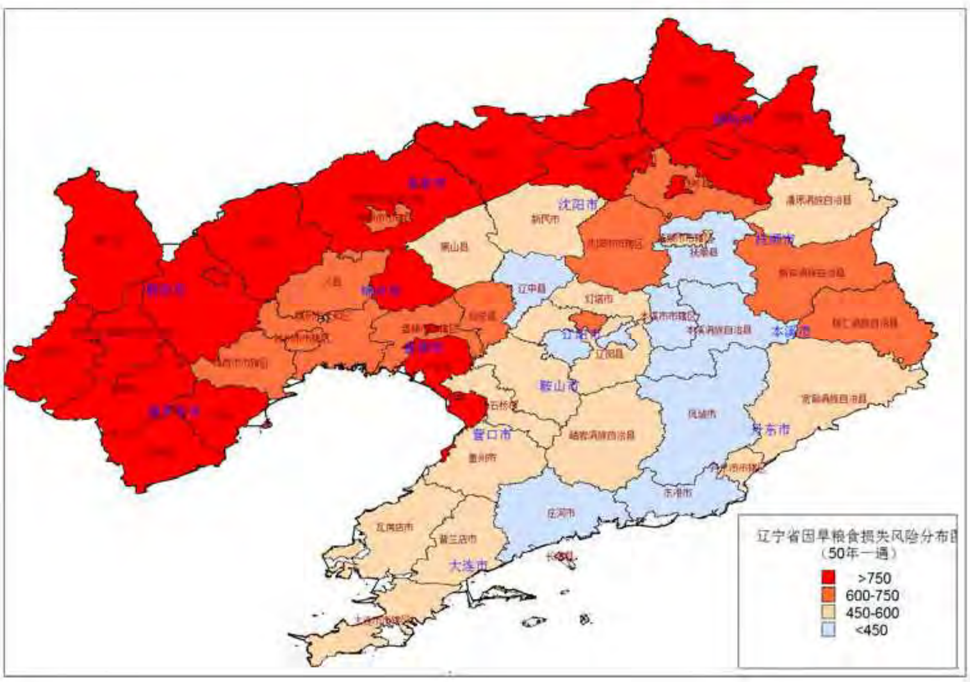


Figure 2.40: Distribution of Risk for Grain Loss in Liaoning(100 years)

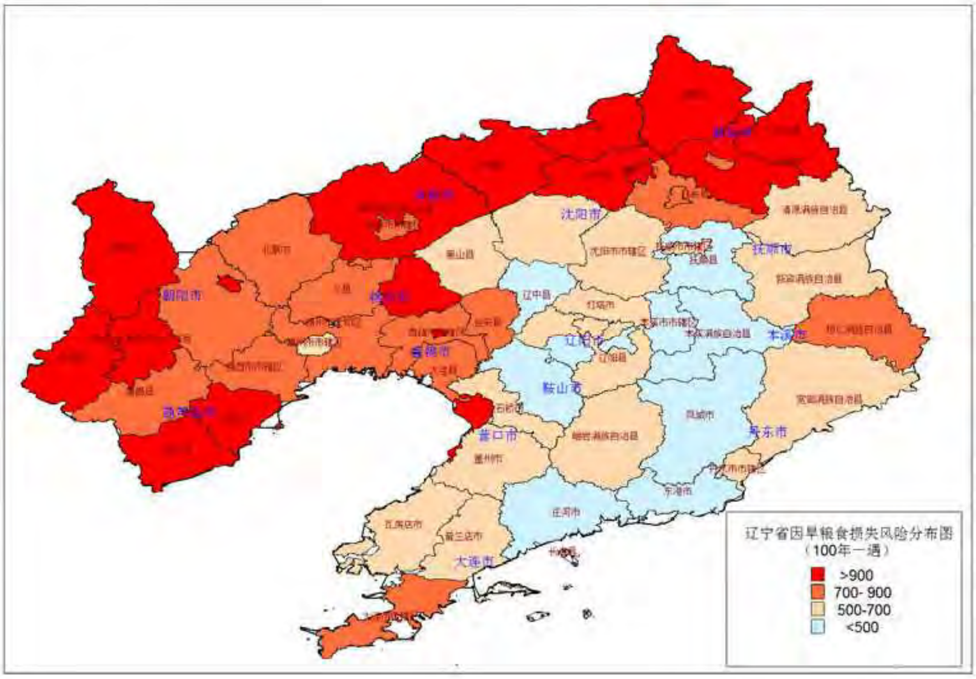
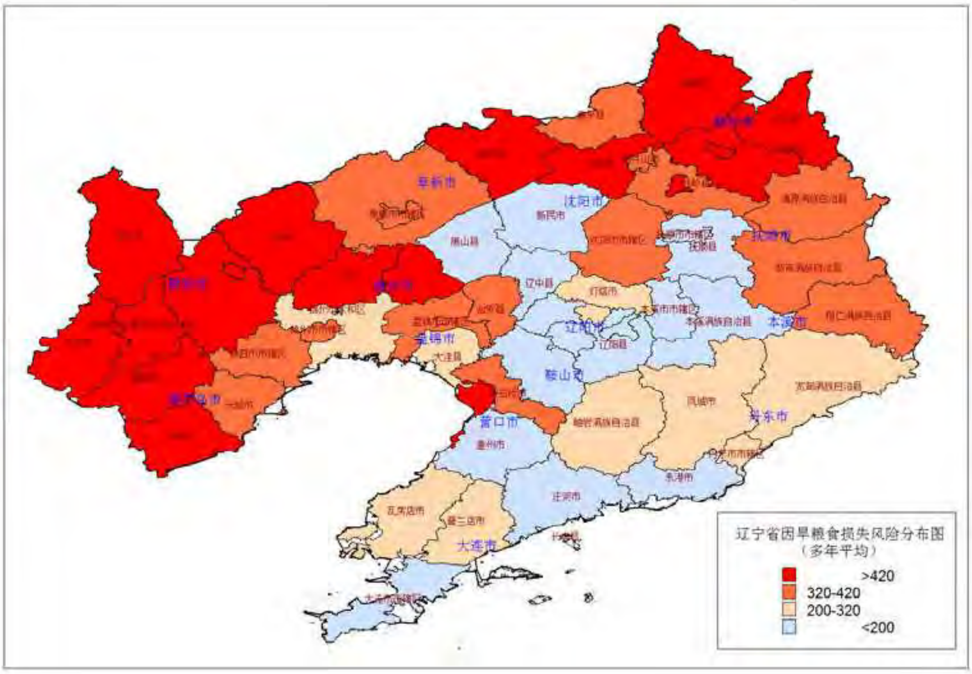


Figure 2.41: Distribution of Risk for Grain Loss in Liaoning(many years average)



2.4.3 Drought Risk Mapping

According to the theory regional drought, drought risk is the risk of exposure and vulnerability results of the combined effects. For Liaoning Province, drought risk estimation using the following formula:

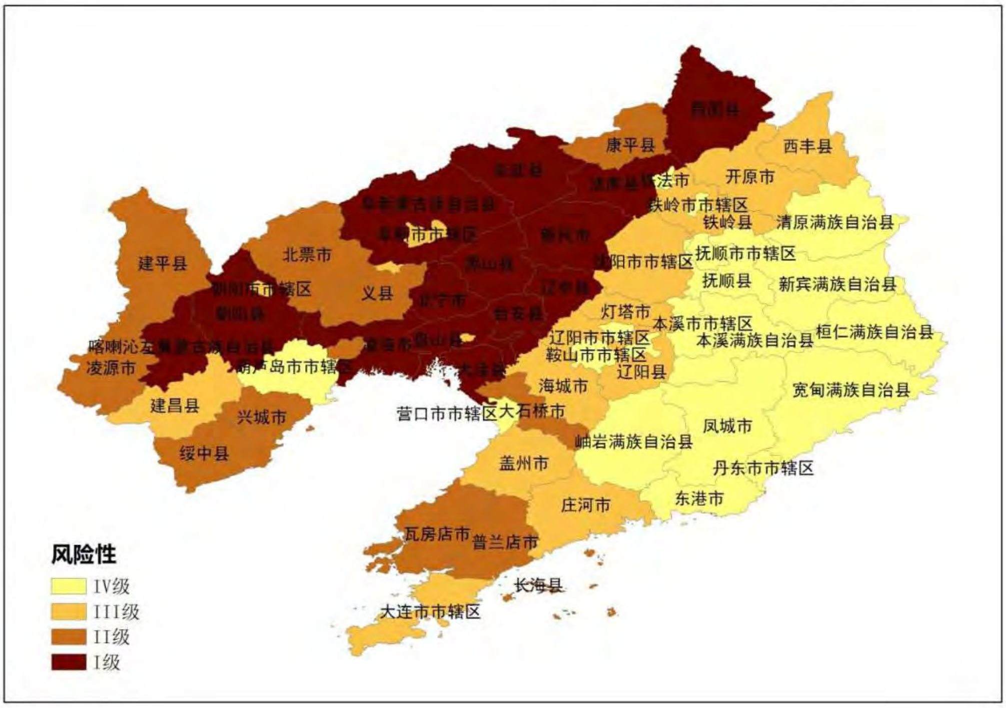
$$R = H * E * V * 100$$

Where:

R is the value of drought risk,
H is the value of drought risk,
E drought exposed property value,
V is the value of drought vulnerability.

The distribution of risk values shown below, we can see the value of drought and drought disaster risk of loss of value of the distribution of food is basically the same, namely the northwest risk, small southeast risk. North of Fushun comprehensive drought risk value than the risk of loss of food value is small, this is due to the region's water resources per capita than 1300 m^3, to ensure that drinking water is high, reducing the overall risk of drought.

Figure 2.42: Distribution of Drought Risk in Liaoning



3. Drought Team and Responsibility

3.1 Drought Team, Responsibilities and Provincial Coordination

3.1.1 Institutional Structure

Drought implementation includes an integrated management system as the center of the executive heads of the drought duty, including governance, accountability and division of labor division for personal drought responsibility.

Chief Executive responsibility system means there need to be a key head from each level of the government to be responsible for the drought management work and take the corresponding administrative responsibilities. Primarily responsibilities include organizing, directing departments to work, studying and formulating policies of drought periods, inspection and supervision of the implementation.

1. Liaoning Provincial People's Government Flood Control and Drought Relief Headquarters.

The Liaoning Provincial People's Government sets its Flood Control and Drought Relief Headquarter to be responsible for leading the province's drought, offices Provincial Flood Control and Drought Relief Headquarters office in the provincial Water Resources Department.

2. Liaoning Provincial Flood Control and Drought Relief Headquarters organization.

Provincial Flood Control and Drought Relief Headquarters consists with the commander, deputy commander and command members.

Commander: the deputy governor.

Deputy Commander: Provincial Military Region Deputy Commander, Provincial Government Deputy Secretary-General, the Provincial Department of Water Resources.

Command Members: Leaders from Publicity Department of CPC provincial Committee, Provincial Development and Reform Commission, Provincial Commission of Economy and Information Technology, the provincial Water Resources Department, Provincial Meteorological Bureau, the Provincial Department of Finance, Provincial Public Security Bureau, the Provincial Transportation Department, Provincial Land and Resources Department, Provincial Environment Protection Department, Provincial Housing and rural-urban Development Department, the Provincial Communications Authority, the provincial civil affairs Office of the Provincial Health Office, the Provincial rural economic Committee, Provincial Press, Publication, Radio and TV Bureau Provincial Oceanic and Fishery Department, Provincial Education Department, Provincial power Company Limited, Shenyang Railway Bureau, Provincial Production Safety Authority, Provincial Forest Department, Property insurance companies and other units.

3. FCDRH at lower levels

The establishment of provincial, municipal and county levels FCDRH agency responsible for the administrative regions of the daily work of flood control and drought and flood and drought disasters emergency response.

4. Experts Group

Provincial FCDRH Group of Experts established by the provincial Water Resources Department and other relevant departments are familiar with the business of drought senior professional and technical personnel and senior (professional) management staff. According to the drought situation and the Group of Experts on meteorological, hydrological forecasting and project status, evaluating drought resistance, develop drought plan for drought relief headquarters of the Organization of action to provide advice and policy advice.

3.1.2 Responsibility

The response to the provincial flood control and drought events and Drought Relief Headquarters unified command, the implementation of grading, sub-sector responsibility principle.

Provincial Flood Control and Drought Relief Headquarters drought duties:

Responsible for leading the organization of the province's drought, consistently enforce the national drought policy, policies, regulations and laws, normative documents; grasp the province's drought, disaster, and the need to publish forecasts, according to the drought warning and drought bulletin; promptly notify each member of the relevant units and related Municipal FCDRH; organization and implementation of drought mitigation measures to organize disaster disposal, to do a good coordination.

Members of the Provincial FCDRH Division unit drought are shown in following table:

Agency	Responsibilities
Provincial Development and Reform Commission	Coordinate the planning of the key drought mitigation infrastructure projects and corresponding supervision and management job.
Provincial Commission of Economy and Information Technology	Overall management of emergency supplies / materials / equipments, with a fous on organising and coordinating the production and allocation of drought mitigation supplies / materials / equipments.
Department of Water Resources	Organize and guide the planning, construction and management of the province's drought project, the province's drought monitoring organization, forecasting, organization and implementation of water projects the province's drought drought engineering repair work.
Provincial Meteorological Bureau	Responsible for weather monitoring and forecasting work, timely analysis of the weather situation and rolling forecasts provide relevant and timely weather information to the Provincial Flood Control and Drought Relief Headquarters and the members of the unit, satellite remote sensing soil moisture and drought monitoring information, timely organization of labor Precipitation work.
Provincial Finance Department	responsible for the implementation of drought relief funds in a timely manner and supervise the use of appropriated
Provincial Public Security Department	Responsible for drought management and security work security, crack down on theft drought supplies, destroy criminal acts drought facilities, maintenance, engineering and facility safety drought.
Provincial Transportation Department	Responsible for the drought to provide timely and necessary vehicles and other modes of transport, the relevant departments to assist drought supplies, equipment, and transportation work to ensure that lines of communication open.
Provincial Housing and rural-urban Development Department	Responsible for the safe operation of the water supply system belongs urban construction projects, do related work under severe water shortage city water supply.

Agency	Responsibilities
Provincial Civil Affairs Department	Responsible for organizing, coordinating relief efforts, verification and timely reporting of organizational disaster relief donations and receives payment of relief funds and materials, and the use of supervision and inspection.
Provincial Health Department	Responsible for the disaster epidemic prevention and medical care, responsible for the organization of medical rescue team.
Economic Commission for Rural Province	Agricultural drought and drought is responsible for collecting information, responsible for directing agricultural drought disaster self-help, recovery work.
Provincial Press, Publication, Radio and TV Bureau	Responsible for carrying out advocacy work drought, according to the provincial FCDRH of the deployment, publish drought-related information.
Provincial Power Company Limited	Good safety supply the province's supply of electricity during the drought disaster responsible for timely dispatch of electricity needed to solve the disaster and repair damaged power facilities.

Other departments should be based on need and drought, and actively provide favorable conditions for the completion of each task undertaken by the drought.

Provincial Flood Control and Drought Relief Headquarters Office duties

Conduct daily works of Provincial Flood Control and Drought Relief Headquarter related with drought; according to the development of the province's drought situation, the proposed Provincial Flood Control and Drought Relief Headquarters timely start drought plan.

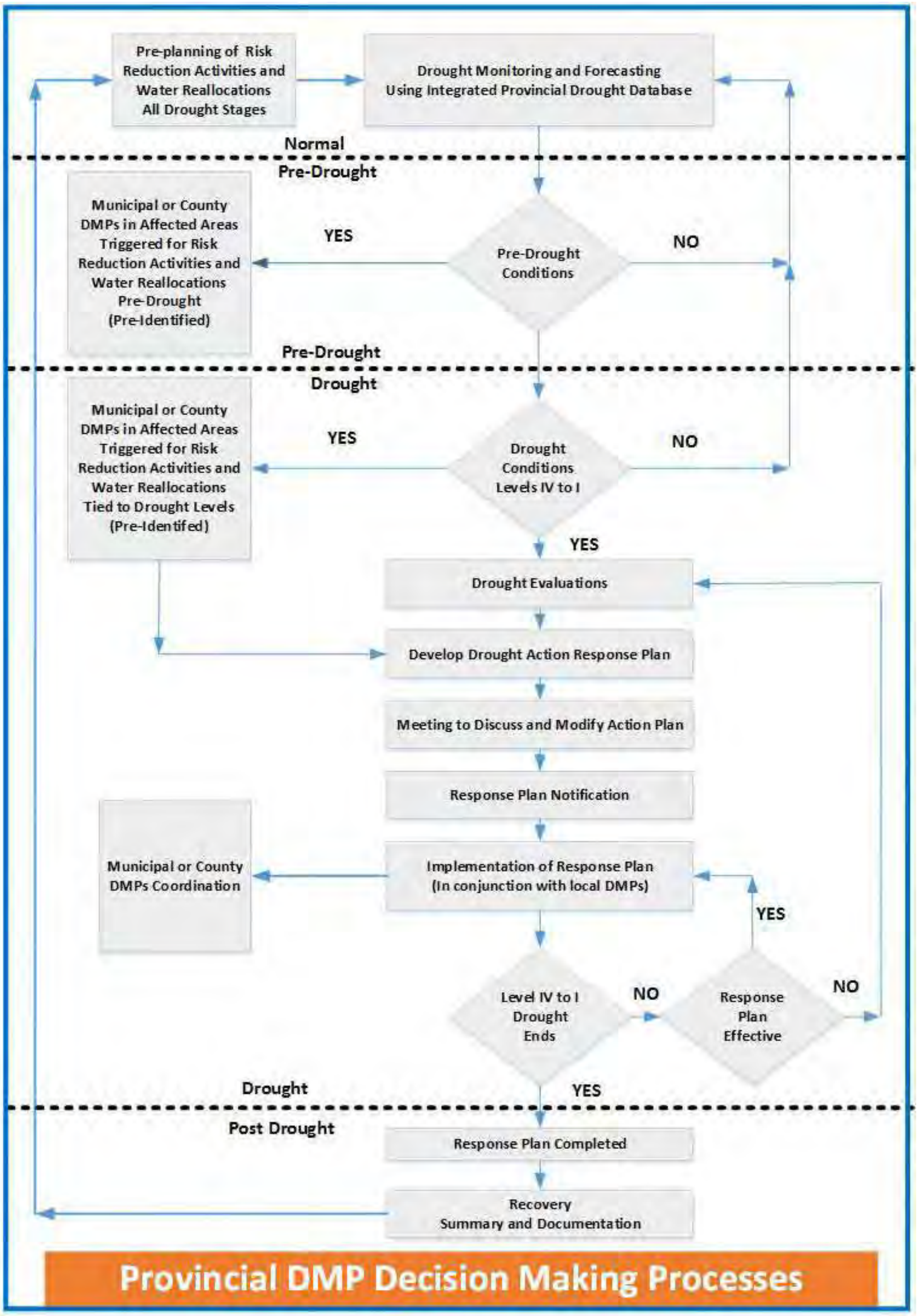
Local people's governments at various levels of FCDRH duty

Under the leadership of flood control and drought relief headquarters higher institutions and the people's government, organization and command of drought in the region.

3.2 Decisions Making Process

Drought management is a very complex system engineering, the executive heads of government at all levels and drought in the region is the leader and organizer, the whole process of drought concerns. Drought management decision-making process shown in Figure 3-1. This figure shows the general and simplified decision process diagram at various drought stages developed in the TA DMPs which are somewhat of a hybrid between the existing drought relief processes with DRM added. Since the TA only produced actual provincial DMPs at this point, the figure refers to the provincial decision-making process but mentions the triggering of local municipal and local level DMP actions. The actual decision making processes with indicators, triggers and pre-identified actions at the local levels will be prepared as part of the local level DMPs. For now, the TA provided a template or example local level DMP as part of the work, but the creation of an actual local level DMP was beyond the TOR scope.

Figure 3.1: Drought Management Command And Decision-Making Process Schematic Liaoning Province



4. Monitoring, Assessment and Prediction

In considering the current drought monitoring system in Liaoning Province and data accessibility based on the combined basis of preliminary work and drought management department of Liaoning Province, as well as provincial geography, and other natural climatic conditions, the drought monitoring proposed in Liaoning Province drought assessment and drought prediction scheme has been developed.

4.1 Drought Monitoring

The main contents include drought monitoring meteorological monitoring, hydrological monitoring, soil moisture monitoring, water monitoring and so on. Meteorological monitoring is mainly to monitor rainfall information, hydrological monitoring the rivers and reservoirs and surface water monitoring wells and other groundwater Chiang policies, soil moisture monitoring is mainly the result of fixed soil moisture monitoring stations. As of 2010, there were all kinds of Liaoning basic hydrological monitoring stations measuring 1300 many, including hydrological stations 120 (112 hydrological stations, eight water stations), 648 rainfall stations, 65 water quality monitoring stations, 528 groundwater monitoring station, 37 evaporation station, 77 the state's basic soil moisture monitoring stations, 90 soil moisture monitoring stations with remote sensing technology. These monitoring stations capable of supporting the current drought basic monitoring and early warning tasks.

4.1.1 Meteorological Monitoring

Liaoning Province, there are 648 existing rainfall observation station, project monitoring daily precipitation data to monitor the frequency of daily monitoring, have been entirely automatic rainfall telemetry, monitoring real-time data into the Liaoning Provincial Bureau of Hydrology water situation database system. By precipitation monitoring data, we can calculate precipitation anomaly, standardized precipitation index (SPI), and number of continuous days without rain drought evaluation.

Figure 4.1: The 648 Automatically/Telemetry Precipitation Stations

4.1.2 Hydrological Monitoring

4.1.2.1 Surface Water Monitoring

Surface water monitoring includes monitoring of river hydrology and hydrological monitoring reservoir. Liaoning Province, there are 93 existing river basic hydrological stations, which have 51 monitoring traffic, automatic data monitoring, and real-time database into water situation in the province and Hydrological Services. Drought assessment monitoring data can be used to calculate the **river runoff anomalies**.

Hydrological stations in Liaoning existing reservoirs include 27 large reservoirs stations, 74 medium-sized reservoir stations, 280(I)-type small reservoir stations, and 10 power stations (including large and medium-sized). These data monitoring water main library through capacity curve can be calculated storage capacity of each case. Monitoring frequency day monitoring, surveillance and late week monitoring range. But the provincial hydrological data regularly generated by these "regimen Xunbao", i.e. at least once every ten days the water resources of the province can be obtained. Drought assessment can be used to calculate the **impoundment data anomalies**.

Figure 4.2: Water Flows Stations

Figure 4.3: Reservoir Stations

4.1.2.2 Groundwater Monitoring

In Liaoning Province, there are 494 existing groundwater monitoring wells, but most of the production and living with wells. Now there are 258 groundwater monitoring wells using automatic telemetry. Groundwater monitoring data is used to assess drought and drought as **auxiliary data, not directly as an indicator of drought assessment**.

4.1.3 Soil Moisture Monitoring

Liaoning Province, there are 90 existing soil moisture telemetry stations, the province's existing fixed stations 115 soil moisture, all equipped with conventional artificial soil moisture monitoring equipment, including 88 also has an automatic telemetry functions. These 88 automatic monitoring stations in soil moisture, include Shenyang 9, Jinzhou City, 12, 15 Fuxin, Tieling City, 14, 23 Chaoyang, Huludao City 15. There are 27 artificial moisture monitoring stations in Dalian, 8, 3 Anshan, Fushun City 2, 5 Benxi, Dandong City 4, Yingkou City 1, 3 Liaoyang, Panjin City 1. In most of the existing stations, crop monitored is corn.

Figure 4.4: The Soil Moisture Stations Manually Measured

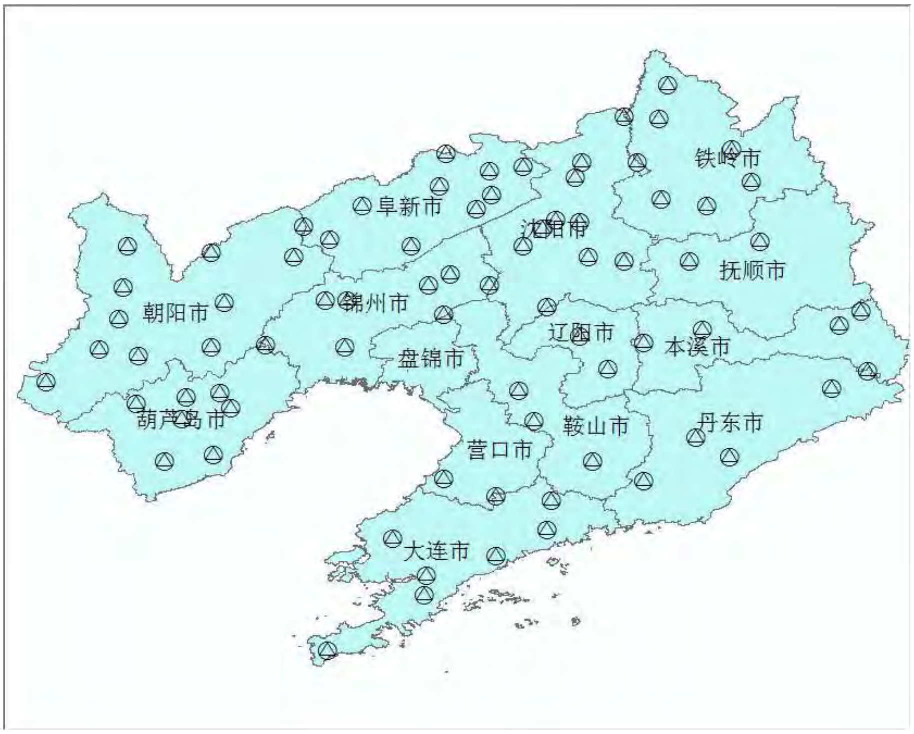
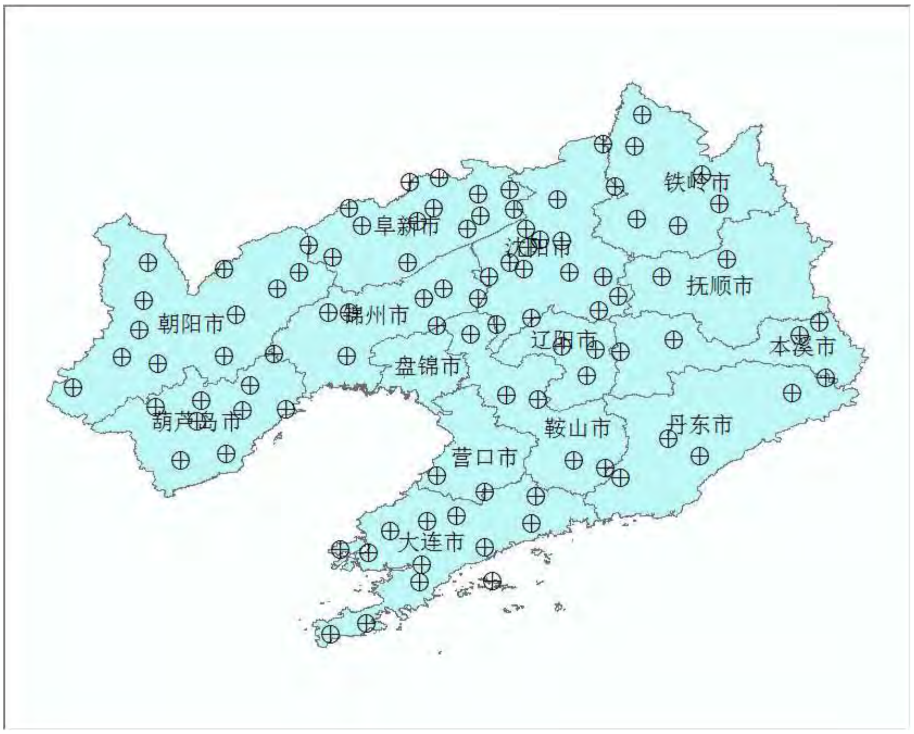


Figure 4.5: The Soil Moisture Stations Remotely Metered



4.1.4 Drinking Water Monitoring

There is no drinking water situation overall, aging monitoring tools rely mainly on statistics reported in the basic way. Monitoring of drinking water quality, although Liaoning Province has 65 surface water quality monitoring stations, 72 water quality monitoring sections, and 95 groundwater quality monitoring stations. But these monitoring sites mainly laid in cities, irrigated agriculture is important, it is difficult to meet the needs of the province-wide water quality monitoring. Also, due to the funding and personnel, equipment and other reasons, water quality monitoring frequency is low, fails to achieve automatic water quality monitoring and mobile monitoring, and is unable to grasp the changes in water quality, It cannot meet the needs of drought.

Thus, the overall monitoring of drinking water is obtained by way of statistical reporting, escalation levels by the administrative authorities, reported the contents of the main population of drought drinking water. This information will be used to monitor **drinking water drought assessment**.

4.2 Drought Assessment

Due to the small proportion of livestock, Liaoning Province, the impact of drought occurs mainly in agriculture, drinking water and urban water shortage problems, etc., so this program is designed primarily for drought assessment of these aspects. Statistical evaluation methods are used to determine threshold levels between the various drought level stages for all of the following assessments.

4.2.1 Agricultural Drought Assessment

Agricultural drought refers to the condition of crops have been affected, namely soil moisture supply cannot meet the requirements of crop germination or normal growth, leading to crop growth was inhibited even dry phenomenon. For a wide range of drought process, not only in different basins, provinces (autonomous regions and municipalities), prefectural (city), varying degrees of drought-hit counties(districts) between, that is, between the different plots in the same area, different between the degree of drought crops are not the same. Therefore, **agricultural drought monitoring and evaluation needs two steps, the first step is the point that agricultural drought assessment of farmland affected by drought or crop degree; second step is the regional agricultural drought assessment.**

4.2.1.1 Point Agricultural Drought Assessment

Point agricultural drought assessment methods include soil relative humidity method, precipitation anomaly method, standardized precipitation index, crop water stress rate method, the number of consecutive days without rain law, reservoir storage and river runoff anomaly method.

1. Soil relative moisture

Water supply depends mainly on root crops drawn directly from the soil, the soil water shortage will affect the normal development of the crop. Soil is one measure of the relative humidity of soil moisture content, soil moisture accounting refers to the ratio of field capacity. Soil moisture is the percentage of a given volume of soil moisture contained, also known as soil moisture content, water content and weight usually have two representations volumetric water content, water content usually used when calculating the weight

of the soil relative humidity. Field capacity refers to the field of soil can remain stable for the highest water content. Soil moisture calculated as follows:

$$\boldsymbol{W} = \frac{\theta}{\boldsymbol{F_c}} \times 100\% \qquad \text{Eq. 4-1}$$

Where:

$\boldsymbol{W}$ - soil relative moisture(%);
θ - unit soil moisture(%);
$\boldsymbol{F_c}$ - soil moisture(%).

Due to the different soil moisture at different depths, so the average moisture content of the soil is usually a weighted average soil moisture at different depths. Liaoning Province, three layers of soil moisture measured, respectively, for the 0 ~ 10cm, 10 ~ 20cm, 20 ~ 30cm, set up layers of soil moisture, respectively. Depending on the crop growing season in Liaoning, the right to re-occupy different layers, as follows:

- In sowing, seedling, seedling stage: the unit soil moisture $\theta = \frac{2}{5}\theta_1 + \frac{2}{5}\theta_2 + \frac{1}{5}\theta_3$;
- formative years(including the jointing stage, milk stage, maturity): unit soil moisture $\theta = \frac{2}{5}\theta_1 + \frac{2}{5}\theta_2 + \frac{1}{5}\theta_3$。

This is because, in sowing, seedling and the seedling stage, shallow root crops, the impact on crops grown in shallow soil moisture is large, so for 0 ~ 10cm and 10 ~ 20cm soil moisture conferred larger weights. In the growth stage, crop roots extend deep into the soil, the greater the impact of deep soil moisture for crop growth, so the soil moisture content 10 ~ 20cm and 20 ~ 30cm conferred greater weight.

Research on soil moisture index is relatively mature, and can better reflect the status of a viable crop drought index for soil moisture monitoring sites have been established in the region, the relative humidity should be given priority assessment of agricultural soil drought. Due to the different properties of different soil texture, soil moisture, in order to make the evaluation has the versatility and comparability, the use of soil relative humidity as evaluation. Grading criteria in following table.

Table 4.1: Relative Soil Moisture Drought Classification Table

Drought Level	Slight drought	Medium drought	Severe drought	Serious drought
Soil relative moisture (%)	60>W⩾ 55	55>W⩾ 45	45>W⩾ 40	W<40

2. Precipitation Anomalies

Precipitation anomaly percentage refers to the difference between precipitation and years within a time period average rainfall over the same period accounted for the same period the ratio of average precipitation years. Calculated as follows:

$$\boldsymbol{D_p} = \frac{\boldsymbol{P} - \overline{\boldsymbol{P}}}{\overline{\boldsymbol{P}}} \times 100\% \qquad \text{Eq. 4-2}$$

Where

D_p - Precipitation anomaly percentage (%)
$\underline{P}$ - The calculation of the period of precipitation (mm)
P - Years of average rainfall over the same period (mm).
(Generally use the average of the past 30 years.)

Precipitation anomalies law reflects the extent of deviation from average precipitation in the same period in the state, with simple, well-defined benefits. For moisture monitoring sites has not been established yet been established farming region rainfall monitoring stations to assess agricultural drought may consider using precipitation anomaly method. Taking into account the impact of drought on agriculture precipitation persistent drought severity related to the size and distribution of rainfall preliminary calculation time can be selected according to the situation monthly scale, quarter scale and in scale. For drought assessment of Liaoning Province, commonly used to calculate monthly scale. Grading criteria in following table.

Table 4.2: Percentage Of Drought Precipitation Anomalies Grading Table

Drought Level	Slight Drought	Medium Drought	Severe Drought	Serious Drought
Dp	-40＜Dp≤-20	-60＜Dp≤-40	-90＜Dp≤-60	Dp≤-90

3. Standardized Precipitation Index (SPI)

Standardized precipitation index is one indicator of how much the probability of precipitation appears to characterize a time when drought is potentially beginning. The method was developed by McKee et al at Colorado State University. Due to the different time scales, in different parts of a large magnitude of changes in precipitation, rainfall is difficult to compare directly with each other on the temporal and spatial scales, and rainfall distribution is a skewed distribution, rather than the normal distribution, therefore, seek first standardized precipitation index the probability distribution of precipitation, and then the normal standardization. Calculated as follows:

Assuming the probability density function of a random variable period of rainfall, its distribution is:

$$f(x) = \frac{1}{\beta^{\gamma}\Gamma(x)} x^{\gamma-1} e^{-x/\beta} \ (x>0) \qquad \text{Eq. 4-3}$$

Where

γ - the shape parameter, using maximum likelihood estimation method to obtain, $\gamma > 0$;
β - scale parameter, using maximum likelihood estimation method is obtained. $\beta > 0$.

$$\hat{\gamma} = \frac{1+\sqrt{1+4A/3}}{4A} \qquad \text{Eq. 4-4}$$

$$\hat{\beta} = \bar{x} / \hat{\gamma} \qquad \text{Eq. 4-5}$$

$$A = \lg \bar{x} - \frac{1}{n}\sum_{i=1}^{n} \lg x_i \qquad \text{Eq. 4-6}$$

Where:
$\bar{x}$ - multi-year averages of precipitation;
x_i - Samples-precipitation data values;
n - length of the sequence.

After determine the probability density function of the parameters, precipitation for a given year, the probability of a random variable is less than can be obtained for the event:

$$F(x < x_0) = \int_0^{\infty} f(x)dx \qquad \text{Eq. 4-7}$$

Estimate the probabilities for events at time 0 of precipitation:

$$F(x = 0) = m/n \qquad \text{Eq. 4-8}$$

Where:
m - number of samples-precipitation of 0;
n - Total number of samples.
normal standardized distribution probability, substitute the Eq 4-7 and Eq 4-8

Probability value into the standardized normal distribution function, that is:

$$F(x < x_0) = \frac{1}{\sqrt{2\pi}} \int_0^{\infty} e^{-z^2/2} dx \qquad \text{Eq. 4-9}$$

Solve Eq 4-9 in Approximation, be standardized precipitation index, the SPI :

$$SPI = S \frac{t - (c_2 t + c_1)t + c_0}{[(d_3 t + d_2)t + d_1]t + 1.0} \qquad \text{Eq. 4-10}$$

Where: $t = \sqrt{\ln \frac{1}{F^2}}$, F is the probabilities obtained from Eq 2-8 and Eq 2-9; and when $F > 0.5$, $S = 1$, when $F \le 0.5$, $S = -1$; c_0=2.515517、c_1=0.802853、c_2=0.010328、d_1=1.432788、d_2=0.189269、d_3=0.001308。

The method is applicable month or more scale drought monitoring and evaluation, to better reflect the intensity and duration of drought, but the application has the characteristics of multiple time scales, and therefore widely used. The calculation requires only precipitation data, information readily than the acquisition, to avoid the complicated mechanism of model calculations and a lot of empirical parameters input.

Although this indicator is more complex than the precipitation anomaly, but generally considered better than the precipitation anomaly index reflects drought conditions, therefore, recommended that in the conditions permit, the indices based on monthly scale. Classification is listed in following table.

Table 4.3: Drought Classification Based on SPIs

Drought Classification	Normal	Pre-Drought	Slight Drought	Medium Drought	Severe Drought	Extreme Drought
SPI	0≤SPI	0≤SPI<-0.5	-1<SPI≤-0.5	-1.5<SPI≤-1	-2<SPI≤-1.5	SPI≤-2

4. Crop water rate

Crop water rate is within a certain period of actual crop water demand and availability of irrigation water for the poor or representing the ratio of the actual provision of actual crop water demand over the same period. Calculated as follows:

$$D_w = \frac{W_r - W}{W_r} \times 100\% \qquad \text{Eq. 4-11}$$

Where:

D_w - Crops water deficiency (%);
W_r - Crops water demand during the calculated period (m^3);
W - irrigation water supply at the same period (m^3).

In assessing agricultural drought crop water rate, or the actual amount of water available for irrigation can be provided by the river, water engineering, groundwater, etc. The amount of water and energy supply, it can be a single form of water supply, water demand can be different from the actual crop using crop coefficient method and Penman computing can also refer to the "Water Demand Contours of main crop in China" . Grading criteria in following table.

Table 4.4: Arid Crop Water Stress Rate Classification Table

Drought Level	Slight Drought	Medium Drought	Severe Drought	Serious Drought
Dw	5<Dw≤20	20<Dw≤35	35<Dw≤50	Dw>50

5. Consecutive days without rain

Consecutive rainless days is the number of consecutive days without effective rainfall. Taking into account the different seasons and climatic differences crop water requirements, usually in the spring (March to May) and autumn (September to November), rainfall is less than 3 mm of rain deemed no effective rainfall, that date shall be deemed non-rainy day; summer (June to August), daily rainfall of less than 5 mm of rainfall considered as no effective rainfall, that date is considered to be no rain date. In some remote areas of rain-fed agriculture, agriculture dependent on the weather, soil moisture monitoring is often very weak base, and even rain did not stop, then you can consider using continuous rainless days to about judgment. Grading criteria in following table.

Table 4.5: Consecutive Days Without Rain Drought Classification Table

Evaluation Period	Slight Drought	Medium Drought	Severe Drought	Extreme Drought
Spring(Mar. – May) Fall (Sept. – Nov.))	15～30	31～50	51～75	>75
Summer (Jun. – Aug.)	10～20	21～35	36～50	>50
Winter (Dec. – Feb.)	20～30	31～60	61～80	>80

6. River runoff anomaly

River runoff anomaly index is the percentage by river runoff anomaly to reflect regional drought conditions. River runoff anomaly is the difference between river flows during the same period and for many years the average flow; river runoff anomaly percentage is the percentage of the value of river runoff anomaly with the same period the average for many years. The larger is the channel region of the river. Calculated as follows:

$$\boldsymbol{D_F} = \frac{\boldsymbol{F}\text{-}\boldsymbol{\bar{F}}}{\boldsymbol{\bar{F}}} \times 100\% \qquad \text{Eq. 4-12}$$

Where:

$\boldsymbol{D_F}$ - River runoff anomaly (%)
$\boldsymbol{F}$ - water flow in the river in the calculation period, m^3/s;
$\boldsymbol{\bar{F}}$ - average many years water flow, m^3/s.

Under Normal circumstances, to the river over time to calculate the cumulative runoff flow anomalies, such as a month or flow past few months, the drought assessment Liaoning Province Select month scale calculation.

This indicator is used to monitor major rivers and lakes, which can be more than one on a river hydrologic monitoring sites, such as the Liaohe River each monitoring site; may also be multiple monitoring stations in several rivers, such as Liaoning Northwest the main control site Liaohe, around the Sun River, Daling, Xiaolinghe, six shares of the river and other rivers. Liaoning Province is currently monitoring hydrological stations can support the calculation of this indicator. Grading criteria in following table.

Table 4.6: Drought Classification Based On Runoff Anomaly Index

Drought Classification	Normal	Pre-Drought	Slight Drought	Medium Drought	Severe Drought	Extreme Drought
Runoff Anomaly Index (%)	$0 \leqslant D_F$	$-15 \leqslant D_F < 0$	$-40 \leqslant D_F < -15$	$-65 \leqslant D_F < -40$	$-90 \leqslant D_F < -65$	$D_F < -90$

7. Impoundment anomaly

Reservoir water storage anomaly index is to reflect the percentage of the reservoir area by drought conditions. Impoundment anomaly refers to the period to calculate reservoir storage capacity (water) and for many years over the same period the average water requirement (level) difference; impoundment anomaly percentage is the average of the years of impoundment anomaly over the same period percentage value. Calculated as follows:

$$\boldsymbol{D_L} = \frac{\boldsymbol{L}\text{-}\boldsymbol{\bar{L}}}{\boldsymbol{\bar{L}}} \times 100\% \qquad \text{Eq. 4-13}$$

Where:

$\boldsymbol{D_L}$ - Impoundment anomaly (%);
$\boldsymbol{L}$- water storage in the calculation period(m^3) / water level (m);
$\boldsymbol{\bar{L}}$ - many years average storage for the same period(m^3) / water level(m), using 30 years average

The index reflects the regional water resources, combined with meteorological indicators are better able to predict the development trend of drought, generally calculated using the monthly scale. Grading criteria in following table.

Table 4.7: Drought Classification Based On Impoundment Anomaly

Drought Classification	Normal	Pre-Drought	Slight Drought	Medium Drought	Severe Drought	Extreme Drought
Impoundment Anomaly (%)	$0 \leqslant D_L$	$-10 \leqslant D_L < 0$	$-30 \leqslant D_L < -10$	$-50 \leqslant D_L < -30$	$-80 \leqslant D_L < -50$	$D_L < -80$

4.2.1.2 Regional Agricultural Drought Assessment

Regional agricultural drought assessment mainly on the county level and above the county level administrative areas to assess the situation of agriculture in general drought. Regional agricultural drought assessment using regional agricultural drought index, calculated as follows:

$$I_a = \sum_{i=1}^{4} A_i \times B_i \qquad \text{Eq. 4-14}$$

Where:

I_a - Regional agriculture index [0,4];
i - Point drought level（i=1, 2, 3, 4 represents slight, medium, severe and extreme drought respectively;
A_i - the percentage of total area of points with level i drought in the arable area (%);
B_i - weight of different drought level(slight, medium, severe, and extreme are 1, 2, 3, 4 respectively).

Regional agricultural drought index is a composite index, in theory, can choose any combination of index calculation, but under normal circumstances, you need to consider the physical meaning of indicators, such as precipitation anomaly index and the Standardized Precipitation Index (SPI) are made of precipitation data calculated, therefore, the information contained in a certain repetitive, so when calculating the regional agricultural drought indices, as far as possible while selecting these two indicators. As another example, the number of consecutive days without rain extensive indicators are simple, comparatively speaking, no soil relative moisture, SPI and other indices to more accurately reflect the drought, therefore, in the calculation of regional agricultural drought indices, if there is a more accurate indicator is not possible to select indicators of poor accuracy, avoid introducing noise.

In view of this, this drought management plan program recommended soil relative moisture, standardized precipitation index, crop water rates, reservoir storage anomaly, river runoff anomalies are calculated regional agricultural drought indices. If the data is not sufficient rainfall in the region, there is no long sequences of daily precipitation data, but only if precipitation observation data, it will use the standardized precipitation index consecutive rainless days instead. If the area has been used to assess drought indices precipitation anomaly, or the lack of technology in the region, there are some difficulties in calculating the standardized precipitation index, then the standardized precipitation index with precipitation anomaly index instead. If soil moisture monitoring in the region, reservoir storage anomaly monitoring or monitoring of river runoff anomalies lack of data, then remove one particular indicator. Grading criteria in following table

Table 4.8: Regional drought classification

Drought Classification	Slight Drought	Medium Drought	Severe Drought	Extreme Drought
Ia	0.1≤Ia<0.5	0.5≤Ia<0.9	0.9≤Ia<1.5	1.5≤Ia≤4

4.2.2 Drinking water drought assessment

Drinking water drought is due to the drought caused temporary drinking water difficulties rural residents, not including long-term drinking water. Drinking water drought monitoring and evaluation, including point and regional drought monitoring drinking water drinking water drought monitoring.

4.2.2.1 Point on drinking water drought assessment

Point drought or drinking water can be changed as per capita water consumption of basic living water sites and drinking water drought duration to assess. Drought drinking water must meet the conditions in following table and a second condition, which can meet the conditions of an arbitrary one.

Table 4.9: Drinking water stress

Conditions			Values
1.	Locations		Reduced during drought
	Water demand (L/capita*d)	Northern	<20
		Southern	<35
2.	Duration(d)		>15

4.2.2.2 Regional Drought Assessment Of Drinking Water

Normally, drinking water drought can be the absolute number of the population ratio of the two indexes or drought drinking water of the total population, this scenario, the province's drought assessment using drinking water drought indicators proportion of people drinking difficulties. The formula is:

$$I_a = \sum_{i=1}^{4} A_i \times B_i \qquad \text{Eq. 4-15}$$

Where:

O - populations that have difficulties to drinking water, using table 4.8 to determine

P – total populations

Table 4.10: Drinking water drought classification

Drought Classification	Slight Drought	Medium Drought	Severe Drought	Extreme Drought
Pa (%)	2.0≤Pa<5.0	5.0≤Pa<7.0	7.0≤Pa<10.0	10.0≤Pa

4.2.3 Urban Drought Assessment

City drought index rate using arid city. Drought is the ratio of the rate of urban cities and urban water shortage day normal daily water supply. The formula is:

$$P_g = \frac{Q_z - Q_s}{Q_z} \times 100\% \qquad \text{Eq. 4-15}$$

Where:

P_g - Urban water deficiency (%)
Q_z - Normal urban water supply (10 thousand m^3)
Q_s - Urban actual water supply (10 thousand m^3)

The above formula helps assessing the drought situation of individual cities. To assess the drought for groups of city in one region, the number of city having drought could be used normally. For example, in Liaoning Province, drought assessment is usually one-third of the city reaches a certain number of drought level as a standard province city of drought. Following table shows grading standards.

Table 4.11: Urban Water Deficiency

Drought Classification	Slight Drought	Medium Drought	Severe Drought	Extreme Drought
Pg	$5 \leq Pg < 10$	$10 \leq Pg < 20$	$20 \leq Pg < 30$	$30 \leq Pg$

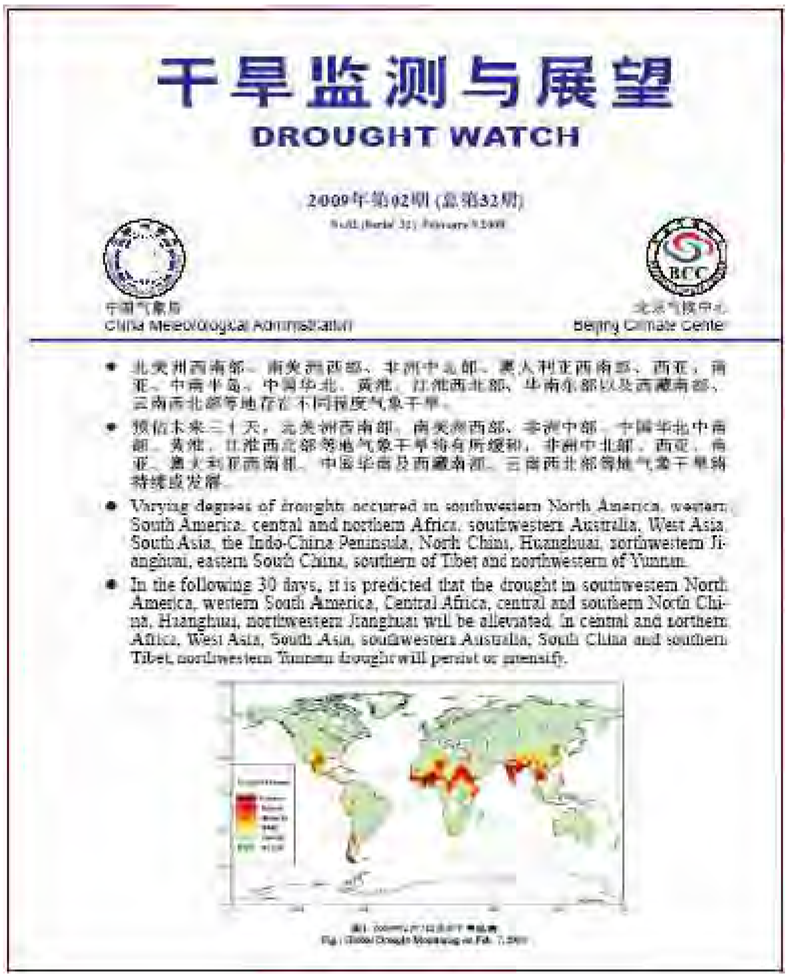
4.3 Drought forecast

Both critical drought forecasting drought risk management is difficult. Actual and existing data acquisition channels based on the work of Liaoning Province, proposed two ways to predict drought and soil moisture drought forecasting model based on weather forecasts.

4.3.1 Based Drought Forecast Weather Forecast

Drought forecast weather forecast weather forecast by the National Meteorological Center released the conduct drought forecast. The weather forecast for the next month release a 30-day weather forecast conditions, including the development trend of drought, with its forecast worldwide, Liaoning Province can focus on the local area. The figure below gives an example of the Drought Watch issued by the National Meteorological Center.

Table 4.12:Monthly Journal of Drought Watch by CMA



干旱监测与展望

DROUGHT WATCH

2009年第02期 (总第32期)

中国气象局
China Meteorological Administration

北京气候中心
Beijing Climate Center

- 北美洲西南部、南美洲西部、非洲中北部、澳大利亚西南部、西亚、南亚、中南半岛、中国华北、黄淮、江淮西北部、华南东部以及西藏南部、云南西北部等地存在不同程度气象干旱。
- 预估未来三十天，北美洲西南部、南美洲西部、非洲中部、中国华北中南部、黄淮、江淮西北部等地气象干旱将有所缓和，非洲中北部、西亚、南亚、澳大利亚西南部、中国华南及西藏南部、云南西北部等地气象干旱将持续或发展。
- Varying degrees of droughts occurred in southwestern North America, western South America, central and northern Africa, southwestern Australia, West Asia, South Asia, the Indo-China Peninsula, North China, Huanghuai, northwestern Jianghuai, eastern South China, southern of Tibet and northwestern of Yunnan.
- In the following 30 days, it is predicted that the drought in southwestern North America, western South America, Central Africa, central and southern North China, Huanghuai, northwestern Jianghuai will be alleviated. In central and northern Africa, West Asia, South Asia, southwestern Australia, South China and southern Tibet, northwestern Yunnan drought will persist or intensify.

4.3.2 Drought Forecast Based on Soil Moisture Prediction Model

Liaoning Province, drought management moisture prediction model was developed to adapt to the province, including the withdrawal of moisture and increase soil moisture empirical models empirical model.

4.3.2.1 Soil Moisture Retreat Model

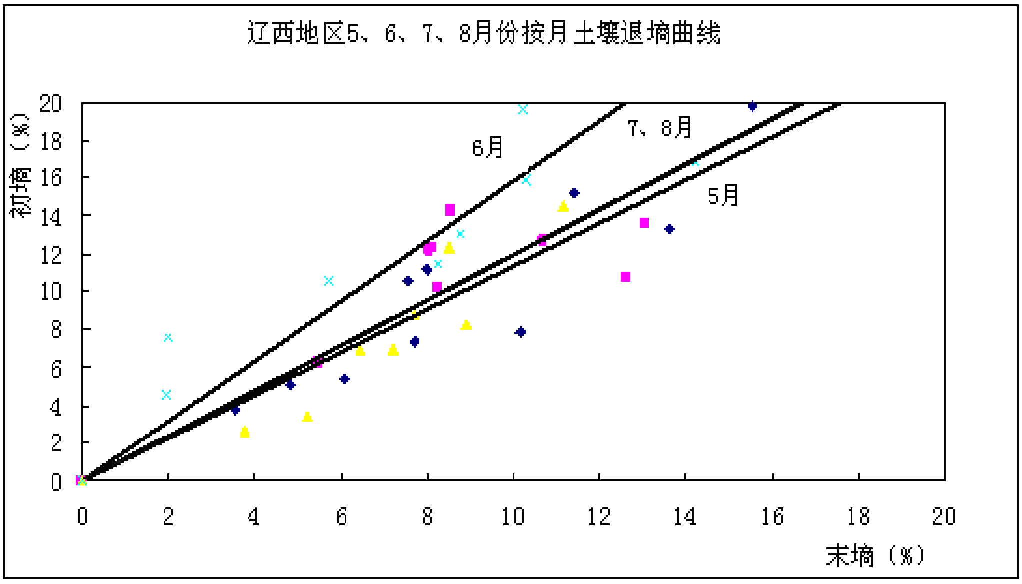
When the precipitation stops, after the ground water disappears, soil moisture in the role of solar radiation, and gradually reduced through evaporation and plant ground to distribute and deep infiltration, etc., into the soil water subsided stage. Changes in soil moisture, not only with evaporation, distribution volume, but also with deep groundwater and soil moisture are also relevant. Because of non-irrigated farmland in western Liaoning groundwater within the generally larger depth, deep groundwater on the upper soil moisture recharge small, may be considered.

Lower soil moisture by capillary force influences water recharge and soil evaporation and the amount of top soil on the upper end of the period are reflected in soil moisture. So, back to the period of the early

moisture empirical models of soil moisture evaporation and reflect, distribute ability to predict the size of the end of time parameters of soil moisture.

Evapotranspiration and growth stage and the solar radiation energy plants, and these factors are associated with the time or the seasons. So back to the time of moisture empirical model parameters established monthly. According to the measured soil moisture content at each station, select a monthly retirement moisture conditions without precipitation reasonable period of time at the beginning and end of the soil moisture ρ0 time soil moisture ρt, monthly plotted ρ0 ~ ρt correlation diagram, drawn in accordance with point group focus (ρ_0 ~ M ~ ρ_t) related lines, thus forecasting the end of the time period of the early soil moisture based on soil moisture.

Table 4.13: Soil Moisture Retreat Curve in Western Liaoning



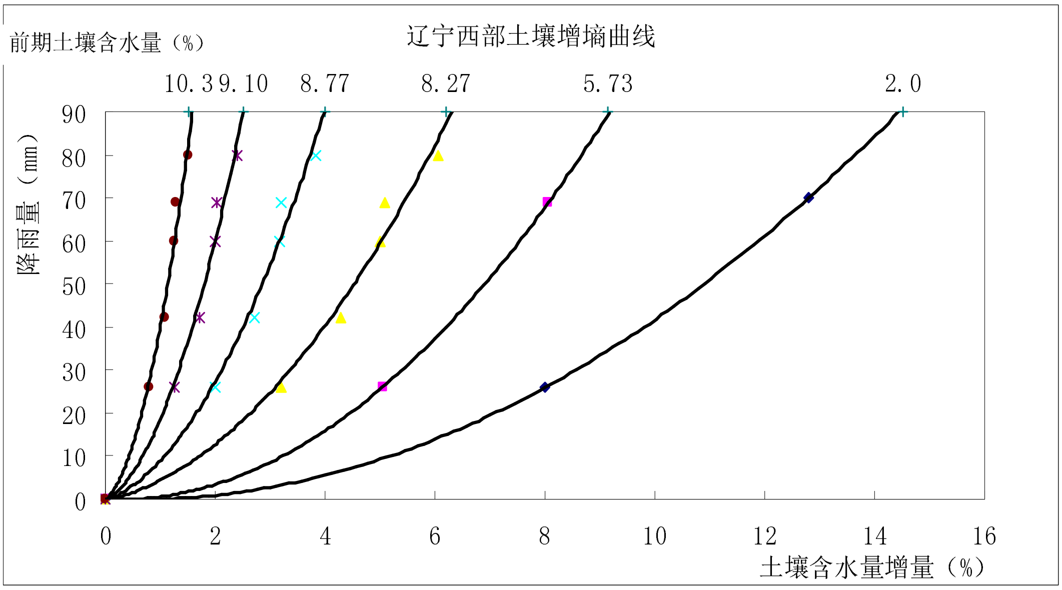
4.3.2.2 Soil Moisture Accumulation Model

For rain fed lands, there are many factors which could affect the increment of soil moisture (Δρ), and no doubt the precipitation is the one most related. In addition, as a result of precipitation, evaporation, infiltration, plant interception, surface runoff and groundwater recharge, and other factors affect the final can be reflected in the rain before rain and soil moisture. Therefore, increase in soil moisture model mainly soil moisture and precipitation consider two factors before and after rainfall, soil moisture before rain rate parameters to establish associated with increased precipitation forecasting model of entropy values Δρ.

The model is based on the measured moisture stations beginning of each period, the end of the soil moisture and precipitation data, select times greater than rainfall 15mm, increasing moisture after rainfall obvious periods were picking their precipitation P(mm), start time, end measured soil moisture. With early retirement after ten days of soil moisture, the soil moisture model calculates the daily retreat before rain soil moisture ρ0; then ten days late withdrawal soil moisture and soil moisture models to calculate the inverse of soil moisture after rain ρt, to calculate the times of precipitation soil growth in the value of the moisture content of Δρ. With precipitation P(mm) for the vertical axis, in order to increase the value of Δρ for horizontal moisture to soil moisture before rain ρ0 parameters, plotting the partition of rainfall stations

increased moisture correlation diagram (P ~ ρ0 ~ Δρ). Increase the amount of moisture in the soil in accordance with this sub- precipitation correlation diagram can be calculated from the precipitation.

Figure 4.6: Soil Moisture Accumulation Model



5. Drought Management Phases and Triggers

5.1 Drought Management Phase and Trigger Points

From drought risk management philosophy, based on the history of drought in Liaoning Province drought analysis, combined with the current drought monitoring the situation, the Drought Management Stages Liaoning Normal phase, alert phase, the actual occurrence of drought and drought stage lifting phase, corresponding discriminant indicators and trigger conditions shown in Table 5-1. In the Normal phase and early warning stage, recommended the use of standardized precipitation index (SPI), river runoff and reservoir storage anomaly index for predicting and early actions on drought. Drought occurred in the actual stage, the use of regional agricultural drought indices, indicators of drought rate ratio and the city drinking water for the discrimination index.

Table 5.1: Liaoning Drought Management Phase

<table>
<tr><th colspan="3" rowspan="2">Management Phase</th><th colspan="2">Indices And Triggers</th><th rowspan="2">Potential Drought Impacts</th></tr>
<tr><th>Indices</th><th>Triggers</th></tr>
<tr><td rowspan="2">Before drought</td><td colspan="2">Normal</td><td>Standard precipitation index (SPI)
River flow anomaly D_F
Reservoir level anomaly D_L</td><td>SPI⩾0
$D_F \geqslant 0$
$D_L \geqslant 0$
at least two conditions are met</td><td>No drought</td></tr>
<tr><td colspan="2">Pre-Drought</td><td>Standard precipitation index (SPI)
River flow anomaly D_F
Reservoir level anomaly D_L</td><td>-0.5⩽SPI<0
$-15\% \leqslant D_F < 0$
$-10\% \leqslant D_L < 0$
at least two conditions are met</td><td>No drought impacts</td></tr>
<tr><td rowspan="4">During drought</td><td rowspan="4">Actual Drought Period</td><td>Slight Drought</td><td>Regional agriculture drought index I_a</td><td>$0.1 \leqslant I_a < 0.5$</td><td>Water shortage in agriculture</td></tr>
<tr><td>Medium Drought</td><td>Regional agriculture drought index I_a
population ratio under drinking water stress P_a</td><td>$0.5 \leqslant I_a < 0.9$
Or $2.0 \leqslant P_a$
One condition is met</td><td>Increasing shortage on agriculture water use, some livestock and resident may be stressed for drinking water shortage in distant area，</td></tr>
<tr><td>Serious Drought</td><td>Regional agriculture drought index I_a
population ratio under drinking water stress P_a
Percentage of urban water shortage P_g</td><td>$0.9 \leqslant I_a < 1.5$
Or $5.0 \leqslant P_a < 7.0$
Or $20 \leqslant P_g < 30$
One condition is met</td><td>Serious shortage on agriculture water use, increased difficulty on drinking water supply in distant area，urban water use may be affected</td></tr>
<tr><td>Severe Drought</td><td>Regional agriculture drought index I_a
population ratio under drinking water stress P_a
Percentage of urban water shortage P_g</td><td>$1.5 \leqslant I_a \leqslant 4$
or$7.0 \leqslant P_a$
or $30 \leqslant P_g$
one condition is met</td><td>Agriculture, rural drinking water and urban water use are all significantly affected</td></tr>
<tr><td>Post Drought</td><td colspan="2">Recovery</td><td></td><td></td><td>The direct impact is relieved</td></tr>
</table>

Note: the percentage of urban water shortage means one third of the cities met the ratio.

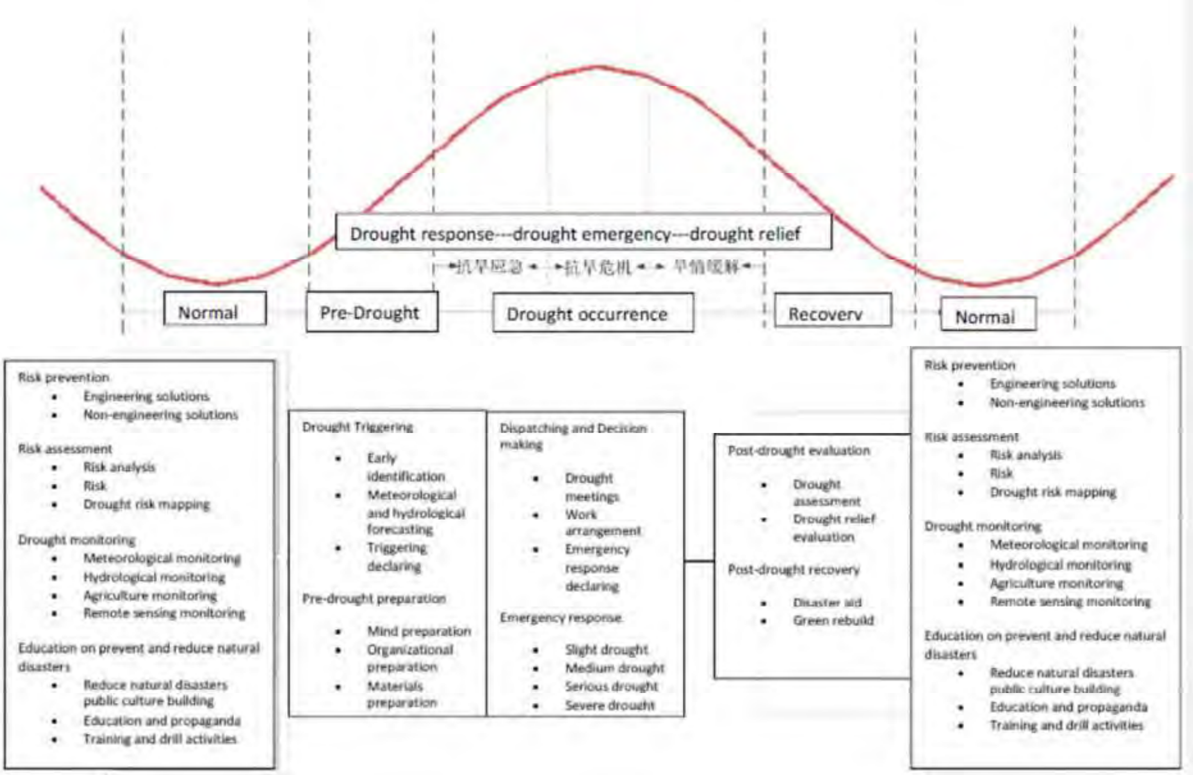
Here, there are two issues to be highlighted. First, due to a lack of understanding of drought, most provinces have a current drought early warning and emergency response and will equate it to proposed system. In fact, these are two entirely different concepts. Before the drought warning means drought, by selecting a set of corresponding drought early warning indicators of changes in hydrological and meteorological factors and runoff and water conditions in the target area to monitor for potential drought early identification and timely notification. Drought early warning information dissemination through various channels to the relevant government departments, various social organizations and the public to prepare for early, to minimize the loss of drought purpose.

The emergency response refers to the drought already occurring after the actual order to alleviate the drought losses taken temporary emergency action. For this reason, in this plan, there is a separate drought early warning and response area for after the occurrence of actual drought. Second, the current drought relief plan of Liaoning, including the drought in most parts of the grading standards existing are unreasonable. Most of the provincial drought plans have been completed before 2009, basically based on the introduction of the 2006 "State Flood Control and Drought contingency plan". Knowledge was limited, and the proven existence of the national grading standards drought plan in two major problems: a drought area only a single factor is difficult to objectively show a true reflection of the area affected by the drought situation, because for a large range of drought process, not only in different basins, provinces (autonomous regions and municipalities), prefectural (city), varying degrees of drought-hit counties (districts) between, that is, between the different plots in the same area. The extent of drought between different crops are not the same, and therefore need to consider both drought area and to consider the extent of the area affected by the drought indicators; two different levels of the national administrative use the same classification threshold is unreasonable.

In view of this, in 2009, China promulgated its first specification drought relief work in industry technical standards " drought level standard," provides a set of methods on agriculture, animal husbandry, population in drinking water crises and urban drought assessment. The goal was to achieve order to achieve a simple, fast and efficient standardized national assessment of drought administrative levels. For this reason, the drought assessment methods and standards are mostly based on the 2009 "drought level standards."

When in different stages of drought management, focusing on drought management action measures are different, see Figure 5-1. As in the Normal phase, the focus is drought risk prevention, risk assessment, disaster prevention and mitigation of drought monitoring and education, and in the early warning stage, the focus is conducted potential drought early identification, early warning and drought before release preparations.

Figure 5.1: Liaoning Drought Management Activities In Different Phases



5.2 Normal Stage of Drought Risk Management

Drought management, in essence is the management of water shortages in times of drought. However, this does not intimate that it is required only in times of drought. Effective and coordinated drought risk management and response to the drought requires that the effort must be conducted at all times. In other words, the Normal stages of drought management is the cornerstone of drought risk management. For a long time, the focus of China's drought management has been concentrated in the emergency phase of the actual occurrence of drought, while ignoring the Normal stages of drought management.

The Normal stage of drought risk management is so important for two reasons: First, from the nature of drought risk management point of view, it is not a passive response to drought risk, but actively prevention and/or reduction of drought risk. Risk reduction and mitigation measures are carefully planned and crafted during Normal operations so they can be quickly applied in Pre-Drought or Drought stages. Second, from the point of view of drought disaster mechanisms and unlike flooding, it is relatively slow process which might take a few months, seasons or even years to develop. Therefore, attention to the Normal stages of drought management. Overall, the Normal stages of drought management should focus on the long term, taking into account the daily management, including the following aspects.

5.2.1 Risk prevention

5.2.1.1 Engineering Solution

Currently, Liaoning Province, has developed water storage projects, water abstraction projects, water transfer projects, water pumping projects and wells, for engineering and other project -based drought preparedness and mitigation system requirements. But in general, the water allocation pattern is not perfect, lack of engineering drought functional potential, drought-resistant water supply capacity cannot meet demand, leading to lower agricultural resilience in some areas, and some urban and rural water supply and other safety risks. Therefore, in order to improve the water supply capacity of drought and drought periods, it requires long-term planning, to strengthen the construction of water conservancy infrastructure.

- Strengthen controlling water projects.
- Increase the dam reinforcement efforts.
- Strengthen farmland water conservancy construction, accelerate the transformation of water-saving irrigation area and to continuously improve the storage capacity of water supply and water use efficiency.
- In the arid region of Northwest Liaoning, the production of small micro- drought facilities which are closely linked with people's livelihoods.
- Strengthen western Liaoning mountainous soil conservation, implementing integrated watershed, improving water conservation capacity.
- After fully exploring the potential of existing infrastructure on drought mitigation, with the priority of securing drinking water supply for people and livestock during drought conditions, a series of proper designed and well-sized emergency water supply infrastructures could be built. Planning principles include exploring potential and refurbishment / rehabilitation existing facilities before constructing new infrastructure.

5.2.1.2 Non-engineering solution

Compared to the engineering system, the system of non-engineering construction has not been given sufficient attention, and lags behind. In recent years, Liaoning Province competent authorities have come to realize the value of non-engineering measures for drought prevention, the importance of drought, and have made some progress, top-down system of drought organization has been formed to carry out the policies and regulations developed gradually, drought plans and planning, information technology and other drought-resistant non-engineering system.

- Further enhance the functions at all levels of drought relief organizations. In times of emergency drought, drought organizations at all levels of command can be efficient and orderly respond and have coordination of relevant departments' linkage. But given that drought has the characteristics of slow development, this drought emergency department of economic and social interaction cannot meet the requirements of the drought management. Therefore, in addition to the functions of the emergency drought, drought organizations at all levels need to strengthen the functions of conventional drought, top-down institutional barriers to break, improve the internal organizational structure, so that the member units become more involved in the Normal work of the drought, the establishment of a unified multi-sectorial coordination mechanism, give full play to its role in organizing and coordinating the daily drought management at all stages.
- Drought management capacity building organization. Currently, there are no specific drought management divisions or sub-divisions for all municipalities in Liaoning Province. Within the 14 municipalities in Liaoning, the drought relief offices of six municipalities were subordinate to the rural

water division and for the remaining eight municipalities, the drought relief office and flood control office share their staff.

- Strengthen laws, regulations and technical standards system. Liaoning Province has no specific terms of drought policies and regulations. These must be practical, to accelerate the construction of local drought and regulations, such as the "Liaoning drought ordinance," and so on. Strengthen the "drought grading standards"(SL424-2008), "Guidelines for drought response plan"(SL590-2013), "drought grading standards"(SL663-2014), "Drought Planning Guide" and other technical standards declaration and training.
- Develop or apply an existing water supply priority framework that uses the following water uses into appropriate priority order based current requirements:
  - Domestic water use for basic needs (urban and rural), hospitals, schools, livestock
  - Minimum flows for the environment and basic needs for downstream water users
  - Pillar industries e.g. power stations
  - Irrigation for vegetable crops
  - Industry
  - Supplementary irrigation of field crops
  - Mining and other industries needing large quantities of water and discharging polluted waste water
  - Non-essential or 'luxury' use
- Plans to revise and improve the drought planning preparation need to be developed. Currently, most of the province's cities and counties have completed the preparation of the drought relief plan, but the basic concept of widespread drought early warning and emergency response is confusing and unclear, drought emergency in response to a trigger condition not scientific enough, operability is not strong including detailed response actions and other issues.
- Agricultural industrial structure adjustment. Encourage the development of agriculture, specialty agriculture, promote energy-saving solar greenhouse and livestock areas, the establishment of efficient water-saving agricultural production structure, and improve agricultural disaster mitigation.
- Material reserves and strengthen drought management. In drought-prone areas and reasonable construction scale, moderate storage for drought supplies and the establishment of appropriate management practices, such as drought supplies.
- Pre-identify potential risk reduction and mitigation measures (including implementation requirements) that can be taken to address vulnerabilities and reduce drought impacts.
- Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
- Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state or region.
- Development of standard protocols and minimum requirements for municipal, county and sectorial DMPs prepared in the Province.

5.2.1.3 Risk assessment

Risk assessment should include the following aspects:

- County as a unit, a comprehensive history of drought collected data and system storage.
- Organize relevant scientific research, the use of fuzzy comprehensive evaluation method based on disaster system theory, based on the theory of random probability and statistics, research progress drought frequency and potential loss of drought risk assessment methods based on the analysis carried out in Liaoning province's drought risk.
- According to drought risk analysis results, the completion of drought risk zoning of the province.
- Drawn diagrams of a typical complete different years or drought risk level year.

- Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.

5.2.1.4 Drought monitoring

Drought monitoring should including the following aspects:
- Unified planning, covering the whole province, rational layout, the information is complete, drought monitoring network resource sharing, including weather monitoring, hydrological monitoring, soil moisture monitoring, water quality monitoring, remote monitoring.
- Strengthen meteorological monitoring, including precipitation, evaporation, temperature and other information.
- Strengthen hydrological monitoring, including rivers, lakes, water reservoirs, flow, storage capacity and other surface water and ground water level information, such as groundwater information.
- Enhance soil moisture monitoring, divided into fixed station, mobile station, and three types of test stations.
- Strengthen water quality monitoring, involving water diversion control section, major rivers, lakes, boundary waters, and an important source of water supply to the water quality monitoring.
- Strengthen remote sensing.
- Established for water monitoring.
- Establish inter-departmental information sharing mechanism, a drought monitoring data information sharing network.

5.2.1.5 Information and education on disaster prevention and mitigation

Public information and education includes the following:
- Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the World Wide Web).
- Strengthen drought mitigation culture. The drought mitigation culture as an important part of strengthening the construction of socialist culture, the culture of service as a national drought mitigation public cultural service system is an important component of the drought disaster reduction into the national education system, strengthening the knowledge of primary and secondary school education and drought mitigation.
- Carry out publicity and education activities and drought mitigation. Combining national "Disaster Prevention and Reduction Day", "International Disaster Reduction Day", "World Water Day", "China Water Week", organized various forms of publicity and education activities and drought relief, the whole society to participate in creating a culture of disaster prevention and mitigation atmosphere. Development and Drought Mitigation series of popular science books, wall charts, and audio-visual products, publicize relevant laws and regulations, the daily water-saving techniques, and disaster prevention and mitigation measures to enhance the whole society's ability to adapt to drought, to raise awareness of disaster self-help skills.
- Organize relevant personnel to the drought emergency training drills. According happened drought readiness test preparations, formulated action if there are problems.

5.3 Drought Management Drought Pre-Drought stage

A key drought risk management stage is pre-drought, with the potential to move toward actual drought, and identified by selecting a set of corresponding drought early warning indicators. These include changes in hydrological and meteorological factors and runoff and water conditions in the target area to monitor for

early identification of potential drought, drought early warning and timely information dissemination through various channels to the relevant government departments, various social organizations and the public to make early preparations to deal with the process. In short, Pre-Drought management requires judgment, and accurate and timely warning information to the relevant institutions and personnel in order to make a timely response. Pre-identified risk reduction and mitigation measures are employed in an attempt to prevent drought or reduce the societal impacts from the drought. Therefore, emphasis on drought triggering's effects, actually improve the levels and capacity of drought triggering is the key.

5.3.1 Drought triggering

The "triggering" of pre-identified actions including risk reductions and mitigation measures is a critical part of the DMP and includes:

- Early recognition. Based on meteorological, hydrological and agricultural drought monitoring data, scroll to calculate the value of drought early warning indicators to determine whether the drought early warning trigger condition. Based on Integrated drought database for continuous monitoring of MWR and NCC data on meteorology using SPI, river flows and reservoir levels, notify potentially affected municipal FCDRH of potential drought conditions
- Meteorological and hydrological forecasts. Based on the short-term climate prediction Provincial Meteorological Bureau and the provincial Bureau of Hydrology Hydrological predictions, forecasts, and the next period of time may be judged trends drought.
- Triggering declaring. Meteorological and Hydrological projections show that if the drought was coming trends, the area may occur in time to release drought early warning information to the community about the drought, drought mobilize the whole society to do the preparatory work. Drought Warning Issued for local FCDRH organizations, released under special circumstances by the local people's government. Can be documents, radio, television, newspapers, Internet, SMS, etc. drought warning issued.
- Oversee implementation of standard protocols and minimum requirements for municipal, county and sectorial DMPs. Coordination of local DMP Pre-drought responses especially where drought affects multiple municipal areas or major sectors.

5.3.2 Drought preparation

The steps involved with drought preparation include:

- Coordination of public information on risk reduction and mitigation activities being applied based on systems developed during Normal stage.
- Mental preparation. Strengthen publicity and enhance people's awareness of self-protection and the prevention of drought, good drought mentally prepared.
- Organizational preparation. Drought sound organizational command structure, the implementation of drought accountability, responsible, strengthen the construction of drought service organizations. FCDRH institutions at all levels should strengthen drought service network, encourage and support social forces to participate in the construction of drought service organizations.
- Drought inspection. Implemented to organize, engineering, plans, materials, grading monitor as the main content censorship, found weaknesses to clarify responsibilities, limited rectification. Focus on examination of organizational leadership, accountability, water projects, drought measures are in place.
- Supplies ready. Levels of responsibility in accordance with the principle of reasonable reserves must drought supplies. Water restrictions initial program development. Promote water-saving irrigation techniques in agricultural production and farming techniques, develop water restriction program; develop rural and urban domestic and industrial water conservation, water restrictions, restrictions for

dryland development of high water consumption, high pollution projects focus on the development of water-saving industries and services.
- Based on the water use priorities established in Normal conditions, work with the WAB water abstraction permits to address water source scheduling and the optimal use of existing water sources of all types. Apply artificial rainfall when practical under climatic conditions. Consider applying principles outlined in SCD460 that allow transfer of water supply from lower value uses to higher value uses (in stages according to potential or actual drought severity) with pre-established compensation systems for entities losing their existing supplies.

5.4 The Actual Occurrence Of Drought Management Drought Stage

According drought assessment methods, procedures, regional drought assessment. Depending on the severity of the drought, the drought classified as mild, moderate drought, severe drought and severe drought in four grades. Different levels of drought stress and drought management key management actions are different for the various stages of Slight Drought (IV) to Severe Drought (I). The requirements are essentially same as in existing drought response guidelines but with the addition of improved risk reduction and mitigation measures at each stage, the impacts will hopefully be reduced.

The following activities relate to all levels of actual drought:
- Based on Integrated drought database for continuous monitoring of MWR and NCC data on meteorology using SL24-2008 identified drought indicators, notify affected municipal FCDRH of actual drought conditions.
- Oversee implementation of standard protocols and minimum requirements for municipal, county and sectorial DMPs.
- Coordination of local DMP drought responses especially where drought affects multiple municipal areas or major sectors.
- Report on activities upward to National FCDRH and downward to local FCDRHs.
- Coordinate public information on risk reduction activities as well as drought relief activities.

5.4.1 Slight drought

During a slight Level IV drought, the following are the requirements:
- Held a consultation meeting. Provincial FCDRH Office of the Deputy Director, chaired television, teleconferencing, analyze drought developments, as the case may start Ⅳ level response.
- Strengthen drought monitoring and forecasting. Hydrology, meteorology, agriculture and other sectors closely, to grasp the trend of drought, drought competent authorities provide the basis for command decisions. Meanwhile, through the network, information, media and other channels, to provide accurate and timely rainfall, hydrological drought and other information to the arid regions farmers.
- Strengthen the guidance of agricultural production. Agricultural technology to the countryside through the media or other means, the information to farmers introduce drought-resistant crops, market supply and demand conditions and prices of various agricultural information, such as drought-resistant farming techniques, to enable farmers to make specific measures to deal with drought conditions in accordance with its own production selection.
- Well planned water arid regions. Under the premise of ensuring drinking water in rural areas, and actively organize water sources and irrigation drought farmland grab temporary facilities.
- Good water-saving publicity. Water users are encouraged to take the initiative to save water, reduce or stop the unnecessary use of water.
- Sustained attention to changes in the drought, moderate drought likely to prepare.

5.4.2 Medium drought

In the event of moderate drought, severe water shortages rainfed agriculture, irrigated agriculture appears dry, a small amount may appear remote mountainous rural drinking water reservoir. When drought assessment results show that for the moderate drought, the trigger moderate drought response actions.

- Held a consultation meeting. Provincial FCDRH Office hosted a formal meeting or television, conference calls, analysis of drought developments, as the case may start Ⅲ level response.
- Strengthen drought monitoring and forecasting. Hydrology, meteorology, agriculture and other sectors closely, to grasp the trend of drought, drought competent authorities provide the basis for command decisions. Meanwhile, through the network, information, media and other channels, to provide accurate and timely rainfall, hydrological drought and other information to the arid regions farmers.
- Strengthen the unified water and drought management. Ensure that living water, drought-hit areas, the rural-owned water starts to ensure drinking water in rural areas. Appropriate compression agricultural water supply, appropriate restrictions on car washing, bathing water and high water service industry. Timely implementation of artificial rainfall operations.
- Strengthen agricultural water conservancy technical guidance. Through the media, or technology to the countryside, etc., to guide farmers to carry out arid regions irrigation water, irrigation, reducing agricultural water use.
- Timely carry out drought watering. Launch drought pumping stations, wells, small wells, all kinds of mobile machinery drought, drought arid areas to carry out timely watering. Channel siltation hit areas, to mobilize labor timely dredging to ensure smooth flow of water.
- Sustained attention to changes in droughts, severe droughts may occur ready.

5.4.3 Severe drought

Severe droughts mean a severe shortage of agricultural water, drinking water for people and livestock in remote mountainous areas further aggravate drought, and city water may be affected. When drought assessment shows severe droughts, they trigger severe drought response actions. At this time the focus is the protection of the urban life of drought and rural drinking water and drinking water, water for production of key industrial enterprises, seed production water, such as water efficient crops.

- Held a consultation meeting. Provincial FCDRH commander or deputy commander entrusted hosted a formal meeting to analyze drought developments, starting grade Ⅱ response, deployment drought.
- Strengthen drought monitoring and forecasting. Hydrology, meteorology, agriculture and other sectors closely, to grasp the trend of drought, drought competent authorities provide the basis for command decisions. Meanwhile, the Provincial FCDRH issued drought regularly informed and to provide timely and accurate intelligence to the arid areas of rain through the network of farmers, information, media and other channels, such as drought hydrological information.
- Strengthen drought guidance. Sent a working group member of the provincial FCDRH unit consisting of experts to guide drought arid areas.
- Protection drought supplies. Provincial Economic Commission for Coordination drought supplies production and scheduling, Provincial Communications Department to provide transport security and drought supplies.
- Protection drought funding. Provincial Department of Finance and timely implementation of drought funds appropriated.
- Strengthen agricultural drought guidance. Provincial Economic Commission responsible for agriculture and drought in rural guidance, advice to farmers on good field crop management and pest control, agricultural production is responsible for self-help, recovery work.

- Start drought water regulation program. Implementation of surface water, groundwater unified. Water supply projects adhere to the unified command, unified scheduling. Organize emergency drought water source projects, the city started a serious water shortage and drought contingency reserve water supply scheme. Deployment of various types of temporary drought devices enable temporary measures, such as temporary set pumping stations, water channel excavation; contingency of wells, springs digging, building reservoirs, etc.; emergency of inter-basin water transfer; ensure the water project under safe conditions, the amount of dead storage reservoir extraction; temporary suspension of water in the rivers and canals; law timely implementation of artificial rainfall operations; serious difficulties for drinking water source areas to implement a temporary artificial water supply.
- Develop and implement emergency water restrictions scheme. Under the premise of ensuring living water, according to the drought situation of shortage of water supply, water identified priorities, limited water supply. Compression of agricultural water supply, agricultural irrigation appropriate narrow range. Control of industrial water. Limit car washing, bathing water high water service industry. Serious water shortage, living water rationed, regular supply.
- Strengthen advocacy and social mobilization. Organization, coordination and timely news media reported that drought disaster to the public, advocacy drought, mobilize all sectors of society to support drought relief work.
- Sustained attention to changes in droughts, severe drought that may arise prepare.

5.4.4 Extreme drought

Catastrophic drought, severe water shortages will occur socio-economic, agricultural drought continued to increase, industrial water restricted exacerbated the difficulties occurred in some cities living water. When drought assessment results show that when severe drought, severe drought triggered a response action. At this point, the focus is the protection of the urban life of drought and rural drinking water and urban drinking water.

- Held a consultation meeting. Provincial FCDRH commander hosted a formal meeting to analyze drought developments, starting Ⅰ level response, deployment drought. The drought reported to the provincial government and the State FCDRH, consult the Provincial Standing Committee, if necessary, will be listening to the reports and the provincial executive decision-making and deployment.
- Strengthen drought, disaster monitoring. Provincial FCDRH should pay more attention on drought forecast, forecasting, statistics and submit the drought, disaster and drought conditions, the timely release of "drought information." Provincial Meteorological Bureau to strengthen weather monitoring and forecasting, to provide relevant and timely weather information to the Provincial FCDRH, soil moisture and satellite remote sensing monitoring information, timely organization of artificial rainfall.
- Strengthen guidance drought relief work. Provincial FCDRH sent within 24 hours after the warning from experts to drought-hit areas of technical guidance, sent a drought inspection team, the Steering Group, inspect and guide the drought relief work, and to mobilize people in areas affected by drought and drought emergency.
- Protection drought supplies. Provincial Economic Commission for Coordination drought supplies production and scheduling, priority delivery drought supplies Provincial Communications Department, providing transport security and drought supplies.
- Protection drought funding. Provincial Department of Finance to implement large funding drought, drought timely allocated special funds.
- Strengthen agricultural drought guidance. Provincial Economic Commission responsible for agriculture and drought in rural guidance, advice to farmers on good field crop management and pest control, agricultural production is responsible for self-help, recovery work.

- Start drought water regulation program. Implementation of surface water, groundwater unified. Water supply projects adhere to the unified command, unified scheduling. Implementation of the province's joint operation of reservoirs, urban and rural life and to meet the water demand in key industries may be appropriate to over-exploitation of groundwater. Increased drought emergency water project construction, start a serious water shortage and drought all cities and emergency backup water supply scheme. Deployment of various types of temporary drought devices enable temporary measures, such as temporary set pumping stations, water channel excavation ; contingency of wells, springs digging, building reservoirs, etc.; emergency of inter-basin water transfer ; ensure the water project under safe conditions, the amount of dead storage reservoir extraction ; temporary suspension of water in the rivers and canals ; law timely implementation of artificial rainfall operations ; serious difficulties for drinking water source areas to implement a temporary artificial water supply.
- According to more severe water shortages, develop and implement emergency water restrictions scheme. Under the premise of ensuring living water, according to the national economic development and the impact of water scarcity in arid conditions, to determine the priorities of water, limited water supply. Narrow range of agricultural irrigation, reducing agricultural water supply. Strict control of industrial water. For the high- water companies, to stop water supply when necessary. Stop washing, bathing water and high water service industry. Water restrictions and rural life. For serious water shortage, living water impose a quota, regular supply. Serious difficulties in regional organizations temporary artificial drinking water and bottled water.
- Propaganda and mobilization. FCDRH at all levels in accordance with relevant state regulations, unified release drought, disaster and drought information, organization, coordination and timely news media reported that drought disaster to the public, advocacy drought, mobilize all sectors of society to support drought relief work.

5.5 Recovery Phase Drought Management

The following activities relate to all levels of drought recovery:

- Based on Integrated drought database for continuous monitoring of MWR and NCC data on meteorology using SL24-2008 identified drought indicators, notify potentially affected municipal FCDRH of end of actual drought conditions.
- Oversee implementation of standard protocols and minimum requirements for municipal, county and sectorial DMPs
- Coordination of local DMP drought relief especially where drought affects multiple municipal areas or major sectors.
- Report on activities upward to National FCDRH and downward to local FCDRHs.
- Coordinate public information on risk reduction activities as well as drought relief activities.
- Determine end of drought relief following end of drought and return to Normal conditions.

After the lifting of the province's drought, drought management moves into the recovery phase.

5.5.1 Post-drought assessment

The post-drought assessment activities include the following:

- Drought rating. Provincial FCDRH Office reported in accordance with municipalities and assess the results of the assessment group verification team organizational disaster, disaster-depth investigation and verification, the final results will be verified with the provincial emergency relief headquarters office (located in the provincial Civil Affairs Department) after coordinated reported to the provincial

Government and the State FCDRH. Meanwhile, according to "drought grading standards" (SL663-2014) determine the province's drought levels.
- Drought assessment. Evaluation carried drought and lessons learned and practical problems of drought acquired.

5.5.2 Post-drought recovery

The post-drought recovery activities include the following:
- Rescue victims. After verification of the disaster, FCDRH at all levels should provide drought relief services and keep records of the work.
- Resume production after the disaster. Governments at all levels, the competent authorities to resume production as soon as possible to help the affected people, as well as facilitate self-recovery by affected people.
- Hydraulic repair. Water administrative departments should check the conditions of water infrastructure and arrange rehabilitation work when necessary, or prioritize the problem in the annual rehabilitation plan. Drought-damaged water conservancy projects generally include irrigation canal, a small dam reservoirs, embankments, lift pump station facilities, water pipelines, and other electromechanical well.
- Supplies, equipment and other restitution. The local governments flood control and drought headquarters shall promptly return of expropriated drought emergency materials, equipment, means of transport, etc., and be compensated in accordance with relevant laws and regulations.

Annex 4 – Gansu Drought Management Plan

目录

图

表

1 简介

1.1 计划目的和目标

长期以来，灾害的危机管理模式在世界各国一直占据着主导地位。干旱危机管理模式是指当干旱发生后才开始作出反应，临时制定应急对策和措施，以期减轻干旱灾害损失和影响。在这种模式下，主要是针对眼前和局部的问题，采取的措施往往是临时性和应急性的，干旱管理也往往局限于实际旱情发生阶段。如此一来，常常是头痛医头、脚痛医脚，完全处于被动应急的局面，很容易陷入“从一个灾害走向下一个灾害”的恶性循环模式。

随着对干旱问题的认识的进一步深化，人们已经认识到要实现对干旱的有序、有效管理，应急状态的抗旱管理已无法满足要求，而要实现常态和应急状态的统合管理，即旱灾风险管理。

旱灾风险管理模式包括几个阶段：

- 监测、分析、预测干旱的发生、发展规律；
- 评估干旱可能造成的损失和影响，优化组合各类抗旱措施，有序、有效应对干旱灾害
- 旱灾后评估

在这种模式下，将高效的风险减免机制和理性的控制过程统合考虑，通过博弈应急管理和常态管理各自牺牲一部分利益，实现全局最优。与干旱危机管理相比，旱灾风险管理是一种主动、有备、周密和有效的防旱减灾管理模式，干旱管理阶段不再局限于实际旱情发生阶段，而是贯穿于干旱发生发展的全过程，表现为应急管理常态化，常态管理应急化。因此，本计划的总体目标是推进甘肃省干旱管理由危机管理向风险管理转变的进程。

具体地说，本计划目标可分解如下：

- 努力将整个干旱管理建立在科学、全面的风险分析的基础之上，清晰掌握全省旱灾风险及其危险性、暴露性、脆弱性等风险构成要素的分布格局及严重程度；
- 努力将干旱管理建立在一个职责明确、协作一致的组织管理架构之上，提高干旱管理各级、各部门之间的合作与协调；
- 努力将干旱管理建立在兼具科学性和可操作性的旱情监测、评估和预测平台之上，提高对旱灾风险的有效监测、预警能力。
- 努力建立涵盖干旱发生发展全过程的管理模式，明确旱灾风险管理各阶段的触发条件、管理措施，实现干旱管理主动、有序和预防。

1.2 计划原则

本计划制定过程中，需要把握以下一些原则：

- 高层的参与、健全的体制、明确的职责和有效的管理都是至关重要的。
- 从事防灾、减灾、抗灾、救灾等不同工作的各有关部门之间需要加强沟通、交流和协调。
- 干旱监测和预警系统在风险识别、评估和管理中至关重要。
- 防灾、减灾和备灾是减轻旱灾风险的核心组成部分，不可仅仅依赖于应急措施，减灾备灾措施的制定和有效实施需要自上而下和自下而上相结合的方法。。
- 提高机构、社区和个人等不同层面的抗旱能力对降低旱灾脆弱性必不可少。
- 减轻旱灾风险需要有长期的资源保障，包括人力、资金、技术、设备等多方面。

- 减轻旱灾风险需综合考虑多种措施，如环境和自然资源综合管理、社会经济发展协调、土地利用规划以及适应气候变化等；
- 应特别注意社会经济中的高风险因素，例如年龄差异、残疾现象、社会不平等和性别问题等。要重点保护那些最脆弱群体，降低灾害影响。
- 为提高风险意识，教育和培训对所有人都是十分必要的。

1.3 干旱风险管理的组成部分

干旱不应当仅仅被视为一种物理现象或自然事件。这一自然事件（降水量较正常气候条件下偏少）和人类用水需求的交互作用导致了干旱对人类社会的影响。人类往往会加剧干旱的影响。包括发展中国家和发达国家在内，近几次干旱所造成的经济、环境影响和给人们生活带来的不便都在昭示着人类社会在面对这一“自然”灾害时所表现出的脆弱性。

脆弱性分析指出了造成干旱影响的社会、经济和环境因素。它着眼于导致脆弱性的原因而非结果和造成的负面影响。例如，降水偏少可能会导致作物减产。但导致这种影响的根本原因，可能是农民没有采用耐寒作物，因为农民不相信这么做会有所帮助、种子成本太高、或者由于其他文化和社会原因。

虽然干旱是一种自然灾害，但人类社会可以降低自身的脆弱性，进而减少同干旱事件有关的风险。干旱的影响，同其他自然灾害一样，可以通过采取减缓措施和预防（风险管理）的方式来加以控制。提前做工作减缓旱情为决策者提供了以最低的代价最大程度的缓解困难的机会。对旱情的“危机模式”做出响应，降低了对自身努力的要求，增加了对政府和救助机构的依赖。

新的干旱管理模式将风险作为主要因素，描述如下：

风险 = 危害性（自然事件）X 暴露性 X 脆弱性（社会因素）

其中危害性包括的因素有：
- 严重程度或等级——强度和历时
- 频率——概率
- 空间范围
- 发展趋势——历史情况，未来预测，影响

暴露性显示了干旱发生的可能性以及受影响的人口和资源情况。有时也将暴露性合并为危害性的一个因素。脆弱性则要求绘制干旱风险图，并对脆弱性进行评估。干旱风险与干旱（旱情的物理属性）发生的频率、程度和空间范围有关，还与易受影响的人口或活动有关。一个地区的脆弱性程度取决于该地区的环境和社会特性，跟该地区预测、应对、抗击干旱以及从干旱中恢复的能力有关。

从原则上来说，旱情指标是对需水量和可用水量之差的衡量，可以作为干旱“决策支持系统”的一部分。当地的水务公司可以根据旱情指标来启动限制用水条件，并向公众发布目前可用水量的情况。流域管理机构则可以利用旱情指标在整个流域内发布和协调用水情况。省级水利主管部门也可以利用指标来衡量全省可用水量的情况。上述各管理层级都可以利用旱情指数开展干旱管理活动。

干旱风险管理的一项主要内容就是根据指数的监测情况，设定一系列合理的行动“触发点”。这些行动可以包括落实预先制定好的风控措施和减缓措施，比如将可用水量重分配给高产值的用户，并对造成损失的用户进行补偿。

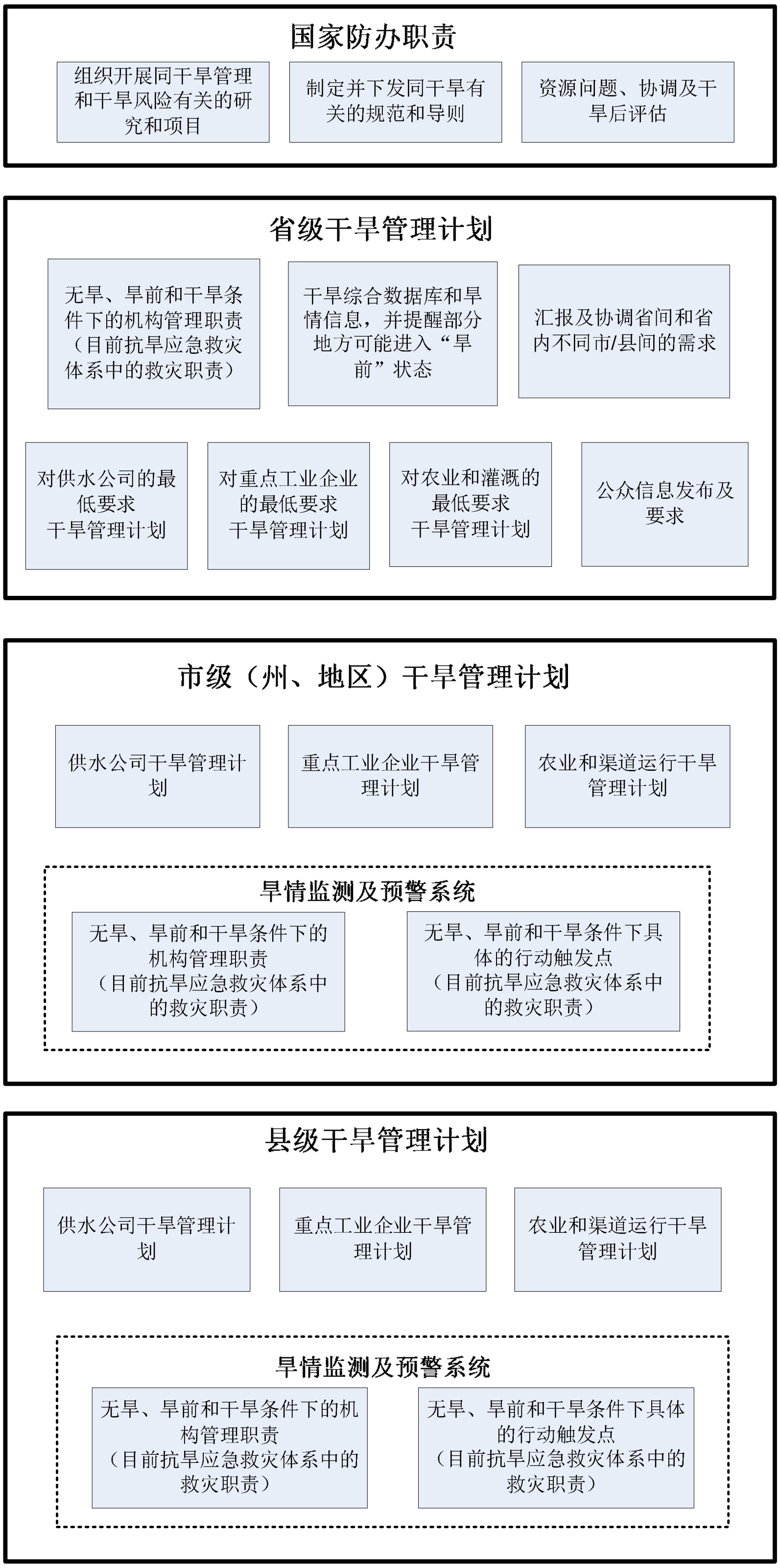
1.4 中国的分级干旱管理模式

干旱风险管理理论（以及广泛意义上的水资源综合管理）支持在恰当的管理层级上做决定，一般是更偏向基层而非高层。基于这一理念，以及中国目前国家、省级和地方防办系统的机构组织构架，本技援项目为中国的干旱风险管理提出了一个战略方法。试点省的干旱管理计划是在一个预计在未来分层级的干旱管理职责体系上建立的，其中各管理层级需紧密配合，各自行使明确的职责。水资源综合管理理念中具体的水资源管理决策由最合理的基层管理者做出。

根据这一构架，省级计划和地方计划同为干旱管理计划体系的一部分。最基层级别是自来水公司、工业用水户和农业用水户。干旱管理活动由县级或市级的干旱计划协调。县级或市级的干旱管理计划由上一级管理计划协调，整个过程由国家层面的干旱管理计划提供指导和监督。省级的管理计划还需要管理和协调跨多个市、地区的大面积干旱。

图 1.1 给出了各级别概念框架和分层的责任。

图 1.1: 旱灾风险分级管理示意图



- 研究立项，规范、导则的制定，干旱风险控制与管理
- 协调涉及多个省份的重大旱情中的管理计划和响应等级
- 同国务院一起确定所需的资源

- 下发省级气象信息/指数
- 审查及协调所有市、地区干旱管理计划中提到的监测、触发点、风险控制和减缓措施
- 协调省内活动，并向上级和公众发布

- 接收省级气象信息/指数
- 协调主要用水户干旱管理计划中提到的监测、触发点、风险控制和减缓措施
- 协调各项活动，并向省级和公众发布
- 管理各主要用水户（用水群体）的风险控制活动
- 协调和监督下属各县的干旱管理计划的制定与实施

- 接收省级气象信息/指数
- 协调主要用水户干旱管理计划中提到的监测、触发点、风险控制和减缓措施
- 协调各项活动，并向市级、省级和公众发布
- 管理各类用水户（用水群体）的风险控制活动

本项目提出的干旱管理框架中采用了一系列基于国际最佳实践和中国法规标准的干旱管理计划标准范本，试图通过这些旱灾管理计划为试点省减少短期和长期水资源短缺造成的影响提供有效且系统的管理手段。干旱管理计划提出了一套相互协调配合的干旱监测、影响评价、干旱应急响应、以及旱灾长效减缓机制。旱灾风险管理计划的三项主要包括：降低影响、响应行动和风险评估。

中国已经开始了各级抗旱应急预案的编制，但在任何时候还都应同时做出干旱管理计划，哪怕是无旱的正常时期。地方的旱灾风险管理计划和抗旱应急预案并存可能只是一个过渡时期，也许最终两者会合并成为一个文件。在中国要实施这些分层旱灾风险管理活动还存在很多潜在的制约因素，包括：

- 各级抗旱资金和预算与抗旱救灾活动紧密相联，在正常阶段和干旱预警阶段没有足够的预算和动机进行干旱管理活动。值得注意的是，很多干旱监测在当前工作中已有实施，但并未计入干旱管理系统。
- 中国的水管理机构间的协作与合作仍存在问题，并且在未确知旱灾危机发生时，合作问题更为严重。
- 有担心指省以下各级政府的水资源管理人员需要接受额外培训才能进行干旱管理。若该情况属实，在为基层水资源管理部门提供必要培训后，就不必由省级决策所有的干旱管理行动，因为水资源综合管理要求受直接影响的管理层级的做出干旱管理决策。
- 市、县级防办将需要大量时间来制定适当的干旱管理计划，因此省级干旱管理计划中需要预留计划时间，用于建立共通的权责机制，并与当地部门协调。
- 本地市，县级官员也需要时间与各行业的水管理人员（城市供水，工业，农业）协同工作，编制行业干旱管理计划，使他们可以被纳入到市、县级干旱管理计划。

基于这些限制因素，在基层市级和县级的管理计划制定完备，并具有了相应的技术实力管理该计划之前的过渡时期，甘肃省的干旱管理计划可视做一个对基层干旱管理控制和指导更多的管理计划，其中还附带一个综合干旱数据库。或者，省级防办和水利部门在过渡期内未为基层提供额外的资源和技术支持。因此，甘肃省干旱管理计划既从长远角度提出了省级和地方层级分级管理的战略模式，又给出从短期内，如何利用综合干旱数据库更多地由省级开展基于风险的干旱管理。

省级干旱管理计划包括如下主要内容：

- 制定管理计划的目标和目的；
- 建立旱情监测综合数据库，利用 SPI、河流流量和库水位等指标对旱情进行监测，确定各级旱情启动的阈值，并建立同气象部门的数据共享机制；
- 建立日报体系，从省级向地方利用省级旱情指数发布旱情，提醒可能受影响的市、县可能的旱情，或通报实际的旱情情势；
- 绘制干旱风险地图，开展省内的脆弱性评估，掌握哪些地区将发生何种程度的旱情，将造成何种破坏；
- 实施标准的风险管理流程，包括在旱前、旱中（IV 级到 I 级）、旱后各个阶段，并预设各阶段将采取的风险控制措施、减缓措施和水资源重分配等措施；
- 无旱时期（正常时期）
  - 优化配水、完善基础设施
  - 旱情指数的监测与汇报
  - 准备工作（旱前和各干旱等级下能采取的各项风险控制、减缓措施、水量重分配措施）
  - 教育
- 旱前时期
  - 触发点
  - 准备并落实各项风险控制措施、减缓措施和水量重分配措施；

  - 限制供水/水量重分配
- 干旱时期
  - 触发点
  - 准备并落实各项风险控制措施、减缓措施和水量重分配措施；
  - 按照现行抗旱应急预案的规定落实救灾行动
- 旱后评估和恢复

1.5 省级与基层及行业干旱管理计划的区别与联系

本技援项目提出了一个分级的决策支持预警系统，采用国家气象局和水利部各级防办气象干旱（和水利农业监测）预测来建立预警机制，并为受影响区域（流域、市、县）提供预警提示。一旦基层防办收到可能干旱的提示，现行的水文指标和其它水文数据就会被用来评估旱情可能性。根据这些信息，结合气象和水文评估以及概率分析，启动基层干旱管理计划并采取节水限水措施。

许多干旱指标可以直接引用旱情等级标准（SL424-2008），并有必要辅以风险减低和缓解措施。依干旱严重性的不同，水资源管理部门可以依据旱灾风险评估以及当地干旱管理计划，考虑重新分配用水许可。虽然在正常时期，一些汇报工作也在进行，但在中国，在没有干旱灾害且没有干旱预警（四级到一级）启动的情况下，对于这些汇报上来的信息的响应行动很有限。

各级防办都在开展干旱前期抗旱规划工作，但是对于干旱指标的监测还不充分，干旱预测以及基于这些预测的风险减低和缓解措施也不完善。在此背景下，本技援项目不建议再改进现有的决策支持框架，而希望建立一个全新的面向干旱全过程（正常、干旱前期、干旱、以及干旱后期）的干旱管理方式。

全省旱情不能一概而论。在省级干旱管理中，正常时期监测的三个基本指标为标准降水指数，降水距平以及水库水位距平。在干旱前期，应将这些省级预警结果及时传达给市级部门。当地部门可以调整本地指标如：1）调整标准降水指数的触发点；2）增加土壤墒情监测站并将数据用于相对土壤墒情计算；3）积雪测量等。

市级将预警结果上报给省级部门，同时传达给县级部门。另外，市级部门可根据预测结果采取行动。县级部门将在市级基础上发布干旱早期预警，并考虑保障重点用水行业。县级部门将管理决策上报给市级至省级并根据预测结果启动抗旱措施。对应省级抗旱措施，市、县级应根据各自预警结果采取适当措施，包括发布信息，减少用水定额等。所有的市、县、以及行业抗旱计划应统一按省级防办制订的标准程序规划。

对于拟提出的省级和基层干旱管理计划，应考虑的干旱管理目标如下：

- 及时，系统地收集和分析干旱有关的信息。
- 建立发布旱情紧急情况和触发各种减缓和应对活动的标准。
- 提供组织结构和系统并保证内部的各级政府的信息传递。
- 定义各机构的职责和责任。
- 政府现行的评估和应对旱灾紧急情况项目的数据库维护
- 找出干旱敏感的省/地区/国家和脆弱行业，个人或环境。
- 找出解决脆弱性并减低干旱影响的缓解措施
- 提供及时准确的评估干旱对农业，工业，城市，野生动物，旅游，娱乐，保健等领域的影响的机制。

- 向媒体（例如电视、广播、以及万维网）准确及时的披露信息，保证公众对于当前情况以及相应措施的知情。
- 建立政策体制，保证缺水时期水的公平分配，制定规范或采取奖励措施，鼓励节约用水。
- 建立标准程序，并坚持执行与评估，不断完善该程序使其符合当地的需求

综上所述，省干旱管理计划包括以下几个方面：

- 干旱综合数据库，用来持续监测的水利部和气象局的气象数据，包括标准化降水指数，河流流量和水库水位。
- 与当地协调进行省内的脆弱性评估
- 建立标准程序，并提出对省内市、县以及行业干旱管理计划的要求
- 协调基层干旱管理计划的响应，尤其当干旱影响范围涉及多区域或主要行业时
- 建立组织结构和通报体制，保证各级防办间的准确沟通
- 依法管理落实抗旱规划工作
- 对上汇报至国家防办，以及对下传达至基层防办

技援项目通过本报告，从长远角度给出了省级干旱管理计划的范本，同时也对基层市级和县级的干旱管理计划提供了范本，供参考。本项目所提出的分级管理模式假定市级和县级能够获得资金和能力建设的支持，能够最终做到自己编制并管理基层的干旱管理计划。在条件完全具备之前，从短期来看，最现实的做法是利用综合干旱数据库、干旱风险图和气象指数，由省级发挥更多的干旱风险管理职责。

2 旱灾风险分析

2.1 危险性分析

危险性分析是研究受干旱威胁地区可能遭受干旱影响的强度和概率。一般而言，气象干旱强度越大，频次越高，即干旱灾害危险性越大，灾害风险也越大。

2.1.1 气象干旱危险分析

甘肃省属于典型的大陆性温带季风气候区域，但具有明显的向大陆性气候过渡的特征。多数地区冬季雨雪少，寒冷时间长；春季时间短、升温快，温差大；夏季气温高，历时相对较长；秋季降水较多，初霜来临早。根据各地气候差异，全省分为陇南南部河谷亚热带湿润区、陇南北部暖温带湿润区、陇中南部温带半湿润区、陇中北部温带半干旱区、河西南部高寒半干旱区、河西西部暖温带干旱区、河西北部温带干旱区、甘南高寒湿润区等 8 个气候区。

全省多年平均降水量只有 280.6mm，降水总量 1275.29 亿 m3。其中内陆河流域多年平均降水量 139.2mm，降水总量 357.89 亿 m3；黄河流域多年平均降水量 469.3mm，降水总量 684.64 亿 m3；长江流域年平均降水量 604.9mm，降水总量 232.77 亿 m3。降水量呈东南多西北少的特点，东南部地区最高达 800mm 以上（康县 860 毫米），西北地区最低只有 30mm 左右（敦煌 29.4 毫米），中部地区一般在 200-500mm 左右。降水年内分配也极为不均，汛期降水量大而集中，6-9 月降水占全年降水量的 65%-75%；年际变化大，最大与最小降水量倍比一般地区为 2-3 倍，表现为越是干旱的地区倍比越大，其中敦煌最高达 16.5 倍。

甘肃省境内有内陆河、黄河、长江 3 个流域，分别占全省总面积的 59.4%、32.1%和 8.5%。这三个流域的干旱发生特点也不同。黄河流域地处甘肃省中东部，包括兰州、白银、定西、平凉、庆阳、临夏、甘南和天水的大部分区域，总人口、农村人口和耕地面积均占全省的 70％左右，大部分土地面积属于黄土高原丘陵沟壑区，现有耕地的 83％是山旱地，降水量 200-500mm，蒸发量高达 1500-2200mm，干旱指数 5-11，是全省旱灾高发区和重点防范区。尤其以定西为代表的中部干旱山区，是全省干旱发生率最高的地区，季节性、区域性干旱几乎年年发生，时段长短和严重程度不同而已。长江流域位于秦岭西段、嘉陵江上游，包括陇南、甘南和天水的部分区域，年降水量 500-800mm，蒸发量 1500mm 左右，干旱指数 2-3。但由于山高沟深，兴修水利的条件极差，整个流域几乎没有大型骨干水利工程，灌溉面积仅占耕地面积的 11.6％。现有耕地多是分布在半山腰的坡耕地，土层薄，失墒快，受旱的机率也较高。内陆河流域包括酒泉、嘉峪关、张掖、金昌、武威 5 个市，年降水量一般小于 100mm，年蒸发量 2400-2800mm，干旱指数 13-55，属于极端干旱地区。但由于河西走廊属灌溉农业区，水利条件较好，供水保证率较高，受灌溉农业之利，受旱机率相对较低，灾情也相对较轻。

甘肃省干旱的季节特征十分明显，春夏两季连旱是甘肃旱灾的基本季节特征。由于降水的年内分配与农作物生长期对水的需求不相一致，农业生产具有显著的季节性干旱特征。一般年份，甘肃冬季雨雪较少，凡是严重旱情都是从上一年的 11 月份露头并逐渐发展，一直持续到第二年春季和夏初，并集中表现在 3-6 月份。而与此同时，3-6 月是甘肃雨养农业区夏禾作物播种期和幼苗期，一旦降雨不及时或者没有有效降雨，就将造成农业生产的大幅度减产以至绝收。新中国成立以来发生的 17 个年份的较严重旱灾，基本上都发生在这一时段。

2.1.2 水文干旱危险分析

甘肃省多年平均水资源总量 584.77 亿 m^3。按流域分，内陆河 74.81 亿 m^3，占 12.79%；黄河 374.72 亿 m^3，占 64.07%；长江 135.24 亿 m^3，占 23.13%。内陆河流域水资源主要依靠祁连山冰雪融水补给，总水资源量为 61.3 亿立方米，占全省的 21%。内陆河流域土地占全省 60%，且后备耕地资源丰富，而自产水资源量仅占全省的 25.4%，水资源开发利用已达 102.7%。黄河流域总水资源量 127.7 亿立方米，占全省的 44%。可供利用的水资源集中在黄河干支流，流域中 90%的耕地为山、坡、塬耕地，基本无地表水可用。长江流域总水资源量 100.4 亿立方米，占全省的 35%，水资源比较丰富。长江流域耕地占全省的 8%，自产水资源量占全省的 45.8%，但山大沟深，地高水低，开发利用难度大。

2.1.2.1 地表水资源

甘肃省多年平均自产地表水资源量 286.21 亿 m^3，入境水资源量 289.83 亿 m^3，出境水资源量 477.75 亿 m^3。三个流域中，黄河流域地表水资源量最多，其次是长江流域，内陆河流域最少。

表 2.1: 甘肃省各流域地表水资源量情况

流域	自产地表水资源量	入境水资源量	出境水资源量
内陆河流域	55.64	14.02	10.23
黄河流域	129.09	242.06	339.14
长江流域	101.47	33.75	132.87
全省	286.21	289.83	477.75

表 2.2: 甘肃省各地市多年平均降水量及地表水资源总量

地级行政区	年降水量 mm	年降水量 万 m^3	年径流量 万 m^3	地表水资源总量 万 m^3
兰州市	325.8	443163.4	19140.5	22658.4
嘉峪关市	80.6	11885.0	103.6	205.0
金昌市	176.1	132013.6	4416.4	7658.1
白银市	279.8	561697.6	14455.0	23645.0
天水市	565.6	807979.4	151692.8	153742.6
武威市	213.9	699932.1	106141.9	121581.6
张掖市	250.4	997274.7	260309.3	274870.4
平凉市	535.4	593853.4	65582.7	66943.6
酒泉市	92.3	1266993.2	51422.0	63366.9
庆阳市	479.4	1304404.9	80188.3	84585.2
定西地区	476.3	935755.7	137482.5	141588.6
陇南地区	614.5	1714224.5	685764.6	685764.6
临夏州	529.9	430258.2	134010.4	135607.3
甘南州	576.3	2120346.8	889634.0	890765.3

2.1.2.2 地下水资源

甘肃省多年平均地下水总补给量 196.41 亿 m^3，其中山丘区 128.54 亿 m^3，占 65.4%；平原区 67.87 亿 m^3，占 34.6%。扣除重复计算量 187.68 亿 m^3，全省纯地下水资源量只有 8.73 亿 m^3。其中内陆河流域 5.14 亿 m^3，黄河流域 3.59 亿 m^3。

2.1.3 危险性评估

在分析甘肃省干旱灾害危险性的影响因素及现状的基础上，根据现有的数据资料条件，选取各个旱灾危险性的主要影响因子，建立旱灾危险性模糊评价指标体系。

采用归一化方法，将各个指标因子无量纲化并统一到[0,1]区间；采用层次分析方法确定各个影响因子对相应旱灾风险组成要素的贡献权重。

区域干旱危险性是对干旱的时空规模、强度、烈度和变异性等特征的描述，它往往是气象、水文等若干个干旱指标的综合反映。对于干旱灾害风险的危险性，选取年降水量、年降水量变差系数、人均水资源量 3 个指标作为影响因子，用经验打分的方法确定比较判断矩阵，并由此计算出权重系数，如下表：

表 2.3: 甘肃省干旱灾害危险性影响因子及权重

	影响因子	指标方向	权重
危险性 (H)	降水量	-	0.297
	年降水量变差系数	+	0.163
	人均水资源量	-	0.540

注：表中，“+”代表该因子越大，危险性越大，“-”代表则该因子越大，危险性越小。

由于甘肃省降水量及地表水资源量少，水资源开发利用率很高，该地区的主要水源是过境水及地下水，这两种资源的多少很大程度上影响了地区的干旱程度，因此人均水资源量这一因子所占评价权重更高。

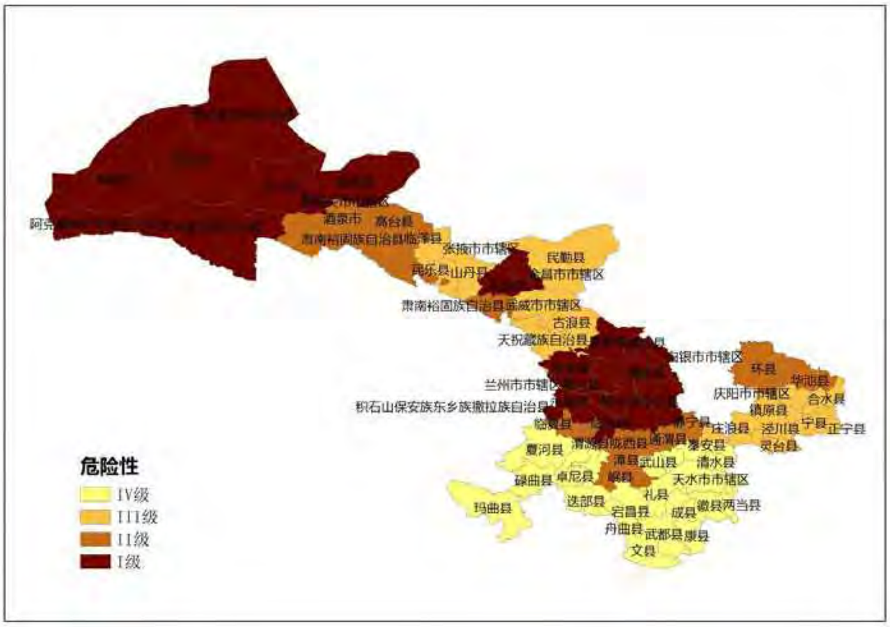
干旱危险性估算公式如下：

$$H = \sum_{1}^{n} \omega_i y_i$$

其中，H 为干旱危险性值，y_i 为危险性影响因子 x_i 经过归一化之后的值，ω_i 为危险性影响因子 x_i 通过层次分析得到的权重。

由上述方法计算得出甘肃省各区县干旱灾害危险性值，并将结果绘制成图，参见图 2-1。由图可见，危险性在流域分布上，黄河流域>内陆河流域>长江流域；在地级市分布上，兰州、金昌、白银、酒泉、定西、临夏市较大，而天水市、陇南市、甘南州较小。

图 2.1: 甘肃省各区县危险性分布图



2.2 暴露性分析

2.2.1 农业干旱暴露性分析

甘肃省现有耕地面积 5173.48 万亩，其中黄河流域 3368.81 万亩，占 65.12%；长江流域 505.48 万亩，占 9.77%；内陆河流域 1299.19 万亩，占 25.11%。全省总灌溉面积 1921.76 万亩，其中黄河流域 657.40 万亩，占全省总灌溉面积的 34.2%；长江流域 99.14 万亩，占 5.2%；内陆河流域 1165.22 万亩，占 60.6%。总灌溉面积中农田有效灌溉面积 1701.79 万亩，灌溉林果面积 180.89 万亩，灌溉草场面积 27.51 万亩，鱼塘补水面积 11.57 万亩。2007 年全省粮食作物播种面积 4030.57 万亩，占全省耕地面积的 77.91%，粮食总产 863.40 万 t，人均粮食占有量 330kg。

表 2.4: 各地市农业生产情况表

市（州）	耕地面积(万亩)	播种面积(万亩)			粮食产量(万吨)	有效灌溉面积(万亩)
		合计	粮食	经济作物及其他		
酒泉市	214.96	225.14	66.05	159.09	36.28	212.18
嘉峪关市	4.26	5.64	1.13	4.52	0.63	4.26
张掖市	331.51	318.47	211.08	107.39	96.88	251.94
金昌市	87.44	99.05	72.29	26.76	34.26	81.47
武威市	452.72	446.67	264.96	181.72	111.29	331.47
兰州市	315.23	309.45	186.08	123.38	37.17	119.04
白银市	449.59	397.73	313.61	84.12	53.46	161.66

市（州）	耕地面积(万亩)	播种面积(万亩) 合计	粮食	经济作物及其他	粮食产量(万吨)	有效灌溉面积(万亩)
临夏州	215.13	234.50	182.78	51.72	49.77	94.86
定西市	770.15	782.43	598.02	184.41	83.05	112.34
天水市	573.97	643.40	473.61	169.79	85.95	86.19
平凉市	558.85	679.50	499.79	179.72	87.27	66.14
庆阳市	665.17	911.97	633.15	278.82	88.10	64.88
甘南州	101.03	101.96	61.04	40.92	9.74	20.37
陇南市	433.47	596.09	467.03	129.06	89.55	95.01
全省	5173.48	5751.96	4030.57	1721.39	863.40	1701.79

甘肃省农业种植以粮食、油料、棉花、烟叶为主，其中粮食作物占到播种面积的7成左右，主要包括稻谷、小麦、玉米和大豆。天水、平凉、庆阳、定西、陇南5市作物播种面积超过40万公顷，是甘肃省主要的粮食生产地区，而嘉峪关、金昌、甘南3市（区）在10万公顷以内。

表 2.5: 各地市农作物种植结构（单位：千公顷）

地区	农作物播种面积	小麦	玉米	棉花	油料
兰州市	213.35	45.72	31.87		16.76
嘉峪关市	3.86	0.42	0.35		0.35
金昌市	70.47	22.60	9.36		8.01
白银市	297.04	53.29	87.79	0.07	15.47
天水市	437.91	135.02	84.77		50.13
武威市	243.58	53.10	51.21	9.67	25.19
张掖市	238.74	46.46	64.47	2.28	29.37
平凉市	449.19	133.24	77.71		47.59
酒泉市	166.70	23.25	20.23	29.75	4.6
庆阳市	628.94	130.57	155.13		73.83
定西市	551.47	73.65	126.33		18.14
陇南市	413.19	99.39	66.75	0.03	22.06
临夏州	159.35	37.07	46.2		16.77
甘南州	69.07	9.99	2.83		14.42
全省	3995.18	879.65	835.48	47.91	345.71

据2010年年鉴统计，全省粮食产量958.3万吨，其中夏粮330.8万吨，秋粮627.5万吨，单位面积粮食产量3422.77kg/hm^2。各地市农作物单产西北部高于东南部，其中嘉峪关最大，甘南州最小。

表 2.6: 各地市单位面积农产品产量（单位：Kg/hm^2）

地区	粮食	谷物	棉花	油菜籽
兰州市	3107	3488		1256
嘉峪关市	8166	8262		2009
金昌市	6406	6352		2700
白银市	2780	3246	1923	1185
天水市	3490	3553		1302
武威市	6472	7326	1686	2190
张掖市	6972	6814	1744	2170
平凉市	2901	3138		1433
酒泉市	7745	7704	1512	1694
庆阳市	2957	3313		1656
定西市	2747	3102		1802
陇南市	3130	3747	563	1592
临夏州	4892	5728		3325
甘南州	2408	2400		1482
全省	3423	3772		1816

2.2.2 农村人饮对干旱的暴露性

全省 2000～2007 年城市累计因旱减少供水量 1.51 亿 m^3，影响人口 276.30 万人，影响工业增加值 18.16 亿元。2000～2007 年 8 年中，全省共有 15 个城市发生 76 次干旱缺水事件，其中，金昌、白银、平凉、庆阳、定西、临夏、玉门 7 个城市连续 8 年发生干旱，天水 8 年间有 7 年发生干旱，其他城市也有不同程度的干旱灾害发生。给城市社会经济发展和生态环境造成了严重影响，工农业生产遭受较大损失，尤其是重点缺水的农业生产损失更加严重。另外，干旱还会对农村人畜饮水造成影响。社会经济越发达、人口密度越大，对水资源的需求量也越多，暴露性越明显。

2.2.3 暴露性分析

区域旱灾风险分析中，影响暴露性的主要因子有：人口、资源、社会经济等。根据这些因子的数量和空间分布，可以确定暴露性值。考虑到甘肃的干旱形势以及数据的代表性和可获取性，选取人均 GDP、人口密度、牲畜密度、单位面积粮食产量、作物播种面积 5 个指标作为暴露性的影响因子，计算权重如下：

表 2.7: 甘肃省干旱灾害暴露性影响因子及权重

	影响因子	指标方向	权重
暴露性 (E)	人均 GDP	+	0.091
	单位国土面积人口	+	0.273
	单位国土面积牲畜数量	+	0.091
	单位面积粮食产量	+	0.273
	作物播种面积	+	0.273

注：表中，“+”代表该因子越大，暴露性越大，“-”代表则该因子越大，暴露性越小。

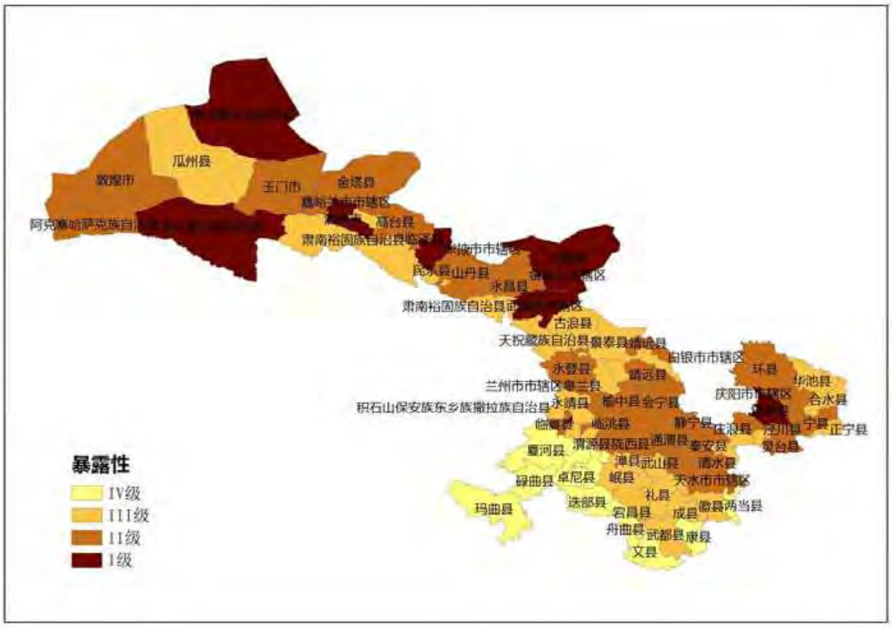
干旱暴露性估算公式如下：

$$E = \sum_{1}^{n} \omega_i y_i$$

其中，E 为干旱暴露性值，y_i 为暴露性影响因子 x_i 经过归一化之后的值，ω_i 为暴露性影响因子 x_i 通过层次分析得到的权重。

由上述方法计算得出甘肃省各区县干旱暴露性值，并将结果绘制成图，参见图 2-2。由图可见，流域的暴露性呈现内陆河流域>黄河流域>长江流域。酒泉、金昌市的部分区县最高，陇南市、甘南州区县最低。

图 2.2: 甘肃省各区县暴露性分布图



2.3 脆弱性分析

2.3.1 社会经济脆弱性分析

截至 2007 年底，全省总人口 2617.16 万人，其中城镇人口 826.76 万人，占 31.6%；农村人口 1790.40 万人，占 68.4%。按流域分，内陆河流域 476.29 万人，其中城镇 176.43 万人，占 37.0%；农村 299.86 万人，占 63.0%。黄河流域 1835.21 万人，其中城镇 578.78 万人，占 31.5%；农村 1256.43 万人，占 68.5%。长江流域 305.66 万人，其中城镇 71.55 万人，占 23.4%；农村 234.11 万人，占 76.6%。

2007 年全省国内生产总值 2665.57 亿元，人均 10225 元，其中内陆河流域 853.71 亿元，占全省的 32.0%，黄河流域 1678.64 亿元，占全省的 63.0%，长江流域 133.22 亿元，占全省的 5.0%。全省一、二、

三产业比例约为 15：48：37；全省工业增加值 1086.43 亿元，其中内陆河流域 427.22 亿元，黄河流域 615.51 亿元，长江流域 43.69 亿元。

可见，甘肃省境内黄河流域覆盖地区广，农村人口和第一产业比例很大，同时也是是全省经济生产的主要地区，一旦发生干旱缺水，对该地区的影响将很大。

表 2.8: 甘肃省各地市社会经济情况

地级行政区	总人口(万人)	城镇人口(万人)	农村人口(万人)	国内生产总值（亿元）			
				第一产业	第二产业	第三产业	合计
酒泉	99.03	50.61	48.42	38.15	94.26	67.99	200.40
嘉峪关	20.53	19.53	1.00	1.49	98.05	20.64	120.18
张掖	127.55	41.14	86.41	44.17	54.23	48.64	147.04
金昌	47.02	28.90	18.12	9.02	179.93	24.27	213.22
武威	190.16	44.44	145.72	47.96	66.54	72.27	186.76
兰州	329.43	239.89	89.54	26.09	333.98	365.05	725.12
白银	175.01	52.68	122.33	26.66	114.53	66.64	207.83
临夏	194.28	27.54	166.74	19.44	21.70	32.76	73.90
定西	293.08	42.80	250.28	38.11	22.59	36.78	97.49
天水	341.32	108.59	232.73	35.81	71.83	86.56	194.20
平凉	219.03	51.35	167.68	35.78	60.69	53.46	149.93
庆阳	251.27	61.96	189.31	32.43	118.85	49.57	200.85
甘南	68.01	15.67	52.34	10.15	8.46	16.35	34.96
陇南	261.44	41.66	219.78	30.90	42.29	40.50	113.69
全省	2617.16	826.76	1790.40	396.16	1287.92	981.49	2665.57

2.3.2 水利工程抗旱能力分析

2007 年全省各类水利工程设计供水能力 146.21 亿 m^3，现状供水能力 141.58 亿 m^3。按供水工程类型可划分为蓄水、引水、提水、调水、机井及其它工程。

2.3.2.1 地表水工程

甘肃省现已建成大中小型水库 287 座，总库容 88.63 亿 m^3。其中大型水库 7 座（包括电力部门管理的 3 座水库），总库容 74.50 亿 m^3，中型水库 27 座，总库容 9.50 亿 m^3，小型水库 253 座，总库容 4.63 亿 m^3。建成各类塘坝 664 座，总库容 0.22 亿 m^3。全省蓄水工程设计供水能力 39.44 亿 m^3，现状供水能力 35.86 亿 m^3。

截至 2007 年底，全省建成各类引水工程 9380 处，设计供水能力 54.68 亿 m^3，现状供水能力 51.65 亿 m^3。提水工程 8248 处，设计供水能力 23.14 亿 m^3，现状供水能力 22.06 亿 m^3。调水工程 2 处，设计供水能力 1.50 亿 m^3，现状供水能力 0.976 亿 m^3。

2.3.2.2 地下水工程

全省现有机井 49101 眼，其中配套 44506 眼，总装机 859.11 千 KW。已建成机电井 45915 眼，其中配套 41588 眼，总装机 813.32 千 KW。现状供水能力 29.98 亿 m^3。

2.3.2.3 其他水源工程

甘肃省其他水源主要包括雨水利用和废污水处理再利用。截至 2007 年底，全省其它水源工程的现状供水能力为 1.05 亿 m^3。

2.3.2.4 抗旱应急备用水源工程现状

全省只有兰州、天水、平凉、酒泉、陇南、玉门、敦煌 7 个城市建成了城市抗旱应急水源工程，用于城市抗旱应急备用水源的地下水井工程 173 眼，供水能力 618.04 万 m^3。其中浅层地下水井有 26 眼，供水能力 122.64 万 m^3，深层地下水井有 147 眼，供水能力 495.40 万 m^3。但目前部分水井净化设备老化，长期带病运行，时常出现故障，影响城区应急供水。见下表。

表 2.9: 甘肃省 2007 年城市抗旱应急（备用）水源工程现状表

城市名称	地表水源工程			地下水源工程			其他		总供水能力
	水源名称	类型	供水能力 (万 m^3)	类型	水井数(眼)	供水能力 (万 m^3)	类型	供水能力 (万 m^3)	(万 m^3)
兰州市				深层	142	409			409
天水市				浅层	12	18			17.60
平凉市				浅层	7	12.3			12.3
酒泉市				深层	5	86.4			86.40
陇南市				浅层	3	20.74			20.74
玉门市				浅层	2	36			36
敦煌市				浅层	2	36			36
合计					173	618.04			618.04

农村人畜饮水工程。截至 2006 年底，甘肃省共建成集中供水农村人畜饮水工程 8 万多处，解决了农村 924.55 万人的供水安全，自来水普及率达到 25%。同时修建农村饮水专用水窖 400 多万眼，缓解了干旱山区农村广大群众的饮水困难。

城市供水工程。甘肃省 14 个地级市政府所在城市和 68 个县（市、区）的城区均建有独立完整的供水系统。其中 14 个市州城市供水的主要水源基本为大江大河和主要河流的河谷潜流、蓄水性良好的地下水以及骨干水库，并建有备用水源地，具备一定的抵御干旱的能力。多数县城能够满足发生严重干旱时的基本需求。

2.3.3 其他抗旱能力

2.3.3.1 旱情监测能力分析

旱情监测预警体系主要包括旱情监测、旱情分析预测和旱情预警等内容。目前，全省仅有土壤墒情站127个，其中固定站90个，移动站29个，试验站8个；现有蒸发站71个；地下水监测站193个，主要分布于内陆河的酒泉、张掖、武威市。除此之外，全省86个县级行政区中，旱情分析预测和旱情预警系统均尚未建立。抗旱指挥调度系统包括抗旱会商和抗旱调度决策系统，建有抗旱指挥调度系统的也只有32个。

2.3.3.2 抗旱减灾管理体系现状

全省抗旱减灾管理体系建立了省、市、县三级行政首长负责制，成立了抗旱防汛指挥机构和办事机构；大多数县编制了抗旱预案；完善了有关抗旱管理制度；成立了基层抗旱服务专业队，并根据各地旱灾特点和抗旱需要，初步拟定抗旱物资使用和调拨的管理办法等，且有目的、有计划地配备了一大批抗旱专用设备，提高其服务功能；基本形成了省、市、县三级防旱抗旱网络，实现了现代化的信息管理。

但是，抗旱减灾管理体系还不完善，主要表现在：市县级专门的抗旱管理机构较少，市、县级抗旱管理机构体系不健全；政策法规缺乏，没有独立的抗旱政策法规；专项预案较少；旱情监测技术落后，自动化程度较低，时效性较差；抗旱物资库还没建立，抗旱的物资保障还没保障；抗旱服务组织发展迟缓，抗旱服务功较弱，开展多种经营能力较差；对干旱灾害风险管理等研究不够深入，尚未建立科学的抗旱理论体系等等。总体上看，抗旱减灾管理体系还不完善，抗旱能力较低，这在一定程度上增加了甘肃省干旱的脆弱性。

分析各地级市的抗旱能力情况，河西内陆区各市水利设施较为完备，耕地灌溉率较高，抗旱能力较强，嘉峪关、金昌两市以工业为主，农业及相关产业较少，且农业基础条件较好，灌溉设施相对比较完善，农业抗旱能力较高；酒泉、张掖、武威3市以灌溉为主，且水库调蓄率、灌溉设施完好率较高，目前主要不足为抗旱专项经费较少，抗旱服务组织建设薄弱，抗旱能力相对较低，但与全省其他市（州）相比，仍属较高水平。黄河、长江流域各市（州）中，除甘南州抗旱能力明显较弱外，其他市（州）抗旱能力基本上处于同一水平，且决定抗旱能力的因子都相对很低，除部分市（州）属资源型缺水外，其他市（州）的水利设施拥有量以及水资源利用量均较低，且部分地区完全处于靠天吃饭的境地，抗旱投入严重不能应对干旱灾害，抗旱服务组织建设尚不完善，基本上每遇严重干旱年就出现颗粒无收的现象。从此可以看出，黄河、长江流域作为全省抗旱工作的重点地区，在今后的抗旱工作中，需加大水利基础设施建设力度，加强旱作农业技术推广，增加抗旱经费比重，提升抗旱服务组织功能，提高应对干旱的水平，增强抵御灾害的综合能力。

2.3.4 脆弱性评估

脆弱性为“一个群体、系统或资产易于遭受干旱威胁并造成损失和影响的性质”，脆弱性分析是干旱灾害风险分析的重点，主要从自然环境与社会经济环境两方面考虑，分析受干旱威胁地区抵抗干旱灾害的能力。干旱灾害脆弱性的高低具有“放大”或“缩小”灾情的作用，同时能客观反映对干旱灾害应对、缓冲和恢复能力的差异。一般而言，孕灾环境的脆弱性越高，灾害风险就越大。针对甘肃省，选取第一产业比例、有效灌溉面积比例、水田比例、农村人口比例、水资源开发利用程度、人均收入、单位面积可供水量、抗旱队伍数量、旱情监测系统数量、应急备用水源个数10个指标作为干旱灾害脆弱性的影响因子。各因子的指标方向和权重计算结果如下表：

表 2.10:　　甘肃省干旱灾害脆弱性影响因子及权重

组成要素	影响因子	指标方向	权重
脆弱性（V）	第一产业比例	+	0.197
	有效灌溉面积比例	-	0.197
	水田比例	+	0.079
	农村人口比例	+	0.197
	水资源开发利用程度	+	0.079
	人均收入	-	0.031
	单位面积可供水量	-	0.079
	抗旱队伍数量	-	0.079
	旱情监测系统数量	-	0.031
	应急备用水源个数	-	0.031

注：表中，“+”代表该因子越大，脆弱性越大，“-”代表则该因子越大，脆弱性越小。

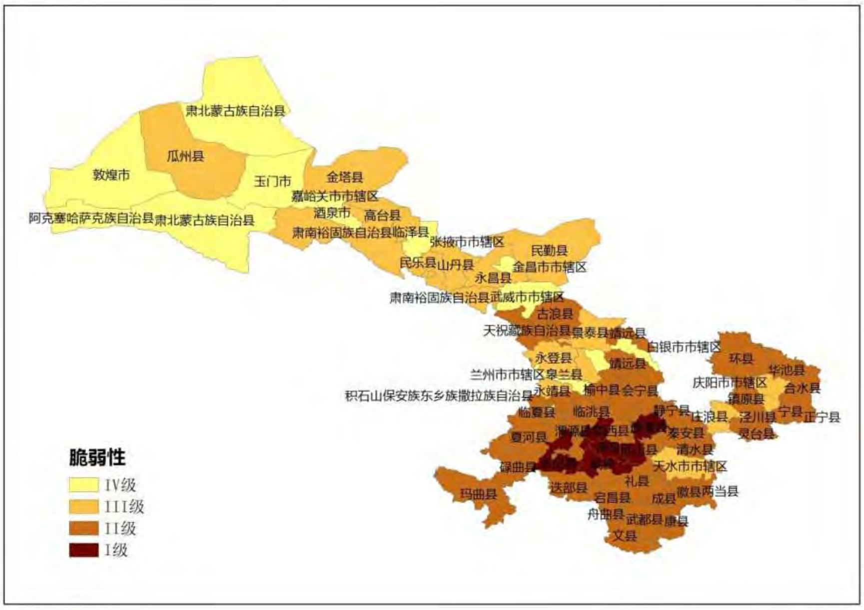
干旱脆弱性估算公式如下：

$$V=\sum_{1}^{n}\omega_i y_i$$

其中，V 为干旱脆弱性值，y_i 为脆弱性影响因子 x_i 经过归一化之后的值，ω_i 为脆弱性影响因子 x_i 通过层次分析得到的权重。

由上述方法计算得出甘肃省各区县干旱脆弱性值，并将结果绘制成图，参见图 2-3。由图可见，甘肃省的脆弱性呈现东南向西北逐渐减轻的趋势，内陆河流域轻于黄河流域及长江流域。其中，定西市、天水市、陇南市，甘南州水资源开发利用程度极高，农村人口比例大，农田有效灌溉比例低，脆弱性较高；而酒泉市及嘉峪关市虽然降水量少，但是农业比重较小，有效灌溉率高，居民收入及抗旱投入较高，因此脆弱性最低。

图 2.3:　　甘肃省各区县脆弱性分布图



2.4 风险评估

2.4.1 历史旱灾

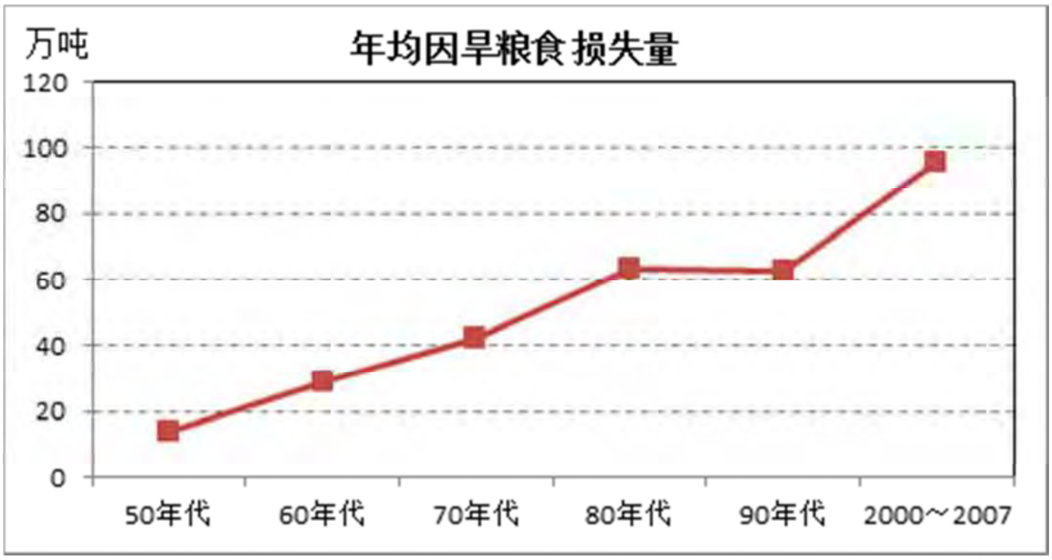
甘肃历史上旱灾频繁，据不完整史料记载，从公元前 206 年到 1949 年的 2100 多年间，全省旱灾平均每 3 年发生一次，较重旱灾平均 13 年发生一次。明代以来的 500 多年间，共记载特大旱灾 10 次。1950-2005 年的 56 年中，有 17 个年份发生较为严重的旱灾，特别是 1990-2007 年的 18 年中，有 7 个年份发生大面积旱灾，平均 2 年发生一次。20 世纪甘肃省共发生了 1928、1995、1999 和 2000 年 4 次大旱，其中 3 次就发生在世纪末。

甘肃省特大干旱约 50 年发生一次，严重干旱约 10 年发生一次，中度干旱约 5 年发生一次，轻度干旱每 2 年发生一次。由于气候变化以及经济社会发展等诸多因素影响，近年来，全省干旱特别是中度以上干旱呈现出频次逐渐增加、旱情逐渐加重的变化趋势。

全省的干旱及旱灾具有一定的持续性和连续性。全省中东部地区的干旱一般都会持续较长时间。新中国成立以来，1971～1973 年发生连续 3 年大旱，3 年累计受灾人口 1762 万人，减产粮食 215 万 t，灾情主要分布在黄河流域和长江流域；1981～1982 年发生连续 2 年大旱，是新中国成立以来甘肃省解最严重的一次旱灾，1981 年春夏秋三季连旱，全省 33 个农业县遭受大旱，占农业县总数的 45%，全省受灾人口 522 万人，减产粮食 124 万吨；1982 年旱情更加严重，全省 9 成县受灾，受灾人口 552 万人，减产粮食 131 万 t，特别是黄河流域受灾面积占播种面积的一半以上，受灾人口 489 万人，减产粮食 113 万 t，占粮食总产的 1/3，全流域达到重旱程度，有些地区达到极重旱程度。

由于旱灾的频发，致使年均因旱粮食损失量呈不断增加趋势，直接影响着农业生产的持续稳定发展，是造成粮食产量出现小幅波动的主要原因。

图 2.4: 甘肃省各年代粮食因旱损失量



2.4.2 农业旱灾风险图

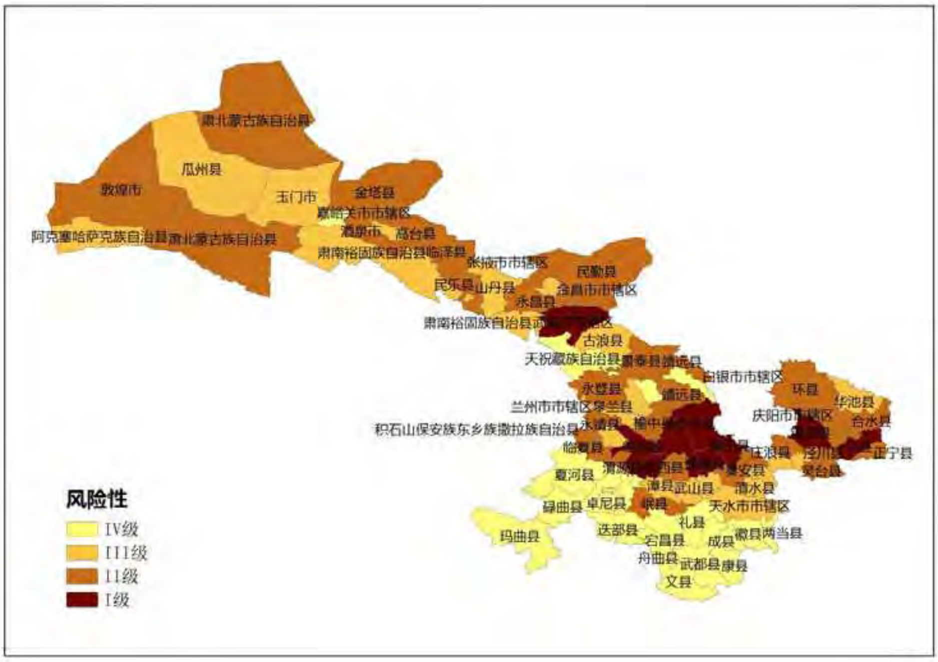
根据区域旱灾理论，干旱风险是危险性、暴露性和脆弱性综合作用的结果。针对甘肃省，采用下式估算干旱风险：

$$R = H * E * V * 100$$

其中，R 为干旱风险值，H 为干旱危险性值，E 为干旱暴露性值，V 为干旱脆弱性值。

由上述方法计算得出甘肃省各区县干旱风险值，并将结果绘制成图，参见图 2-4。由图可见，各流域的风险大小规律呈现黄河流域>内陆河流域>长江流域。风险最高的出现在武威、庆阳、白银、定西市的部分区县，南部地区风险最低。

图 2.5: 甘肃省各区县风险值分布图



3 旱灾风险管理组织机构及决策过程

3.1 组织机构及职责分工

3.1.1 组织机构

3.1.1.1 省抗旱指挥机构

甘肃省人民政府设立甘肃省抗旱防汛指挥部，负责领导组织全省抗旱工作，办事机构省抗旱防汛指挥部办公室设在省水利厅。

甘肃省抗旱防汛指挥部是全省防、抗旱工作的指挥机构，指挥部总指挥由分管副省长担任，副指挥由省水利厅厅长、省军区副参谋长担任，省水利厅分管副厅长任副指挥并兼任秘书长。

指挥部成员由省发改委、经贸委、建设厅、民政厅、财政厅、公安厅、水利厅、农业厅、广播电视厅、商务厅、兰州铁路局、气象局、交通厅、卫生厅、国土资源厅、省军区、电力总公司、扶贫开发办公室、物资局、邮电局、地震局、供销社等 22 个成员单位组成。各成员单位有关负责同志均为省抗旱防汛指挥部的领导成员。指挥部下设办公室。

3.1.1.2 地方各级人民政府防汛抗旱指挥部

设立省、市、县三级防汛抗旱指挥机构，负责本行政区域的抗旱日常工作及干旱灾害突发事件应对工作。

有防汛抗旱任务的县级以上地方人民政府设立防汛抗旱指挥部，由有关部门、事发地驻军、军分区系统负责人组成，由各级人民政府首长担任指挥，在上级人民政府防汛抗旱指挥部和同级人民政府的领导下，组织和指挥本地区的抗旱工作。防汛抗旱指挥部办事机构设在同级水行政主管部门。

3.1.2 职责

省防汛抗旱指挥部抗旱职责

省抗旱防汛指挥部的主要职责是指挥全省防旱抗旱工作，研究解决防旱抗旱工作中的重大事项，协调指挥部成员单位职责，制定全省抗旱预案，发布和解除抗旱预警。

省防汛抗旱指挥部成员单位抗旱工作分工

各成员单位在抗旱防汛指挥部的统一领导下，按照职能分工，做好有关抗旱工作。

省发改委负责相关规划的指导，做好应急抗旱工程设施建设的计划安排和监督管理。确保大旱期间物价稳定；

省公安部门负责及时处置抗旱期间灾区发生的各类治安和刑事案件，维护社会稳定；

省民政部门负责干旱灾害的救助工作，妥善安排灾区群众的基本生活；

省财政部门负责抗旱救灾经费筹措工作，确保抗旱资金及时足额到位，并监督抗旱资金的使用；

省建设部门负责城市供水管理工作，及时向抗旱防汛指挥部提供城市供水信息；在执行干旱预警期间，协助抗旱指挥部门搞好城乡水资源调度。

省交通、铁路部门做好抗旱物资及设备的运输工作；

省水利部门做好水资源的统一管理、科学调度和有效保护，组织好抗旱水源工程建设与管理，保证农村供水安全，并向抗旱防汛指挥部及时提供水情、灌溉、蓄水等防旱抗旱信息；

省农业部门做好受旱地区农业种植结构调整的指导和农用物资的储备、调剂、管理工作，及时向抗旱指挥部门提供农情信息；

省商务、供销部门做好受旱地区重要商品市场运行和供求形势监控，协调抗旱救灾物资的供应；

省卫生部门做好受旱地区防疫和医疗救护工作，监督、监测饮用水源卫生状况，确保饮用水的卫生安全；

省新闻宣传部门做好抗旱宣传工作，适时报道旱情、灾情和抗旱救灾工作；

省气象部门做好气象监测和预报工作，及时向抗旱防汛指挥部提供气象信息，实施人工影响天气技术。

省电力部门做好抗旱用电的供应和调度，执行国家有关抗旱用电政策。

省驻地人民解放军和武警部队是抗旱救灾的重要力量，执行国家赋予的抗旱救灾任务。

省防汛抗旱指挥部办公室职责

省抗旱防汛办公室是省抗旱指挥部的办事机构，行使全省防旱抗旱工作的行政职能，其主要职责是：

1. 拟定全省防旱抗旱法规性文件，落实国家和省人民政府的抗旱政策；
2. 研究全省旱灾规律，拟定全省防旱抗旱战略规划；
3. 组织落实省防旱抗旱指挥部和国家防汛抗旱总指挥部布置的各级工作任务；
4. 拟定抗旱预案、预警和应急响应的有关文件，组织有关专家的评估工作；
5. 管理中央特大抗旱补助等经费；
6. 掌握全省旱情和灾情，及时向省抗旱指挥部和国家防总报告旱情和灾情，组织实施抗旱减灾措施；
7. 推广防旱抗旱工作的先进经验和先进技术，组织实施有关防旱抗旱科研项目；
8. 指导基层抗旱服务队伍建设；
9. 搞好全省防旱抗旱工作宣传；
10. 指导市、县抗旱防汛办公室的工作，督促市县抗旱预案的落实。

各级防汛抗旱指挥系统及职责

各市、县抗旱防汛指挥部和指挥部办公室，是市、县人民政府的抗旱指挥机构和办事机构，参照省级模式，结合市、县实际制定和落实工作职责，并报上一级指挥部办公室备案。

3.2 决策过程

干旱管理是一项十分复杂的系统工程，各级政府行政首长是本地区抗旱工作的领导者和组织者，关注抗旱的全过程。

抗旱决策就是为了最大限度地减免干旱灾害损失，经过分析比较，从工程调度、水源配置等安排部署的备选方案中作出选择，并组织领导、付诸实施。指挥决策的依据是经批准的各类水量调度方案、防汛抗旱应急预案、调度规程等。同时，要服从有指挥权的上级防汛抗旱指挥部的统一指挥和调度，严格执行所下达的调度指令。

抗旱指挥决策的制定时，需要分析四个方面的问题：一是旱情、灾情现状及其发展趋势；二是可能产生的最不利后果，特别是与群众饮水安全、经济社会稳定相关的因素；三是按照各类预案、方案或规程，所能够运用的工程调度、水量调配等方案、措施，及其各自的利弊分析；四是组织实施最优方案涉及的相关组织机构、工程技术、专家队伍、物资装备、经费支持、运用补偿、生活安置等因素。

抗旱减灾指挥决策的行动方案主要针对如何通过采取措施确保城乡居民饮水安全、如何通过抗旱浇灌减少对农业生产的影响和如何通过水量调度解决城乡供水、生态用水短缺等问题，要坚持统一调度、保证重点、兼顾一般的原则，全力保障城乡居民基本生活用水安全。

决策方案制定完成后，省防汛抗旱指挥部组织召开会议，对行动方案进行讨论和审查，确定最终行动方案。方案经指挥部会议讨论批准后，下达至指挥部各成员单位和下级防汛抗旱指挥部门，并上报至国家防汛抗旱指挥部。成员单位及下一级防汛抗旱指挥部门按照各自职责进行方案实施及监督指导。在行动实施过程中，要实时关注旱情变化情况，当变化较大时，如干旱等级发生变化时，及时上报。成员单位及各级防汛抗旱指挥部门要对行动方案的实施情况及效果做总结和上报，省防汛抗旱指挥部根据实施效果，可对原方案进行修改调整。

4 旱情监测、评估及预测

在考虑甘肃省现有旱情监测体系和数据可获取性基础上，结合甘肃省抗旱管理部门前期工作基础和甘肃省气候地理等自然情况，提出了甘肃省干旱监测、旱情评估和旱情预测方案，具体如下。

4.1 干旱监测

干旱监测的内容主要包括气象监测、水文监测、土壤墒情监测、饮用水情况监测等。气象监测主要是降水信息、蒸发信息的监测，水文监测是河道和水库等地表水的监测和水井等地下水监测，土壤墒情监测主要是固定土壤墒情监测站的监测结果。截止目前，甘肃省有河道水文测站约 100 处，水库水位站约 400 处，雨量站约 1000 处（包括气象部门的站点），水质监测站 93 处，地下水监测站 90 处，蒸发站 71 处，固定土壤墒情监测站 90 处，移动土壤墒情监测站 28 处，土壤墒情试验站 8 处。除此之外，每类监测还有规划的站点待建设。这些监测站点基本能够支撑目前的旱情监测预警任务。

4.1.1 气象监测

甘肃省现有降水量观测站约 1000 个，包含气象部门的降水监测站点，监测的项目为日降水量。通过降水监测数据，可以计算降水量距平、标准化降水指数（SPI）、连续无雨日数等旱情评估指标。

4.1.2 水文监测

4.1.2.1 地表水监测

地表水监测包括河道水文监测和水库水文监测。

甘肃省现有河道水文水库水位站约 400 处。监测数据进入省水文部门的水雨情数据库中。旱情评估中可以利用该监测数据进行河道径流距平的计算。

通过水库的水位，利用库容曲线，可以计算各自的蓄水量情况。监测频率分日监测、周监测和旬监测不等。但省水文部门通过这些数据定期生成《水情旬报》，即至少每旬可以获得全省的水资源情况。旱情评估中可以利用该数据进行水库蓄水距平的计算。

由于甘肃省处于干旱和半干旱地区，水资源匮乏，河流较少，许多地区没有径流数据，因此，本方案中不建议采用河道径流距平作为旱情评估的指标。此外，甘肃省有许多的小水窖、小水井等小微型水利工程，这些工程在抗旱过程中发挥了立竿见影的作用，对于解决人畜饮水困难具有重要的意义。但是这些小微型水利工程的蓄水情况很难统计，难以汇总如全省水资源情况中。所以，利用水库水位数据计算水库蓄水距平指标在旱情评估中将作为辅助指标，给予较小的权重，或将其用于旱情发展趋势的比较判断。

4.1.2.2 地下水监测

甘肃省现有地下水监测站 90 处。地下水监测数据将作为旱情评估和抗旱决策的辅助数据，不直接作为旱情评估的指标。

4.1.3 土壤墒情监测

甘肃省现有土壤墒情监测站 126 处，其中固定土壤墒情监测站 90 处，移动土壤墒情监测站 28 处，土壤墒情试验站 8 处。日常可利用的主要是固定土壤墒情监测站的监测数据，利用该数据可以计算土壤相对湿度。此外，移动和试验土壤墒情的监测结果可以作为辅助数据验证和校准。

4.1.4 饮用水情况监测

饮用水水量情况目前尚无全面的、时效的监测手段，主要依靠统计上报的方式获得。

饮用水水质监测方面，虽然目前甘肃省有地下水水质监测站 93 个，但这些监测站点主要布设在大中城市、重要农业灌区，难以满足全省范围的水质监测需要。并且，由于经费与人员、仪器设备等原因，水源地水质监测频次低，未能实现水质自动监测和移动监测，无法及时掌握水质变化情况，还不能满足抗旱工作的需要。

因此，饮用水监测整体是通过统计上报的方式获得，由各级行政区主管部门逐级上报，上报的内容主要是因旱饮水困难的人口数量。此监测信息将用于因旱饮水困难的评估。

4.2 旱情评估方法及步骤

甘肃省旱情的影响主要体现在农业、人畜饮水困难和城市干旱缺水等方面，因此本方案主要针对这几方面进行旱情评估的设计。

4.2.1 农业旱情评估

农业旱情是指作物受旱状况，即土壤水分供给不能满足作物发芽或正常生长要求，导致作物生长受到抑制甚至干枯的现象。对于一次较大范围的干旱过程而言，不仅不同流域、省（自治区、直辖市）、地（市）、县（区）之间的受旱程度不同，就是同一区域内不同地块之间、不同作物之间的受旱程度也不尽相同。因此，农业旱情监测评估需要分两步进行，第一步是点上农业旱情即耕地或农作物受旱程度评估；第二步是区域农业旱情评估。

4.2.1.1 点上农业旱情评估

点上农业旱情评估的方法主要包括土壤相对湿度法、降水量距平法、标准化降水指数法、作物缺水率法、连续无雨日数法、水库蓄水距平法等。

1. 土壤相对湿度

农作物的水分供应主要是靠根系直接从土壤中吸取的，土壤中水分不足会影响农作物的正常发育。土壤相对湿度是衡量土壤水分含量的指标之一，是指土壤含水量占田间持水量的比值。土壤含水量是指一定体积的土壤中所含有水分的百分比，又称土壤含水率，通常有重量含水量和体积含水量两种表示方法，计算土壤相对湿度时通常采用重量含水量。田间持水量是指田间土壤能稳定保持的最高含水量。土壤相对湿度的计算如下：

$$W=\frac{\theta}{F_c}\times 100\%$$ 式 4-1

其中：W —土壤相对湿度（%）；

θ —土壤平均重量含水量（%）；

F_c —土壤田间持水量（%）。

土壤含水量指标是目前研究比较成熟，且能较好反映作物旱情状况的可行指标，对于已建立土壤墒情监测站点的地区，应优先采用土壤相对湿度评估农业旱情。由于不同质地的土壤保墒性能不同，为使评价指标具有通用性和可比性，采用土壤相对湿度作为评估指标。等级划分标准参见表 4-1。

表 4.1: 土壤相对湿度旱情等级划分表

干旱等级	轻度干旱	中度干旱	严重干旱	特大干旱
土壤相对湿度(%)	60>W≥ 55	55>W≥ 45	45>W≥ 40	W<40

2. 降水量距平

降水量距平百分率是指某一时段内降水量与多年同期平均降水量之差占多年同期平均降水量的比值。计算公式如下：

$$D_p=\frac{P-\overline{P}}{\overline{P}}\times 100\%$$ 式 4-2

式中：D_p —降水量距平百分率〔%〕；

P —计算时段内降水量（mm）；

$\overline{P}$ —多年同期平均降水量（mm），一般采用近 30 年的平均值。

降水距平法反映了降水与同期平均状态的偏离程度，具有方法简单、意义明确的优点。对于尚未建立墒情监测站点但已建立雨量监测站点的雨养农业区，可考虑采用降水量距平法评估农业旱情。考虑到降水对农业旱情的影响有持续性，旱情严重程度与前期雨量大小和分布有关，计算时段可根据情况选用月尺度、季尺度和年尺度。对于甘肃省的旱情评估，推荐采用月尺度和季尺度相结合的方式。等级划分标准参见表 4-2。

表 4.2: 降水距平百分比干旱等级划分表

旱情等级	轻度干旱	中度干旱	严重干旱	特大干旱
Dp（月尺度）	-40＜Dp≤-20	-60＜Dp≤-40	-80＜Dp≤-60	Dp≤-80
Dp（季尺度）	-35＜Dp≤-25	-45＜Dp≤-35	-55＜Dp≤-45	Dp≤-55

3. 标准化降水指数（SPI）

标准化降水指数是表征某时段降水量出现的概率多少的指标之一，该方法是由 McKee 等在评估美国科罗拉多干旱状况时提出的。由于不同时间尺度、不同地区降水量变化幅度很大，直接用降水量在时空尺度上很难相互比较，而且降水分布是一种偏态分布，而不是正态分布，因此，标准化降水指数先求出降水量Γ分布概率，然后再进行正态标准化。计算步骤如下：

假设某时段降水量为随机变量，则其分布的概率密度函数为：

$$f(x)=\frac{1}{\beta^{\gamma}\Gamma(x)}x^{\gamma-1}e^{-x/\beta}\ (x>0) \quad \text{式 4-3}$$

式中：γ—形状参数，用极大似然估计方法求得，$\gamma>0$；β—尺度参数，用极大似然估计方法求得，$\beta>0$。

$$\hat{\gamma}=\frac{1+\sqrt{1+4A/3}}{4A} \quad \text{式 4-4}$$

$$\hat{\beta}=\bar{x}/\hat{\gamma} \quad \text{式 4-5}$$

$$A=\lg\bar{x}-\frac{1}{n}\sum_{i=1}^{n}\lg x_i \quad \text{式 4-6}$$

式中：$\bar{x}$—降水量多年平均值；x_i—降水量资料样本值；n—计算序列的长度。

确定概率密度函数中的参数后，对于某一年的降水量x_0，可求出随机变量x小于x_0事件的概率为：

$$F(x<x_0)=\int_0^{\infty}f(x)dx \quad \text{式 4-7}$$

估计降水量为 0 时的事件概率：

$$F(x=0)=m/n \quad \text{式 4-8}$$

式中：m—降水量为 0 的样本数；n—总样本数。

对Γ分布概率进行正态标准化处理，即将（式 4-7）（式 4-8）求得的概率值代入标准化正态分布函数，即：

$$F(x<x_0)=\frac{1}{\sqrt{2\pi}}\int_0^{\infty}e^{-z^2/2}dx$$ 式 4-9

对（公式 4-10）进行近似求解，得到标准化降水指数，即 SPI ：

$$SPI=S\frac{t-(c_2t+c_1)t+c_0}{[(d_3t+d_2)t+d_1]t+1.0}$$ Eq. 4-10

式中：$t=\sqrt{\ln\frac{1}{F^2}}$， F 为（公式 4-8）或（公式 4-9）求得的概率；当 $F>0.5$ 时， $S=1$，当 $F\le 0.5$ 时， $S=-1$； c_0=2.515517、c_1=0.802853、c_2=0.010328、d_1=1.432788、d_2=0.189269、d_3=0.001308。

该方法适用于月以上尺度旱情监测与评估，能较好地反映干旱强度和持续时间，而且具有多时间尺度应用的特性，因而得到广泛应用。 SPI 的计算只需要降水量资料，资料容易较获取，避免了机理模型繁杂的计算和大量经验性的参数输入。

虽然该指标较降水距平指数复杂，但普遍认为比降水距平指数更好的反映干旱情况，因此，建议在条件允许的情况下，优先选择该指数进行旱情评估，计算的时段为月尺度。等级划分标准参见表 4.3。

表 4.3: SPI 指数干旱等级划分表

旱情等级	正常阶段	预警阶段	轻度干旱	中度干旱	严重干旱	特大干旱
SPI	0≤SPI	0≤SPI＜-0.5	-1＜SPI≤-0.5	-1.5＜SPI≤-1	-2＜SPI≤-1.5	SPI≤-2

4. 作物缺水率

作物缺水率是指某一时段内农作物实际需水量与可用或实际提供的灌溉水量之差占同期农作物实际需水量的比值。计算公式如下：

$$D_w=\frac{W_r-W}{W_r}\times 100\%$$ 式 4-11

式中 D_w—作物缺水率（％）；W_r—计算期内作物实际需水量（m^3）；W—同期可用或实际提供的灌溉水量（m^3）。

在用作物缺水率评估农业旱情时，可用或实际提供的灌溉水量可以是河道、蓄水工程、地下水等能供给的水量之和，也可以是单一形式的供水量，不同作物实际需水量可采用作物系数法和彭曼公式计算，也可查阅《中国主要农作物需水量等值线图》确定。等级划分标准参见表 4.4。

表 4.4: 作物缺水率干旱等级划分表

旱情等级	轻度干旱	中度干旱	严重干旱	特大干旱
D_w	5＜Dw≤20	20＜Dw≤35	35＜Dw≤50	Dw>50

5. 连续无雨日数

连续无雨日数是指连续无有效降雨的天数。考虑到不同季节气候以及作物需水量的差异性，一般在春季（3～5 月份）和秋季（9～11 月份），日雨量小于 3 毫米的降雨视为无有效降雨，该日即视为无雨日；夏季（6～8 月份），日雨量小于 5 毫米的降雨视为无有效降雨，该日即视为无雨日。在一些偏远的雨养农业区，农业靠天吃饭，墒情监测基础往往非常薄弱，甚至连雨量站也没有，此时可以考虑用连续无雨日数来大概评判。等级划分标准参见表 4-5。

表 4.5: 连续无雨日数干旱等级划分表

评估时段	轻度干旱	中度干旱	严重干旱	特大干旱
春季(3～5 月)	15～30	31～50	51～75	＞75
夏季(6～8 月)	10～20	21～35	36～50	＞50
秋季(9～11 月)	15～30	31～50	51～75	＞75
冬季(12～2 月)	20～30	31～60	61～90	＞90

6. 水库蓄水距平

水库蓄水距平指数是通过水库蓄水距平百分率来反映区域干旱情况。水库蓄水距平是指计算期内水库蓄水量（水位）与多年同期平均需水量（水位）的差值；水库蓄水距平百分率是指水库蓄水距平值与多年同期平均值的百分比值。计算公式如下：

$$D_L = \frac{L - \bar{L}}{\bar{L}} \times 100\% \qquad \text{式 4-12}$$

其中：D_L —计算期内水库蓄水距平百分比（%）；

L — 计算期内水库蓄水量（m^3）/水位（m）；

$\bar{L}$ — 计算期内多年同期平均水库蓄水量（m^3）/水位（m），采用近 30 年的平均值。

该指数能够反映区域的水资源情况，与气象指标结合，能够更好的预测旱情的发展趋势，一般采用月尺度进行计算。等级划分标准参见表 4-6。

表 4.6: 水库蓄水距平指数干旱等级划分表

旱情等级	正常阶段	预警阶段	轻度干旱	中度干旱	严重干旱	特大干旱
水库蓄水距平（%）	0≤D_L	-10≤D_L＜0	-30≤D_L＜-10	-50≤D_L＜-30	-80≤D_L＜-50	D_L＜-80

4.2.1.2 区域农业旱情评估

区域农业旱情评估主要是对县级和县级以上行政区域农业总体受旱状况进行评估。区域农业旱情评估采用区域农业旱情指数法，计算公式如下：

$$I_a = \sum_{i=1}^{4} A_i \times B_i \qquad \text{式 4-14}$$

式中：I_a—区域农业旱情指数（指数区间为 0~4）；

i—点上农业旱情等级（i=1、2、3、4 依次代表轻度、中度、严重和特大干旱）；

A_i—评价区域内 i 级点上农业旱情对应的农作物面积之和与耕地总面积的比值（%）；

B_i—不同旱情等级的权重系数（轻度、中度、严重和特大干旱的权重系数 B_i 分别赋值为 1、2、3、4）。

区域农业旱情指数是一个复合指数，理论上可以选择任意指标进行组合计算，但是通常情况下，需要考虑指标的物理意义，比如，降水量距平指数和标准化降水指数（SPI）都是由降水量数据计算得到的，因此，包含的信息具有一定的重复性，所以，在计算区域农业旱情指数时，尽可能避免同时选择这两个指标。再比如，连续无雨日数属于简单粗放的指标，相比较而言，没有土壤相对湿度、SPI 等指数能更准确地反映旱情，因此，在计算区域农业旱情指数时，如果有更准确的指标，则尽可能不选择准确性较差的指标，避免引入噪声。

鉴于此，本方案建议采用土壤相对湿度、标准化降水指数、作物缺水率、水库蓄水距平进行区域农业旱情指数的计算。如果该区域降水量数据不充分，没有长序列的逐日降水量数据，而只有是否降水的观测数据，则将标准化降水指数用连续无雨日数代替。如果该区域一直采用降水量距平指数进行旱情评估，或者该区域的技术力量不足，在计算标准化降水指数方面存在一定困难，则将标准化降水指数用降水量距平指数代替。如果该区域在土壤墒情监测或水库蓄水距平监测方面缺少数据，则去掉其中某项指标。等级划分标准参见表 4-7。

表 4.7: 区域农业旱情等级划分表

干旱等级	轻度干旱	中度干旱	严重干旱	特大干旱
I_a	0.1≤Ia＜0.5	0.5≤Ia＜0.9	0.9≤Ia＜1.5	1.5≤Ia≤4

4.2.2 因旱饮水困难评估

因旱饮水困难是指由于干旱造成城乡居民临时性的饮用水困难，不包括长期饮水困难。因旱饮水困难监测评估包括点上因旱饮水困难监测和区域因旱饮水困难监测。甘肃省旱灾影响导致的饮水困难问题向来比较突出。

4.2.2.1 点上因旱饮水困难评估

点上因旱饮水困难可根据取水地点的改变或人均基本生活用水量以及因旱饮水困难持续时间来评估。因旱饮水困难必须同时满足表 4-8 中条件一和条件二，其中条件一任意一项符合即可。

表 4.8: 因旱饮水困难判别条件

判别条件		判别标准
条件一	水平取水距离（km）	>1
	垂直取水高度（m）	>100
	基本生活用水量（L/人.天）	<20
条件二	因旱饮水困难持续时间（天）	>15

4.2.2.2 区域因旱饮水困难评估

通常，可采用因旱饮水困难人口的绝对数量或因旱饮水困难人口占总人口的比例两个指标，本方案中，对全省因旱饮水困难的评估采用因旱人饮困难比例的指标。计算公式为：

$$\mathrm{Pa} = \frac{\mathrm{O}}{\mathrm{P}} \times 100\% \qquad \text{式 4-15}$$

式中：O – 因旱饮水困难人口数量，即通过点上因旱饮水困难评估标准进行判断；

P – 该区域的总人口数量；

表 4.9: 因旱饮水困难干旱等级划分表

旱情等级	轻度干旱	中度干旱	严重干旱	特大干旱
P_a（%）	3.0≤Pa＜5.0	5.0≤Pa＜7.0	7.0≤Pa＜10.0	10.0≤Pa

4.2.3 城市旱情评估

城市旱情指标采用城市干旱缺水率。城市干旱缺水率是指城市日缺水量与城市正常日供水量的比值。计算公式为：

$$P_g = \frac{Q_z - Q_s}{Q_z} \times 100\% \qquad \text{式 4-16}$$

式中 P_g—城市干旱缺水率（%）

Q_z—城市正常日供水量（万立方米）

Q_s—城市实际日供水量（万立方米）

本方案中，城市旱情评估是逐个城市进行判断，对于区域城市旱情评估，通常采用受旱城市的数量比例作为评判标准，比如甘肃省城市旱情评估通常以三分之一数量的城市达到某一旱情等级作为全省城市干旱的标准。等级划分标准参见表 4-10。

表 4.10: 城市干旱缺水率干旱等级划分表

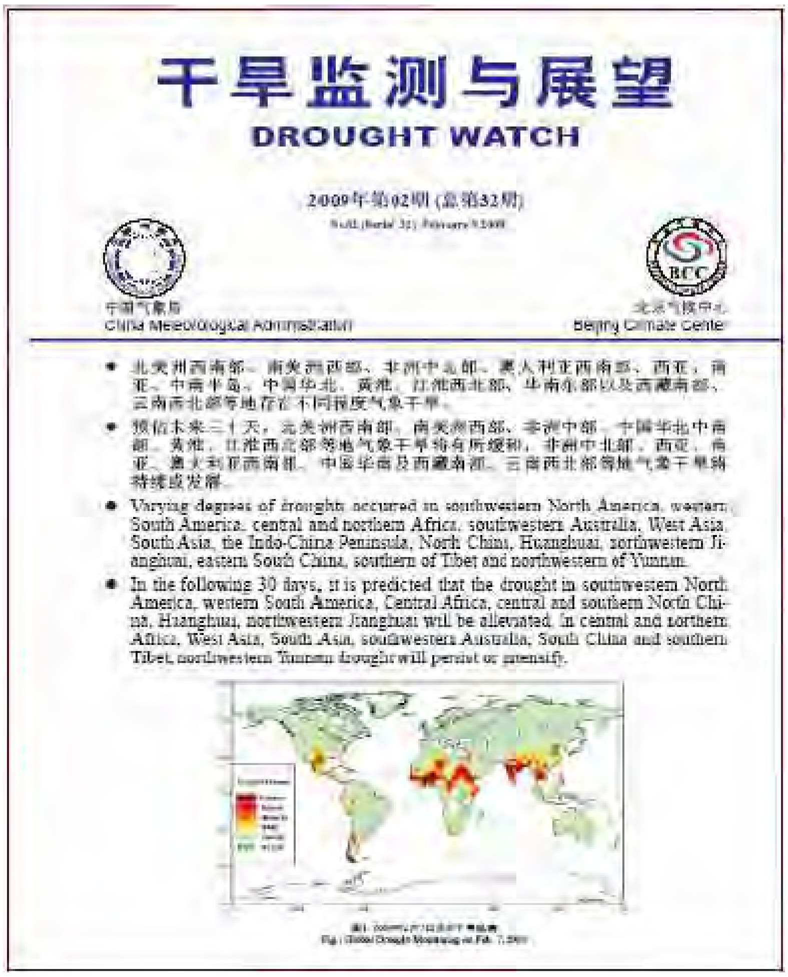
旱情等级	轻度干旱	中度干旱	严重干旱	特大干旱
P_g	5≤Pg＜10	10≤Pg＜20	20≤Pg＜30	30≤Pg

4.3 旱情预测方法

旱情预测既是干旱灾害风险管理的关键，也是难点。根据甘肃省的工作实际和现有的数据获取渠道，提出了基于气象预报的旱情预测方法。

气象预报旱情预测是通过国家气象中心发布的气象预报进行旱情预测。该气象预报每月发布未来 30 天的天气预报情况，包括干旱的发展趋势等，其预测是全球范围的，甘肃省可以关注局部地区。如下所示是中国气象局发布的干旱监测与展望。

图 4.1: 中国气象局干旱发布的《干旱监测与展望》月报


干旱监测与展望
DROUGHT WATCH

2009年第02期 (总第32期)

中国气象局
China Meteorological Administration

北京气候中心
Beijing Climate Center

- 北美洲西南部、南美洲西部、非洲中北部、澳大利亚西南部、西亚、南亚、中南半岛、中国华北、黄淮、江淮西北部、华南东部以及西藏南部、云南西北部等地存在不同程度气象干旱。
- 预估未来三十天，北美洲西南部、南美洲西部、非洲中部、中国华北中南部、黄淮、江淮西北部等地气象干旱将有所缓和；非洲中北部、西亚、南亚、澳大利亚西南部、中国华南及西藏南部、云南西北部等地气象干旱将持续或发展。
- Varying degrees of drought occurred in southwestern North America, western South America, central and northern Africa, southwestern Australia, West Asia, South Asia, the Indo-China Peninsula, North China, Huanghuai, northwestern Jianghuai, eastern South China, southern of Tibet and northwestern of Yunnan.
- In the following 30 days, it is predicted that the drought in southwestern North America, western South America, Central Africa, central and southern North China, Huanghuai, northwestern Jianghuai will be alleviated. In central and northern Africa, West Asia, South Asia, southwestern Australia, South China and southern Tibet, northwestern Yunnan drought will persist or intensify.

5 旱灾风险管理阶段划分和触发点

5.1 管理阶段划分和触发点

受认识所限，长期以来，灾害的危机管理模式在世界各国一直占据着主导地位。干旱危机管理模式是指当干旱发生后才开始作出反应，临时制定应急对策和措施，以期减轻干旱灾害损失和影响。在这种模式下，主要是针对眼前和局部的问题，采取的措施往往是临时性和应急性的，干旱管理也往往局限于实际旱情发生阶段。如此一来，常常是头痛医头、脚痛医脚，完全处于被动应急的局面，很容易陷入“从一个灾害走向下一个灾害”的恶性循环模式。但是，随着对干旱问题的认识的进一步深化，人们已经认识到要实现对干旱的有序、有效管理，应急状态的抗旱管理已无法满足要求，而要实现常态和应急状态的统合管理，即干旱风险管理。干旱风险管理模式是通过监测、分析、预测干旱的发生、发展规律，评估干旱可能造成的损失和影响，优化组合各类抗旱措施，有序、有效应对干旱灾害，并对干旱灾害进行后评价的全过程。在这种模式下，将高效的风险减免机制和理性的控制过程统合考虑，通过博弈应急管理和常态管理各自牺牲一部分利益，实现全局最优。与干旱危机管理相比，干旱风险管理是一种主动、有备、周密和有效的防旱减灾管理模式，干旱管理阶段不再局限于实际旱情发生阶段，而是贯穿于干旱发生发展的全过程，表现为应急管理常态化，常态管理应急化。

从干旱风险管理理念出发，基于对甘肃省历史旱情旱灾的分析，结合目前的干旱监测状况，将甘肃省干旱管理阶段划分为正常阶段、预警阶段、实际旱情发生阶段和旱情解除阶段，相应的判别指标及触发条件参见表 5-1。在正常阶段和预警阶段，推荐采用标准化降水指数（SPI）、河道径流距平指数和水库蓄水距平指数为判别指标。在实际旱情发生阶段，采用区域农业旱情指数、因旱饮水困难比例和城市干旱缺水率指标为判别指标。

表 5.1: 甘肃省干旱管理阶段

管理阶段			判别指标及触发点		可能的干旱影响
			指标	触发点	
旱前	正常阶段		标准化降水指数 SPI	SPI≥0	没有任何旱象
	预警阶段		标准化降水指数 SPI 水库蓄水量距平 D_L	-0.5≤SPI<0 -10%≤ D_L <0 以 SPI 指数为主，水库蓄水量距平为辅	尚未造成影响
旱中	实际旱情发生阶段	轻度干旱	区域农业旱情指数 Ia 因旱人饮困难人口 Pa 城市干旱缺水率 Pg	0.1≤Ia<0.5 3.0≤Pa<5.0 5%≤Pg<10% 有 1 个条件满足即可	农业用水出现短缺
		中度干旱	区域农业旱情指数 Ia 因旱人饮困难比例 Pa 城市干旱缺水率 Pg	0.5≤Ia<0.9 5.0≤Pa<7.0 10%≤Pg<15% 有 1 个条件满足即可	农业用水短缺加剧，部分偏远山区可能发生因旱人畜饮水困难
		严重干旱	区域农业旱情指数 Ia 因旱人饮困难比例 Pa 城市干旱缺水率 Pg	0.9≤Ia<1.5 7.0≤Pa<10.0 20%≤Pg<30%	农业用水短缺严重，偏远山区因旱人畜饮水困难加重，城市用水可能受到影响

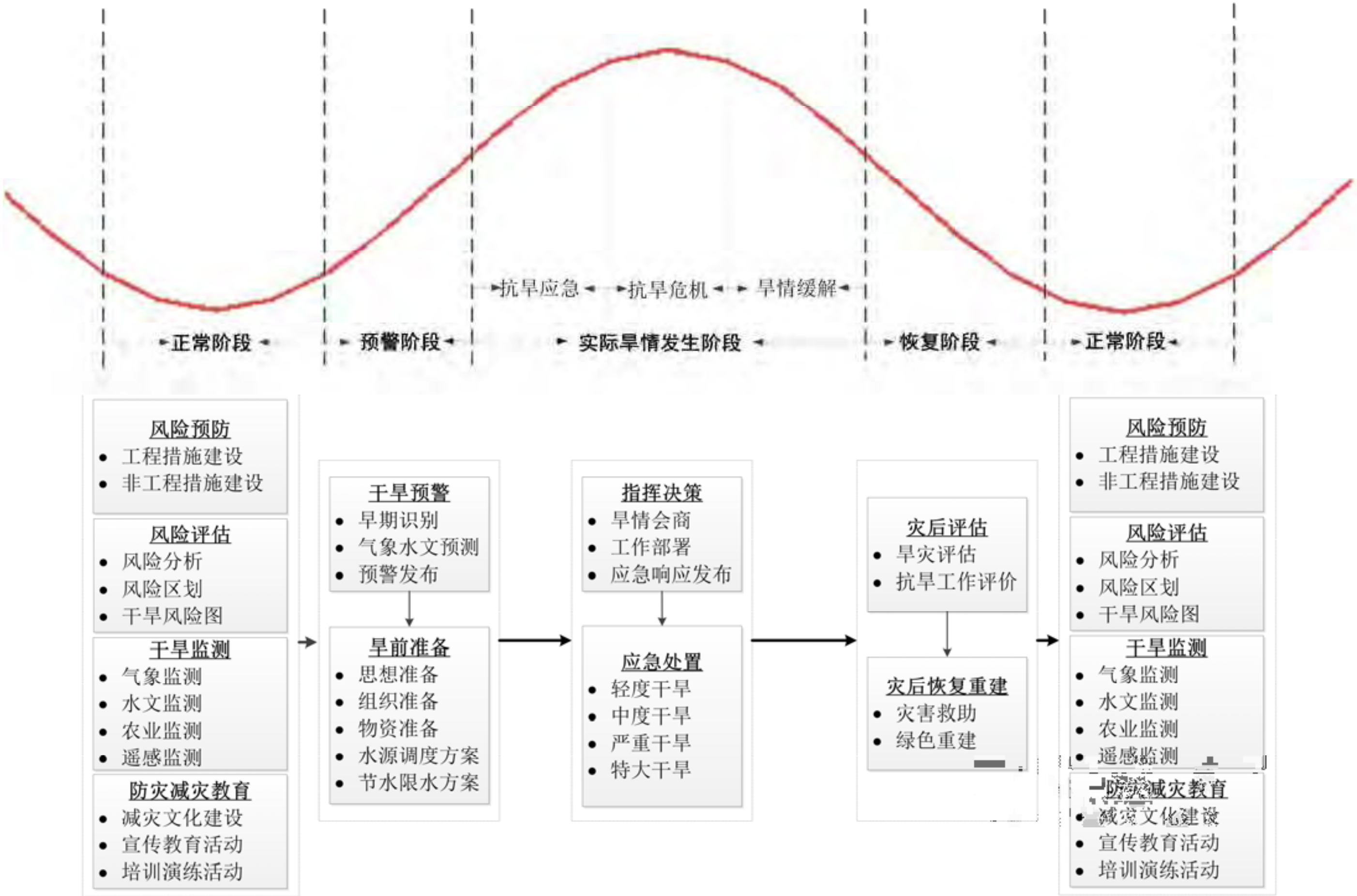
管理阶段		判别指标及触发点 指标	触发点	可能的干旱影响
			有 1 个条件满足即可	
	特大干旱	区域农业旱情指数 Ia 因旱人饮困难比例 Pa 城市干旱缺水率 Pg	1.5≤Ia≤4 10.0≤Pa 30%≤Pg 有 1 个条件满足即可	农业用水、农村人畜饮水、城市用水都受到较大影响
旱后	恢复阶段			直接影响解除

注：表中正常阶段、预警阶段的指标计算时段均采用月尺度；城市干旱缺水率是指全省有 1/3 的城市达到此标准。

这里，有两个问题需要特别指出。首先，由于对干旱问题缺乏深入的认识，我国目前大部分省份都将干旱预警和应急响应等同起来，而实际上，这是两个完全不同的概念。干旱预警是指在干旱发生之前，通过选择一组相应的干旱预警指标，对目标区域内的水文和气象因子变化以及来水和用水状况进行监视，对潜在的干旱进行早期识别，并及时将干旱预警信息通过各种途径发布给政府相关部门、各类社会机构和公众，以提早做好应对准备，达到最大限度地减轻干旱损失的目的。而应急响应是指在实际旱情发生之后，为减轻干旱损失而所采取的临时性、应急性行动。为此，在本计划中，将干旱预警和实际旱情发生之后的响应区分开来。其二，包括甘肃在内的我国大部分地区的现行抗旱预案中旱情等级标准存在不合理之处。各省的抗旱预案大都在 2009 年以前已经完成，基本都是依据 2006 年出台的《国家防汛抗旱应急预案》制定。限于当时的认识，且经实践证明，该国家预案中旱情等级标准存在两个主要的问题：一个是仅用受旱面积单一要素难以客观真实反映区域受旱情况，因为对于一次较大范围的干旱过程而言，不仅不同流域、省（自治区、直辖市）、地（市）、县（区）之间的受旱程度不同，就是同一区域内不同地块之间、不同作物之间的受旱程度也不尽相同，因此需要既考虑受旱面积又考虑受旱程度的区域旱情指标；二是全国不同级别行政区使用同一等级划分阈值是不合理的。鉴于此，我国于 2009 年颁布了第一个规范抗旱减灾工作的行业技术标准《旱情等级标准》，提供了一整套关于农业、牧业、因旱人饮困难、城市旱情评估的方法，以期实现全国各级行政区旱情评估的统一规范、简便易行、快速高效。为此，在本计划中，将依据《旱情等级标准》确定甘肃省旱情评估方法及标准。

当处于不同的干旱管理阶段时，干旱管理行动措施的重点也是不同的，参见图 5-1。如在正常阶段，重点是进行干旱风险预防、风险评估、干旱监测以及防灾减灾教育等，而在预警阶段，则重点是进行潜在干旱早期识别、预警发布以及旱前准备等。

图 5.1: 甘肃省各阶段主要干旱管理行动



5.2 正常阶段的干旱管理

干旱管理，从本质上说是对干旱时期缺水问题的管理。但是，这并不意味着干旱管理只在干旱时期才进行，相反，要真正做到有序、有效应对干旱，功夫还须下在平时。换言之，正常阶段的干旱管理是整个干旱管理的奠基石。长期以来，我国干旱管理的关注点主要还是集中在实际旱情发生阶段的应急处置，而忽视了正常阶段的干旱管理。正常阶段的干旱管理之所以如此重要，主要有两方面的原因：一是从干旱风险管理的本质来看，它不是被动地应对干旱风险，而是积极地预防干旱风险。因此，旱期应对和旱后恢复只是风险管理的一部分，而旱前预防才是风险管理的根本所在。二是从干旱成灾机理来看，不同于洪水几天、几小时甚至几分钟就可能成灾，干旱成灾过程较为缓慢，可能是数月、数个季节甚至数年。因此，干旱管理应该向常态化管理发展，重视正常阶段的干旱管理。总的来说，正常阶段的干旱管理应着眼于长远，同时兼顾日常管理，主要包括以下几个方面：

风险预防

工程措施建设

目前，甘肃省已基本形成以蓄水工程、引水工程、提水工程、调水工程和水井工程等为主的防旱抗旱减灾工程体系。但总的来说，水资源配置格局尚不完善，工程抗旱功能挖潜不足，抗旱供水能力远远不能满足需求，导致一些地区农业抗灾能力低、部分城乡供水安全隐患较多等。因此，为了提高干旱期间的抗旱供水能力，需要长远计划，大力加强水利基础设施的建设。

- 加大病险水库除险加固力度。
- 加强农田水利工程建设，加快灌区续建配套和节水改造，不断提高蓄供水能力和水资源利用效率。
- 在干旱缺水地区，做好与群众生产生活息息相关的场、窖等小微型抗旱设施建设。
- 加强山区水土保持，实施小流域综合治理，提高水源涵养能力。以小流域为单元，生物措施和工程措施结合，对 25 度以上坡耕地退耕还林，对 25 度以下坡耕地进行梯田建设，山、水、田、林、路综合治理。
- 在充分拓展和挖掘现有水利设施抗旱功能的基础上，以保障干旱期间人畜饮水安全为首要目标，按照先挖潜、后配套，先改建、后新建的原则，因地制宜建设一批规模合理、标准适度的抗旱应急备用水源工程。

非工程措施建设

相比于工程体系来说，我国非工程体系建设一直没有得到足够的重视，滞后较多。近年来，甘肃省抗旱主管部门也逐渐认识到非工程措施对于防旱、抗旱的重要性，并取得了一定的进展，自上而下的抗旱组织体系已经形成，逐步开展了政策法规制定、抗旱预案及规划编制、抗旱信息化建设等非工程体系建设。

- 进一步充实各级抗旱组织机构职能。在旱情紧急时期，各级抗旱组织机构可以高效有序地指挥和协调相关部门联动响应，但是鉴于干旱灾害具有缓慢发展的特性，这种旱情紧急期的部门联动不能满足经济社会对抗旱工作的要求。因此，除应急抗旱职能外，各级抗旱组织机构还需要强化常规抗旱职能，自上而

下突破体制障碍，完善内部组织结构，让各成员单位更多地参与日常抗旱工作，建立多部门的统一协作机制，充分发挥其日常干旱管理的组织和协调作用。

- 加强法规、制度和技术标准体系建设。甘肃省还没有专门的抗旱方面政策法规，要结合实际，加快建设地方性抗旱法规，如《甘肃省抗旱条例》等。加强《旱情等级标准》（SL424-2008）、《抗旱预案编制导则》（SL590-2013）、《干旱灾害等级标准》（SL663-2014）、《抗旱规划编制导则》等技术标准的宣贯和培训。
- 修改完善抗旱预案、抗旱规划的编制。目前，全省大部分县市已经完成抗旱预案的编制，但普遍存在将干旱预警与应急响应混为一谈等基本概念不清、抗旱应急响应触发条件科学性不够、响应行动可操作性不强等问题。
- 进行农业产业结构调整。鼓励发展设施农业、特色农业，推进节水节能的日光温室大棚和畜牧小区，建立高效节水型农业生产结构，提高农业抗灾减灾能力。
- 加强抗旱物资储备和管理。在易旱地区建设规模合理、标准适度的抗旱物资库，同时建立相应的抗旱物资管理办法等。

风险评估

- 以县为单元，全面收集整理历史干旱数据，并进行系统入库。
- 组织相关科研力量，运用基于灾害系统理论的模糊综合评估方法、基于随机理论的概率统计方法、基于干旱频率及潜在损失的旱灾风险评估方法等研究进展开展甘肃全省干旱风险分析。
- 根据干旱风险分析结果，完成全省干旱风险区划。
- 绘制完成干旱风险图，并定期更新。

干旱监测

- 统一规划，形成覆盖全省、布局合理、信息完备、资源共享的旱情监测站网，包括气象监测、水文监测、土壤墒情监测、水质监测、遥感监测等。
- 加强气象监测，包括降水、蒸发、气温等信息。
- 加强水文监测，包括河流、湖泊、水库的水位、流量、蓄水量等地表水信息和地下水水位等地下水信息。
- 加强土壤墒情监测，分为固定站、移动站和试验站三类监测站。
- 加强水质监测，涉及引水调水控制断面、重要江河、湖泊、区界水体、重要供水水源地的水质监测。
- 加强遥感监测。
- 建立供用水情况监测。
- 建立部门间信息共享机制，形成干旱监测数据信息共享网络。

防灾减灾信息公开及教育

- 加强抗旱减灾文化建设。将抗旱减灾文化建设作为加强社会主义文化建设的重要内容，将抗旱减灾文化服务作为国家公共文化服务体系的重要组成部分，把抗旱减灾纳入国民教育体系，加强中小学校抗旱减灾知识教育。

- 开展抗旱减灾宣传教育活动。结合全国"防灾减灾日"、"国际减灾日"、"世界水日"、"中国水周"等，组织开展多种形式的抗旱减灾宣传教育活动，营造全社会共同参与防灾减灾的文化氛围。开发抗旱减灾系列科普读物、挂图和音像制品等，宣传相关的法律法规、日常节水技巧以及避灾减灾措施等，增强整个社会对干旱的适应能力、提高人们灾害自救能力。
- 组织相关人员进行抗旱应急培训演练。根据发生过的干旱，检验准备工作是否就绪，制定的行动是否存在问题。

5.3 干旱预警阶段的干旱管理

干旱预警阶段的干旱管理，是在干旱发生之前，通过选择一组相应的干旱预警指标，对目标区域内的水文和气象因子变化以及来水和用水状况进行监视，对潜在的干旱进行早期识别，并及时将干旱预警信息通过各种途径发布给政府相关部门、各类社会机构和公众，以提早做好应对准备的过程。简而言之，干旱预警是对可能发生的干旱进行预先的判断，并将准确及时的预警信息传递给相关的机构和人员，以期能作出及时的响应。因此，重视干旱预警的作用，切实提升干旱预警的能力和水平，是降服"旱魔"的重要法宝。

干旱预警

- 早期识别。基于气象、水文、农业等干旱监测数据，进行干旱预警指标值滚动计算，判断是否达到干旱预警触发条件。
- 气象水文预测。基于省气象局短期气候预测以及省水文局水文预测结果，预测并研判未来一段时间内可能的干旱发展趋势。
- 发布预警。如果气象水文预测情况表明未来干旱呈发展趋势，则及时向可能发生干旱的区域发布预警信息，向社会通报旱情，动员全社会做好抗旱准备工作。干旱预警发布单位为当地防汛抗旱指挥机构，特殊情况下由地方人民政府发布。可采用公文、广播、电视、报刊、网络、短信等方式进行干旱预警发布。

旱前准备

- 思想准备。加强宣传，增强全民预防干旱和自我保护的意识，做好抗旱思想准备。
- 组织准备。健全抗旱组织指挥机构，落实抗旱责任制、责任人，加强抗旱服务组织建设。各级防汛抗旱指挥机构应当加强抗旱服务网络建设，鼓励和支持社会力量参与抗旱服务组织建设。
- 抗旱检查。实行以组织、工程、预案、物资、监测为主要内容的分级检查制度，发现薄弱环节要明确责任，限时整改。重点检查组织领导、责任制、水源工程、抗旱措施等是否到位。
- 物资准备。按照分级负责的原则，合理储备必须的抗旱物资。
- 抗旱水源调度初步方案制定。受旱地区要按照"先生活、后生产，先地表、后地下，先节水、后调水"的原则，进行抗旱水源的调度。抓住有利的气候条件，加大人工增雨力度。
- 限水初步方案制定。农业生产推广节水灌溉技术和耕作技术，制定限水方案；制定城乡生活及工业节水、限水方案，限制缺水地区发展高耗水、高污染项目，着力发展节水型工业和服务业。

5.4 实际旱情发生阶段的干旱管理

根据旱情评估方法、步骤，进行区域旱情评估。根据旱情的严重程度不同，划分为轻度干旱、中度干旱、严重干旱和特大干旱四个等级。不同旱情等级的干旱管理重点和主要管理行动也是不同的

轻度干旱

- 召开会商会议。由省抗旱防汛指挥部办公室组织召开会商会议，分析旱情发展动态，视情况启动Ⅳ级响应。
- 加强旱情监测和预报工作。水文、气象、农业等部门密切配合，及时掌握旱情变化趋势，为抗旱主管部门指挥决策提供依据。同时，通过网络、信息、媒体等渠道，及时向旱区农民提供准确的雨情、水情等旱情信息。
- 保障抗旱经费。省筹救灾资金主要依靠从中央支持、省级财政和信贷解决。其中申请中央特大抗旱补助费 2000～5000 万元、省财政专项安排 500 万元。信贷资金重点以小额贷款方式向农户提供生产自救，最大限度满足受灾农户购买籽种、化肥等生产资料和发展家庭经济的需求。救灾专项资金由省抗旱防汛指挥部统一管理，财政和审计部门负责资金跟踪，保证资金及时足额到位和专款专用。
- 加强对农业生产的指导。通过媒体或农业技术下乡等方式，向农民介绍耐旱作物信息，各种农产品的市场供求状况和价格信息，耐旱耕作技术等，使农民根据自身的生产条件做出应对干旱的具体办法选择。
- 做好旱区计划用水。在确保农村人畜饮水的前提下，积极组织抗旱水源及临时设施抢灌受旱农田。
- 做好节水宣传工作。鼓励用水户主动节水，减少或停止没必要的用水。
- 持续关注干旱变化情况，为可能出现的中度干旱做好准备。

中度干旱

当发生中度干旱时，雨养农业出现严重缺水，灌溉农业出现缺水，少量偏远山区可能出现农村人蓄饮水困难。当旱情评估结果显示为中度干旱时，触发中度干旱响应行动。

- 召开会商会议。由省抗旱防汛指挥部办公室组织召开会商会议，分析旱情发展动态，视情况启动III级响应，同时报省政府备案。
- 加强旱情监测和预报工作。水文、气象、农业等部门密切配合，及时掌握旱情变化趋势，为抗旱主管部门指挥决策提供依据。同时，通过网络、信息、媒体等渠道，及时向旱区农民提供准确的雨情、水情等旱情信息。
- 保障抗旱经费。省筹救灾资金主要依靠中央支持、省级财政和信贷解决。其中申请中央特大抗旱补助费 5000 万元～1 亿元、省财政专项安排 500～1000 万元。信贷资金重点以小额贷款方式向农户提供生产自救，最大限度满足受灾农户购买籽种、化肥等生产资料和发展家庭经济的需求。救灾专项资金由省抗旱防汛指挥部统一管理，财政和审计部门负责资金跟踪，保证资金及时足额到位和专款专用。
- 保障抗旱物资。抗旱救灾的急需物资主要靠主管部门调拨和市场解决。省发改委、商业、供销、物价、铁路、交通等部门应互相配合，保证化肥、农药、柴汽油、农用膜、粮食、籽种和生活必须品等大宗生产、生活资料的调运和市场供应，必要时开通绿色通道并实施价格干预。

- 加强抗旱水源的统一调度和管理。确保居民生活用水，干旱严重地区，启动农村自备水源，保证农村人畜饮水。适当压缩农业供水，适当限制洗车、洗浴等高耗水服务行业用水。适时实施人工增雨作业。
- 加强农业水利技术指导。通过媒体或技术下乡等方式，指导旱区农民开展缺水灌溉、节水灌溉，减少农业用水。
- 适时开展抗旱浇灌。发动抗旱泵站、机井、小口井、各类抗旱流动机械，适时开展旱区抗旱浇灌。渠道淤积严重地区，要发动劳力及时清淤疏浚，保证输水畅通。
- 持续关注干旱变化情况，对可能出现的严重干旱做好准备。

严重干旱

发生严重干旱，农业用水短缺严重，偏远山区因旱人畜饮水困难进一步加重，城市用水可能受到影响。当旱情评估结果显示为严重干旱时，触发严重干旱响应行动。此时抗旱重点是保障城镇生活用水和农村人畜饮用水、重点工业企业生产用水、种子生产用水、高效经济作物用水等。

- 召开会商会议。由省抗旱防汛指挥部组织召开会商会议，分析旱情发展动态，提出响应级别建议，经省政府批准后，启动Ⅱ级响应，部署抗旱工作。
- 加强旱情监测和预报工作。水文、气象、农业等部门密切配合，及时掌握旱情变化趋势，为抗旱主管部门指挥决策提供依据。同时，省抗旱防汛指挥部定期发布旱情通报，并通过网络、信息、媒体等渠道，及时向旱区农民提供准确的雨情、水情等旱情信息。
- 加强抗旱指导工作。向灾区市（州）派遣由厅级领导干部带队的省政府抗旱救灾工作队，主要任务是深入抗旱救灾第一线，掌握抗旱救灾的第一手资料，协助各地政府搞好应急抗旱工作，帮助解决实际问题。
- 保障抗旱经费。救灾资金主要从中央支持、省级财政、信贷、省长预备金和社会公募 5 个渠道争取和筹措。其中申请中央特大抗旱补助费 1～2 亿元、省财政专项安排 1000～3000 万元。信贷资金重点以小额贷款方式向农户提供生产自救资金，最大限度满足受灾农户购买籽种、化肥等生产资料和发展家庭经济的需求。社会捐助资金在省民政厅设专户接收，并通过新闻媒体向社会公布。省筹救灾资金由省抗旱防汛总指挥部统一管理，财政和审计部门负责资金跟踪，保证资金及时足额到位和专款专用。
- 保障抗旱物资。抗旱救灾的急需物资主要靠主管部门调拨和市场解决。省发改委、商业、供销、物价、铁路、交通等部门应互相配合，开放绿色通道保证化肥、农药、柴汽油、农用膜、粮食、籽种和生活必须品等大宗生产、生活资料的调运和市场供应，同时对灾区实施价格干预，维护市场正常秩序。对趁机控制市场、欺行霸市的不法行为，要依法严厉治裁。
- 加强农业抗旱指导。省农村经济委员会负责农业抗旱指导，指导农民做好农作物的田间管理和病虫害防治，负责农业生产自救、恢复等工作。
- 启动抗旱水量调度方案。内陆河各流域以流域机构为依托，和流域内各市政府共同组成流域应急水资源调度领导小组。黄河流域和长江流域灾区，由市、州政府和辖区各县共同组成市、州应急水资源调度领导小组。应急水资源调度领导小组的主要任务是根据应急响应期间的水情制定水资源应急调度方案，统一调度区内水资源（包括河流来水、库塘蓄水、地下水、外调水、企业自备水源以及其他备用水源）并监督应急调度方案的实施，调配各类临时抗旱设备，启用临时性措施，如临时设置抽水泵站、开挖输水渠道、应急性打井、挖泉、建蓄水池等，最大限度保障应急响应期间上下游用水、生产生活用水、工农业用水以及各市、县用水的和谐有序。各流域和市州政府制定的应急水资源调度方案，须上报省政府抗旱救灾总指挥部批准后执行。

- 根据更严重的缺水情况，制定并实施用水量紧急限制方案。在确保居民生活用水的前提下，根据对国民经济发展的影响程度及干旱期供水紧缺状况，确定用水优先次序，限定供水量。优先保证限额条件下城乡居民的生活供水，在节约用水原则下，保证消防、医院、发电以及重点工矿企业的生产用水。城镇人口按人均 30 升/日配置，农村人口按人均 15 升/日配置，必要时采取定时供水，分区（村）供水。农业灌溉面积严重限制在基本农田范围内，灌水定额限定为冬灌 80 立方米/亩、春灌 60 立方米/亩、苗期灌溉 45 立方米/亩。必要时可以对服务型高耗水经营体实施关停。各机关、企事业单位都必须做出阶段性节约用水计划，自觉接受限额供水和水资源调度的应急措施。人畜饮水严重困难的地区，组织省、市机关、事业单位、大中型厂矿企业以及地方驻军出车出人出油临时人工送水。
- 加强社会宣传和动员。组织、协调新闻媒体向社会公众及时报道旱情、灾情，宣传抗旱工作，动员社会各方面力量支援抗旱救灾工作。
- 持续关注干旱变化情况，对可能出现的特大干旱做好准备。

特大干旱

发生特大干旱，将出现社会经济严重缺水，农业干旱持续加重，工业用水受限加剧，部分城市发生居民生活用水困难。当旱情评估结果显示为特大干旱时，触发特大干旱响应行动。此时，抗旱重点是保障城镇生活用水和农村人畜饮用水。

- 召开会商会议。由省抗旱防汛指挥部组织召开会商会议，分析旱情发展动态，提出响应级别建议，经省政府批准后，启动Ⅰ级响应。
- 加强旱情、灾情监测。省抗旱防汛指挥部做好旱情预测、预报，做好旱情、灾情及抗旱工作情况的统计和报送，及时发布旱情。省气象局加强天气监测和预报，及时向省抗旱防汛指挥部提供相关的气象信息、土壤墒情和卫星遥感监测信息，适时组织人工增雨作业。
- 加强抗旱救灾指导工作。成立全省执行Ⅰ级响应的领导、议事和协调机构——省抗旱救灾总指挥部，负责审定全省Ⅰ级应急预案，协调有关市州、省级各部门提供全方位的应急保障，制定和组织实施有关救助方案，组织新闻发布，及时向国务院报告应急响应执行情况等。由省长任总指挥，分管副长、省军区、武警甘肃总队主要负责人任副总指挥，省抗旱防汛指挥部成员单位主要负责同志为总指挥部成员。总指挥部办公室设在省政府，由省政府秘书长任办公室主任。
- 保障抗旱经费。救灾资金主要从中央支持、省级财政、信贷、省长预备金和社会公募 5 个渠道争取和筹措。其中申请中央特大抗旱补助费 2～5 亿元、省财政专项安排 3000～5000 万元。信贷资金重点以小额贷款方式向农户提供生产自救资金，最大限度满足受灾农户购买籽种、化肥等生产资料和发展家庭经济的需求。社会捐助资金在省民政厅设专户接收，并通过新闻媒体向社会公布。省筹救灾资金由省抗旱救灾总指挥部统一管理，财政和审计部门负责资金跟踪，保证资金及时，足额到位和专款专用。
- 保障抗旱物资。由省经济委员会协调抗旱物资的生产和调度，省交通厅优先运送抗旱物资，为抗旱物资提供运输保障。抗旱救灾的急需物资主要靠主管部门调拨和市场解决。省发改委、商业、供销、物价、铁路、交通等部门应互相配合，开放绿色通道保证化肥、农药、柴汽油、农用膜、粮食、籽种和生活必须品等大宗生产、生活资料的调运和市场供应，同时对灾区实施价格干预，维护市场正常秩序。对趁机控制市场、欺行霸市的不法行为，要依法严厉治裁。
- 启动抗旱水量调度方案。内陆河各流域以流域机构为依托，和流域内各市政府共同组成流域应急水资源调度领导小组。黄河流域和长江流域灾区，由市、州政府和辖区各县共同组成市、州应急水资源调度领

导小组。应急水资源调度领导小组的主要任务是根据应急响应期间的水情制定水资源应急调度方案，统一调度区内水资源（包括河流来水、库塘蓄水、地下水、外调水、企业自备水源以及其他备用水源）并监督应急调度方案的实施，调配各类临时抗旱设备，启用临时性措施，如临时设置抽水泵站、开挖输水渠道、应急性打井、挖泉、建蓄水池等，最大限度保障应急响应期间上下游用水、生产生活用水、工农业用水以及各市、县用水的和谐有序。各流域和市州政府制定的应急水资源调度方案，须上报省政府抗旱救灾总指挥部批准后执行。当黄河流域发生特大旱灾时，由省政府向国务院和水利部申请启动针对甘肃省特大旱灾的"黄河水量应急调度预案"，增加甘肃的黄河水量分配指标。

- 根据更严重的缺水情况，制定并实施用水量紧急限制方案。在确保居民生活用水的前提下，根据对国民经济发展的影响程度及干旱期供水紧缺状况，确定用水优先次序，限定供水量。优先保证限额条件下城乡居民的生活供水，在节约用水原则下，保证消防、医院、发电以及重点工矿企业的生产用水。城镇人口按人均 30 升/日配置，农村人口按人均 15 升/日配置，必要时采取定时供水，分区（村）供水。农业灌溉面积严重限制在基本农田范围内，灌水定额限定为冬灌 80 立方米/亩、春灌 60 立方米/亩、苗期灌溉 45 立方米/亩。必要时可以对服务型高耗水经营体实施关停。各机关、企事业单位都必须做出阶段性节约用水计划，自觉接受限额供水和水资源调度的应急措施。人畜饮水严重困难的地区，组织省、市机关、事业单位、大中型厂矿企业以及地方驻军出车出人出油临时人工送水。
- 加强农业抗旱指导。省农村经济委员会负责农业抗旱指导，指导农民做好农作物的田间管理和病虫害防治，负责农业生产自救、恢复等工作。
- 宣传动员。各级防汛抗旱指挥部根据国家有关规定，统一发布旱情、灾情及抗旱信息，组织、协调新闻媒体向社会公众及时报道旱情、灾情，宣传抗旱工作，动员社会各方面力量支援抗旱救灾工作。

5.5 恢复阶段的干旱管理

当全省旱情解除之后，进入恢复阶段的干旱管理。

灾后评估

- 干旱灾害等级评估。省防汛抗旱指挥部办公室根据各市上报情况及评估组的评估结果组织灾情核查组，深入灾区进行调查核实，最后将核查结果与省救灾应急指挥部办公室（设在省民政厅）协调一致后上报省政府及国家防汛抗旱总指挥部。同时，根据《干旱灾害等级标准》（SL663-2014）确定全省干旱灾害等级。
- 抗旱工作评价。进行抗旱工作效果评价，并总结实际抗旱工作中取得的经验和存在的问题。

灾后恢复重建

- 灾民救助。灾情核实后，各级防汛抗旱指挥部对受灾地区救助对象进行登记，实施救助。
- 恢复灾后生产。各级人民政府、有关主管部门帮助受灾群众尽快恢复生产，做好灾后自救。
- 水利工程修复。水行政主管部门应当对水利工程进行检查评估，并及时组织修复遭受干旱灾害损坏的水利工程，或优先列入年度修复建设计划。受旱灾损毁的水利工程一般包括农业灌溉渠系、小型水库坝体、塘坝、扬水泵站设施、输水管线、机电井等。

- 物资、设备等归还。有关地方人民政府防汛抗旱指挥机构应当及时归还紧急抗旱期征用的物资、设备、交通运输工具等，并按照有关法律规定给予补偿。

Annex 5 – Sichuan Drought Management Plan

目录

图

表

1 简介

1.1 计划目的和目标

长期以来，灾害的危机管理模式在世界各国一直占据着主导地位。干旱危机管理模式是指当干旱发生后才开始作出反应，临时制定应急对策和措施，以期减轻干旱灾害损失和影响。在这种模式下，主要是针对眼前和局部的问题，采取的措施往往是临时性和应急性的，干旱管理也往往局限于实际旱情发生阶段。如此一来，常常是头痛医头、脚痛医脚，完全处于被动应急的局面，很容易陷入“从一个灾害走向下一个灾害”的恶性循环模式。

随着对干旱问题的认识的进一步深化，人们已经认识到要实现对干旱的有序、有效管理，应急状态的抗旱管理已无法满足要求，而要实现常态和应急状态的统合管理，即旱灾风险管理。

旱灾风险管理模式包括几个阶段：

- 监测、分析、预测干旱的发生、发展规律；
- 评估干旱可能造成的损失和影响，优化组合各类抗旱措施，有序、有效应对干旱灾害
- 旱灾后评估

在这种模式下，将高效的风险减免机制和理性的控制过程统合考虑，通过博弈应急管理和常态管理各自牺牲一部分利益，实现全局最优。与干旱危机管理相比，旱灾风险管理是一种主动、有备、周密和有效的防旱减灾管理模式，干旱管理阶段不再局限于实际旱情发生阶段，而是贯穿于干旱发生发展的全过程，表现为应急管理常态化，常态管理应急化。因此，本计划的总体目标是推进四川省干旱管理由危机管理向风险管理转变的进程。

具体地说，本计划目标可分解如下：

- 努力将整个干旱管理建立在科学、全面的风险分析的基础之上，清晰掌握全省旱灾风险及其危险性、暴露性、脆弱性等风险构成要素的分布格局及严重程度；
- 努力将干旱管理建立在一个职责明确、协作一致的组织管理架构之上，提高干旱管理各级、各部门之间的合作与协调；
- 努力将干旱管理建立在兼具科学性和可操作性的旱情监测、评估和预测平台之上，提高对旱灾风险的有效监测、预警能力。
- 努力建立涵盖干旱发生发展全过程的管理模式，明确旱灾风险管理各阶段的触发条件、管理措施，实现干旱管理主动、有序和预防。

1.2 计划原则

本计划制定过程中，需要把握以下一些原则：

- 高层的参与、健全的体制、明确的职责和有效的管理都是至关重要的。
- 从事防灾、减灾、抗灾、救灾等不同工作的各有关部门之间需要加强沟通、交流和协调。
- 干旱监测和预警系统在风险识别、评估和管理中至关重要。
- 防灾、减灾和备灾是减轻旱灾风险的核心组成部分，不可仅仅依赖于应急措施，减灾备灾措施的制定和有效实施需要自上而下和自下而上相结合的方法。。
- 提高机构、社区和个人等不同层面的抗旱能力对降低旱灾脆弱性必不可少。
- 减轻旱灾风险需要有长期的资源保障，包括人力、资金、技术、设备等多方面。

- 减轻旱灾风险需综合考虑多种措施，如环境和自然资源综合管理、社会经济发展协调、土地利用规划以及适应气候变化等；
- 应特别注意社会经济中的高风险因素，例如年龄差异、残疾现象、社会不平等和性别问题等。要重点保护那些最脆弱群体，降低灾害影响。
- 为提高风险意识，教育和培训对所有人都是十分必要的。

1.3 干旱风险管理的组成部分

干旱不应当仅仅被视为一种物理现象或自然事件。这一自然事件（降水量较正常气候条件下偏少）和人类用水需求的交互作用导致了干旱对人类社会的影响。人类往往会加剧干旱的影响。包括发展中国家和发达国家在内，近几次干旱所造成的经济、环境影响和给人们生活带来的不便都在昭示着人类社会在面对这一“自然”灾害时所表现出的脆弱性。

脆弱性分析指出了造成干旱影响的社会、经济和环境因素。它着眼于导致脆弱性的原因而非结果和造成的负面影响。例如，降水偏少可能会导致作物减产。但导致这种影响的根本原因，可能是农民没有采用耐寒作物，因为农民不相信这么做会有所帮助、种子成本太高、或者由于其他文化和社会原因。

虽然干旱是一种自然灾害，但人类社会可以降低自身的脆弱性，进而减少同干旱事件有关的风险。干旱的影响，同其他自然灾害一样，可以通过采取减缓措施和预防（风险管理）的方式来加以控制。提前做工作减缓旱情为决策者提供了以最低的代价最大程度的缓解困难的机会。对旱情的“危机模式”做出响应，降低了对自身努力的要求，增加了对政府和救助机构的依赖。

新的干旱管理模式将风险作为主要因素，描述如下：

风险 = 危害性（自然事件）X 暴露性 X 脆弱性（社会因素）

其中危害性包括的因素有：

- 严重程度或等级——强度和历时
- 频率——概率
- 空间范围
- 发展趋势——历史情况，未来预测，影响

暴露性显示了干旱发生的可能性以及受影响的人口和资源情况。有时也将暴露性合并为危害性的一个因素。脆弱性则要求绘制干旱风险图，并对脆弱性进行评估。干旱风险与干旱（旱情的物理属性）发生的频率、程度和空间范围有关，还与易受影响的人口或活动有关。一个地区的脆弱性程度取决于该地区的环境和社会特性，跟该地区预测、应对、抗击干旱以及从干旱中恢复的能力有关。

从原则上来说，旱情指标是对需水量和可用水量之差的衡量，可以作为干旱“决策支持系统”的一部分。当地的水务公司可以根据旱情指标来启动限制用水条件，并向公众发布目前可用水量的情况。流域管理机构则可以利用旱情指标在整个流域内发布和协调用水情况。省级水利主管部门也可以利用指标来衡量全省可用水量的情况。上述各管理层级都可以利用旱情指数开展干旱管理活动。

干旱风险管理的一项主要内容就是根据指数的监测情况，设定一系列合理的行动“触发点”。这些行动可以包括落实预先制定好的风控措施和减缓措施，比如将可用水量重分配给高产值的用户，并对造成损失的用户进行补偿。

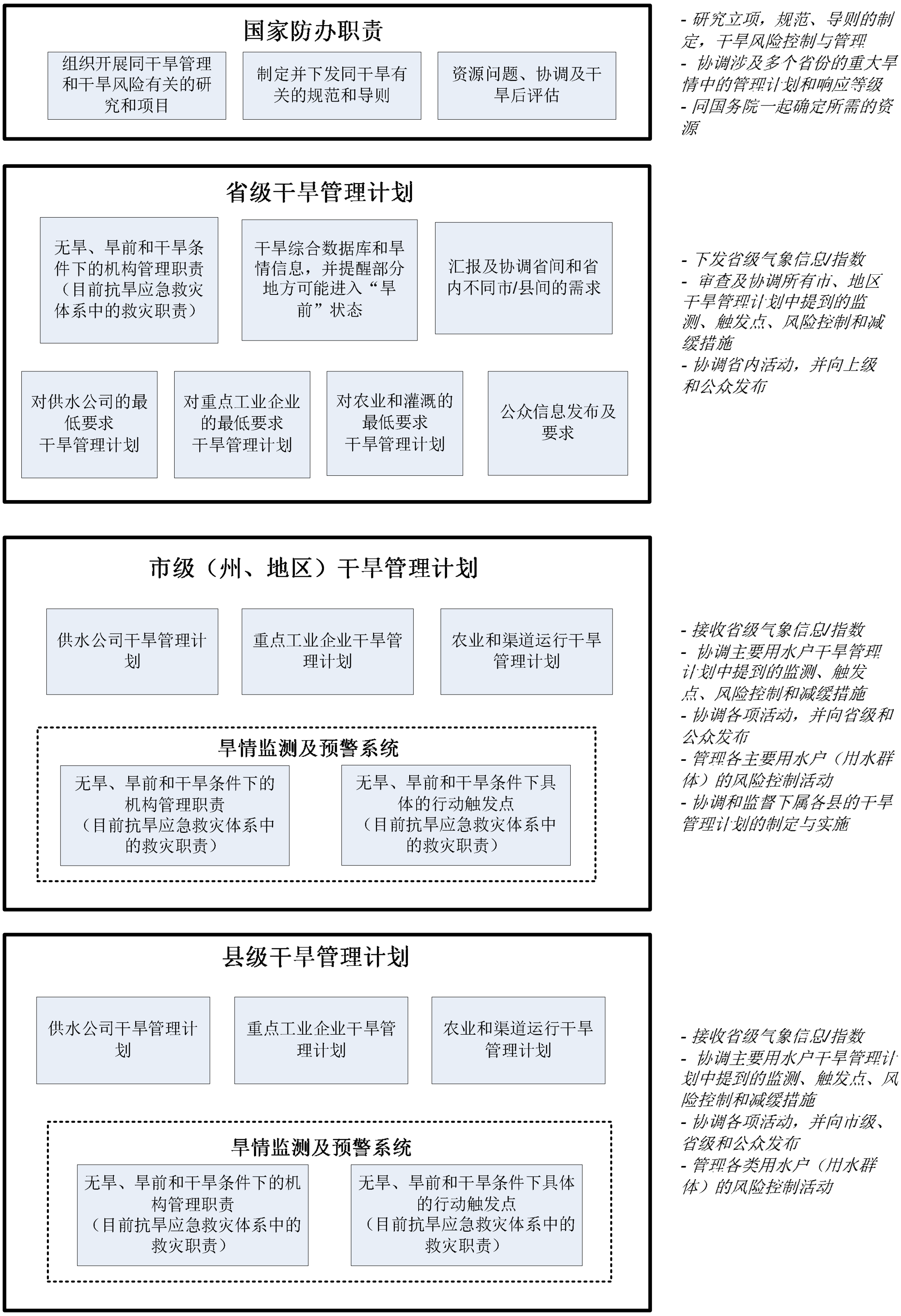
1.4 中国的分级干旱管理模式

干旱风险管理理论（以及广泛意义上的水资源综合管理）支持在恰当的管理层级上做决定，一般是更偏向基层而非高层。基于这一理念，以及中国目前国家、省级和地方防办系统的机构组织构架，本技援项目为中国的干旱风险管理提出了一个战略方法。试点省的干旱管理计划是在一个预计在未来分层级的干旱管理职责体系上建立的，其中各管理层级需紧密配合，各自行使明确的职责。水资源综合管理理念中具体的水资源管理决策由最合理的基层管理者做出。

根据这一构架，省级计划和地方计划同为干旱管理计划体系的一部分。最基层级别是自来水公司、工业用水户和农业用水户。干旱管理活动由县级或市级的干旱计划协调。县级或市级的干旱管理计划由上一级管理计划协调，整个过程由国家层面的干旱管理计划提供指导和监督。省级的管理计划还需要管理和协调跨多个市、地区的大面积干旱。

图 1.1 给出了各级别概念框架和分层的责任。

图 1.1: 旱灾风险分级管理示意图



本项目提出的干旱管理框架中采用了一系列基于国际最佳实践和中国法规标准的干旱管理计划标准范本，试图通过这些旱灾管理计划为试点省减少短期和长期水资源短缺造成的影响提供有效且系统的管理手段。干旱管理计划提出了一套相互协调配合的干旱监测、影响评价、干旱应急响应、以及旱灾长效减缓机制。旱灾风险管理计划的三项主要包括：降低影响、响应行动和风险评估。

中国已经开始了各级抗旱应急预案的编制，但在任何时候还都应同时做出干旱管理计划，哪怕是无旱的正常时期。地方的旱灾风险管理计划和抗旱应急预案并存可能只是一个过渡时期，也许最终两者会合并成为一个文件。在中国要实施这些分层旱灾风险管理活动还存在很多潜在的制约因素，包括：

- 各级抗旱资金和预算与抗旱救灾活动紧密相联，在正常阶段和干旱预警阶段没有足够的预算和动机进行干旱管理活动。值得注意的是，很多干旱监测在当前工作中已有实施，但并未计入干旱管理系统。
- 中国的水管理机构间的协作与合作仍存在问题，并且在未确知旱灾危机发生时，合作问题更为严重。
- 有担心指省以下各级政府的水资源管理人员需要接受额外培训才能进行干旱管理。若该情况属实，在为基层水资源管理部门提供必要培训后，就不必由省级决策所有的干旱管理行动，因为水资源综合管理要求受直接影响的管理层级的做出干旱管理决策。
- 市、县级防办将需要大量时间来制定适当的干旱管理计划，因此省级干旱管理计划中需要预留计划时间，用于建立共通的权责机制，并与当地部门协调。
- 本地市，县级官员也需要时间与各行业的水管理人员（城市供水，工业，农业）协同工作，编制行业干旱管理计划，使他们可以被纳入到市、县级干旱管理计划。

基于这些限制因素，在基层市级和县级的管理计划制定完备，并具有了相应的技术实力管理该计划之前的过渡时期，四川省的干旱管理计划可视做一个对基层干旱管理控制和指导更多的管理计划，其中还附带一个综合干旱数据库。或者，省级防办和水利部门在过渡期内未为基层提供额外的资源和技术支持。因此，四川省干旱管理计划既从长远角度提出了省级和地方层级分级管理的战略模式，又给出从短期内，如何利用综合干旱数据库更多地由省级开展基于风险的干旱管理。

省级干旱管理计划包括如下主要内容：

- 制定管理计划的目标和目的；
- 建立旱情监测综合数据库，利用 SPI、河流流量和库水位等指标对旱情进行监测，确定各级旱情启动的阈值，并建立同气象部门的数据共享机制；
- 建立日报体系，从省级向地方利用省级旱情指数发布旱情，提醒可能受影响的市、县可能的旱情，或通报实际的旱情情势；
- 绘制干旱风险地图，开展省内的脆弱性评估，掌握哪些地区将发生何种程度的旱情，将造成何种破坏；
- 实施标准的风险管理流程，包括在旱前、旱中（IV 级到 I 级）、旱后各个阶段，并预设各阶段将采取的风险控制措施、减缓措施和水资源重分配等措施；
- 无旱时期（正常时期）
  - 优化配水、完善基础设施
  - 旱情指数的监测与汇报
  - 准备工作（旱前和各干旱等级下能采取的各项风险控制、减缓措施、水量重分配措施）
  - 教育
- 旱前时期
  - 触发点
  - 准备并落实各项风险控制措施、减缓措施和水量重分配措施；

  - 限制供水/水量重分配
- 干旱时期
  - 触发点
  - 准备并落实各项风险控制措施、减缓措施和水量重分配措施；
  - 按照现行抗旱应急预案的规定落实救灾行动
- 旱后评估和恢复

1.5 省级与基层及行业干旱管理计划的区别与联系

本技援项目提出了一个分级的决策支持预警系统，采用国家气象局和水利部各级防办气象干旱（和水利农业监测）预测来建立预警机制，并为受影响区域（流域、市、县）提供预警提示。一旦基层防办收到可能干旱的提示，现行的水文指标和其它水文数据就会被用来评估旱情可能性。根据这些信息，结合气象和水文评估以及概率分析，启动基层干旱管理计划并采取节水限水措施。

许多干旱指标可以直接引用旱情等级标准（SL424-2008），并有必要辅以风险减低和缓解措施。依干旱严重性的不同，水资源管理部门可以依据旱灾风险评估以及当地干旱管理计划，考虑重新分配用水许可。虽然在正常时期，一些汇报工作也在进行，但在中国，在没有干旱灾害且没有干旱预警（四级到一级）启动的情况下，对于这些汇报上来的信息的响应行动很有限。

各级防办都在开展干旱前期抗旱规划工作，但是对于干旱指标的监测还不充分，干旱预测以及基于这些预测的风险减低和缓解措施也不完善。在此背景下，本技援项目不建议再改进现有的决策支持框架，而希望建立一个全新的面向干旱全过程（正常、干旱前期、干旱、以及干旱后期）的干旱管理方式。

全省旱情不能一概而论。在省级干旱管理中，正常时期监测的三个基本指标为标准降水指数，降水距平以及水库水位距平。在干旱前期，应将这些省级预警结果及时传达给市级部门。当地部门可以调整本地指标如：1）调整标准降水指数的触发点；2）增加土壤墒情监测站并将数据用于相对土壤墒情计算；3）积雪测量等。

市级将预警结果上报给省级部门，同时传达给县级部门。另外，市级部门可根据预测结果采取行动。县级部门将在市级基础上发布干旱早期预警，并考虑保障重点用水行业。县级部门将管理决策上报给市级至省级并根据预测结果启动抗旱措施。对应省级抗旱措施，市、县级应根据各自预警结果采取适当措施，包括发布信息，减少用水定额等。所有的市、县、以及行业抗旱计划应统一按省级防办制订的标准程序规划。

对于拟提出的省级和基层干旱管理计划，应考虑的干旱管理目标如下：

- 及时，系统地收集和分析干旱有关的信息。
- 建立发布旱情紧急情况和触发各种减缓和应对活动的标准。
- 提供组织结构和系统并保证内部的各级政府的信息传递。
- 定义各机构的职责和责任。
- 政府现行的评估和应对旱灾紧急情况项目的数据库维护
- 找出干旱敏感的省/地区/国家和脆弱行业，个人或环境。
- 找出解决脆弱性并减低干旱影响的缓解措施
- 提供及时准确的评估干旱对农业，工业，城市，野生动物，旅游，娱乐，保健等领域的影响的机制。

- 向媒体（例如电视、广播、以及万维网）准确及时的披露信息，保证公众对于当前情况以及相应措施的知情。
- 建立政策体制，保证缺水时期水的公平分配，制定规范或采取奖励措施，鼓励节约用水。
- 建立标准程序，并坚持执行与评估，不断完善该程序使其符合当地的需求

综上所述，省干旱管理计划包括以下几个方面：

- 干旱综合数据库，用来持续监测的水利部和气象局的气象数据，包括标准化降水指数，河流流量和水库水位。
- 与当地协调进行省内的脆弱性评估
- 建立标准程序，并提出对省内市、县以及行业干旱管理计划的要求
- 协调基层干旱管理计划的响应，尤其当干旱影响范围涉及多区域或主要行业时
- 建立组织结构和通报体制，保证各级防办间的准确沟通
- 依法管理落实抗旱规划工作
- 对上汇报至国家防办，以及对下传达至基层防办

技援项目通过本报告，从长远角度给出了省级干旱管理计划的范本，同时也对基层市级和县级的干旱管理计划提供了范本，供参考。本项目所提出的分级管理模式假定市级和县级能够获得资金和能力建设的支持，能够最终做到自己编制并管理基层的干旱管理计划。在条件完全具备之前，从短期来看，最现实的做法是利用综合干旱数据库、干旱风险图和气象指数，由省级发挥更多的干旱风险管理职责。

2 旱灾风险分析

2.1 危险性分析

危险性分析是研究受干旱威胁地区可能遭受干旱影响的强度和概率。一般而言，气象干旱强度越大，频次越高，即干旱灾害危险性越大，灾害风险也越大。

2.1.1 气象干旱危险分析

受季风环流和复杂地形的综合作用，四川省降水局地性差异极为明显。全省多年平均降水总量 4869.8 亿 m3，平均降雨量为 1003.1mm。在地理分布上，降雨量从东南向西北减少，四川盆地、川西南山地多于川西北高山高原区。最多雨带在四川盆地西缘，最少雨区在得荣一带的金沙江河谷。盆地周围山区降水相对丰沛，降水量在 1200-1600mm，而盆地腹部、川西北高原及金沙江干热河谷为降水低值区，降水量多在 300-800mm 之间。在年内分配上，5-10 月降水量占年降水量的 80%-90%，12 月至次年 3 月的降水量仅占年降水量的 10%左右，夏季雨量比例自东向西逐渐增大。

四川省地形以山地为主，丘陵次之，平原和高原较少，面积分别占全省幅员面积的 77.1%、12.9%、5.3%和 4.7%。按地形、地貌大致以岷山、龙门山、大相岭，大凉山为界，可分为东西两大部分，东部为四川盆地区，西部为高山高原区。地势为西北高东南低。根据地形地貌、水资源特性和开发利用条件，以及经济发展水平，东部四川盆地区又划分为盆地腹部区和盆周山区；西部高山高原区又划分为川西南山地区和川西北高山高原区。根据四川省地形的复杂性，全省气候大体可分为三个区域，川西北高原温带寒带气候区，四川盆地中亚热带湿润气候区，川西南山地半湿润气候区。其中，四川盆地中亚热带湿润气候区主要受副热带季风影响，盆西多春夏旱，少伏旱，盆东多伏旱少春夏旱，盆中则春夏伏旱交错发生，为常旱区。

不同季节干旱的区域分布较为明显。春旱主要发生在绵阳、德阳、广元、遂宁、资阳、内江、自贡等 6 市及宜宾、泸州两市的长江以北部分、南充市的西北部、成都市大部、乐山、眉山两市的岷江以东部分，以及凉山州、攀枝花市和雅安市的一小部分，其中干旱发生频率大于 60%的地区主要分布盆地西部的绵阳、资阳、内江、自贡一带，区内平均干旱频率在 80%左右。最高的简阳、安岳可达 80%以上，成为名副其实的“十年九旱”。重灾区在龙泉山东侧的绵阳、金堂、龙泉驿、仁寿、荣县及安宁河谷的仁和、米易、德昌、西昌一带。夏旱主要发生在绵阳、成都、德阳、广元、乐山、宜宾、资阳、内江、遂宁、南充、广安、达州、巴中及凉山、攀枝花等 15 个市（州），几乎覆盖除川西高原外全省所有的农业区。高频区集中在广元、绵阳和成都平原及盆中丘陵区的部分县，区内干旱最大频率为 76%。重旱区主要分布在梓潼、盐亭、三台、中江、剑阁、元坝、简阳、威远一带。近 10 年南充一带夏旱出现频率有所增大，出现了几年大面积的夏旱。伏旱主要发生在盆地东部和东南部的达州、南充、巴中、广安、泸州、自贡、遂宁、内江等 8 个市。高频区在达州、广安、南充、内江一带，频率大致在 65%。总体上伏旱发生频率有由东向西逐渐降低趋势，达州、广安、南充、巴中是伏旱的重灾区。除川南部分县外，全省大部分地区均存在不同程度的冬旱。干旱频率在 30%以上，成都、仁寿、射洪、达县以北地区冬干频率在 60%以上，其中广元、通江频率在 80%左右，为冬干的中心区。由此向南，干旱频率逐渐降低。

据统计，1950-2007 年的 58 年中，除 1967 年未见干旱灾害记录外，其余年份中每年都有不同程度的干旱灾害发生，干旱出现的季节，除 1950、1954、1967、1973 年缺资料外，其余 54 年中单独出现春旱、夏旱或伏旱的概率为 26%，一年内出现春、夏旱，夏、伏旱，春、夏、伏旱的概率则达 74%。

2.1.2 水文干旱危险分析

四川省年径流分布情况与年降水的分布基本一致。东部盆地多于西部高原，盆周多于盆中。径流深东部一般为 300-800mm，盆地腹部地涪、沱中游地区不到 300mm，为省内径流低值区，盆地东部鹿头山、青衣江暴雨区为 1000-1600mm，最大可达 1966mm，是省内径流高值区。盆周山地在 800mm 以上；西部高原北纬 30 o 以北地区在 200-600mm 之间，以南由于气候条件与下垫面条件错综复杂，无论是山谷、迎风面与背风面。径流的局部差异显著，如安宁河中游为 500-700mm，而其上、下游却在 800-1400mm 之间。

径流时程变化大体情况是盆地腹部变化最大，外围山地区及西部高原变化较小。盆地东部渠江上游因受东南季风最先进入影响，4-10 月为汛期，径流占 60%-80%，其中最大月径流占 25%左右；春季径流占 25%-35%。由东向西，汛期变到 5-10 月，径流占 60%-70%，其中最大的月径流达 30%以上，春季径流占 15%-25%。但盆地中部少水地区，特别是涪、沱江中下游地区，汛期在 6-9 月，径流比重高达 75%-85%，其中最大月径流在 30%以上，春季径流比重不到 10%。盆西边缘，汛期为 6-10 月。西部高原区，汛期在 6-10 月，径流占 70%-80%，其中最大月径流为 20%-25%，春季径流小于 10%。

全省多年平均地表水资源量 2614.54 亿立方米。全省地下水与地表水不重复计算量 1.15 亿立方米，水资源总量 2615.69 亿立方米。人均水资源量地区分布不均。川西北部高山高原地区虽然径流深较小，但人口少，人均水资源达 68186m3；川西南山地区人口不多，水资源亦富裕，人均 7925m3；而人口、耕地和工农业最集中的盆地腹部区，却是全省水资源最贫乏地区。该区面积占全省的 18.7%，而人口、耕地、工农业产值分别占全省的 74.3%、71.9%和 84.8%。人均水资源量为 925m3，在人均 1000m3 缺水下限之下。尤其是盆地腹部区经济发达区域如自贡、遂宁、内江、资阳人均低于 400 m3，加之水质污染严重，使本区工农业生产和人民生活将得不到足够水资源供应干旱灾害的危险性相对较高。

2.1.3 危险性评估

在分析四川省干旱灾害危险性的影响因素及现状的基础上，根据现有的数据资料条件，选取旱灾危险性的主要影响因子，建立旱灾危险性模糊评价指标体系。采用归一化方法，将各个指标因子无量纲化并统一到[0,1]区间；采用层次分析方法确定各个影响因子对相应旱灾风险组成要素的贡献权重。

区域干旱危险性是对干旱的时空规模、强度、烈度和变异性等特征的描述，它往往是气象、水文等若干个干旱指标的综合反映。对于干旱灾害风险的危险性，以县为单元，选取年降水量、年降水量变差系数、人均水资源量三个指标作为影响因子，用经验打分的方法确定比较判断矩阵，并由此计算出权重系数，如下表：

表 2.1: 四川省干旱灾害危险性影响因子及权重

	影响因子	指标方向	权重
危险性 (H)	降水量	-	0.429
	年降水量变差系数	+	0.429
	人均水资源量	-	0.143

注：表中，“+”代表该因子越大，危险性越大，“-”代表则该因子越大，危险性越小。

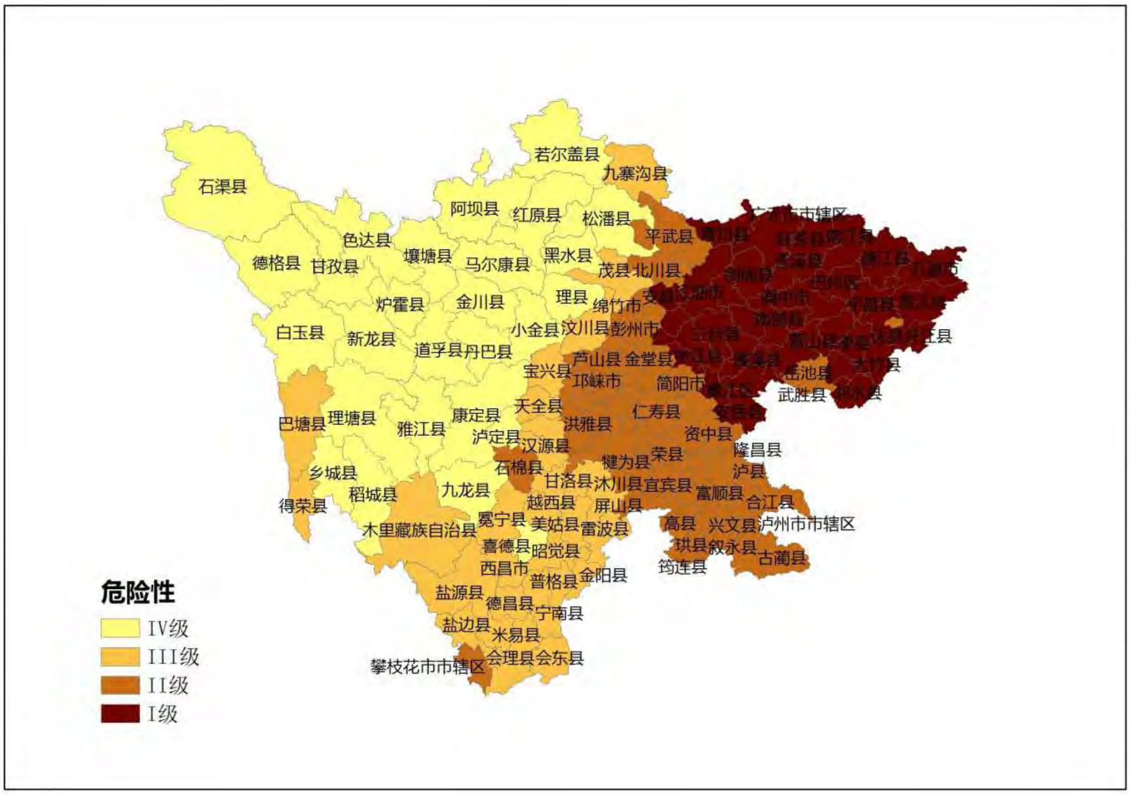
干旱危险性估算公式如下：

$$H = \sum_{1}^{n} \omega_i y_i$$

其中，H 为干旱危险性值，y_i 为危险性影响因子 x_i 经过归一化之后的值，ω_i 为危险性影响因子 x_i 通过层次分析得到的权重。

由上述方法计算得出四川省各区县干旱灾害危险性值，并将结果绘制成图，参见图 2-1。从图可见，东部盆地及丘陵地区危险性显著高于西部山区，主要是受到降水少、农业发达、人口密度大等多因素的影响。其中，自贡市危险性是全省中最大的，其次是成都、攀枝花、德阳，这是由于这些地区年均降水量相对较小，年降水变差系数大，人口密度大，水资源人均占有量较低，而甘孜州由于人均水资源量达到 60000m3/人，危险性最小，其次是凉州、阿坝州、雅安市年均降水量均超过 1000 毫米，人口密度低，人均占有水资源量较高，相对其他地市，危险性最小。

图 2.1: 四川省各区县危险性分布图



2.2 暴露性分析

2.2.1 农业干旱暴露性分析

农业生产规模越大、单产越高的地区，暴露性越明显，受到干旱灾害的影响也越大。

四川省现有耕地面积 3951.26 千公顷，其中有效灌溉面积 2489.76 千公顷，占 63.0%。但是，有效灌溉面积的 80%左右集中在盆地腹部地区和川西南山地区，有效灌溉面积低于全省平均水平的有 16 个市、州。全省平均单位面积粮食产量 5273.4 公斤/公顷，主要种植粮食和经济作物，粮食作物包括水稻、小麦、玉米，经济作物包括油料、花生、油菜籽、棉花、甘蔗、烟叶等。

表 2.2: 四川省各地市农业概况

地级行政区	耕地面积(千公顷)	农田有效灌溉面积(千公顷)	播种面积(千公顷)			粮食产量(万公斤)	
				其中			其中：
			总计	粮食作物	经济作物	总量	谷物
成都	349.8	332.28	809.28	463	346.28	284764	243739.8
自贡	127.887	75.61	305.01	223.2448	81.77	125991	102057.1
攀枝花	34.53	26.02	60.79	38.83	21.96	22330	21894
泸州	208.31	108.87	482.09	378.03	104.06	215893	153601.8
德阳	190.82	152.69	468.42	312.10	156.32	182755	176430
绵阳	283.71	208.55	664	431.8	232.00	223435	191896
广元	161.89	84.63	421.76	269.88	151.88	143077.00	119224.6
遂宁	154.99	121.68	415.19	312.8	102.39	156288.00	115155.2
内江	163.61	109.67	429.2	318.08	111.12	149176	110792.1
乐山	150.27	97.33	358.32	245.73	112.59	109901.00	61482.8
南充	298.22	198.22	1037.3	647.23	390.07	326353.0	241334.10
眉山	172.84	172.56	424.66	304.83	119.83	184063	140216
宜宾	240.2	111.84	521.89	408.06	113.83	257113.00	176396.00
广安	168.42	93.39	497.72	392.83	104.89	176409.00	104096.90
达州	280.07	155.27	830.010	565.81	264.20	308796.00	200319.37
雅安	57.62	43.56	185	124.60	60.31	57227	44751.50
巴中	150.35	71.9	452.80	333.4	119.40	158870.00	129600
资阳	275.35	160.01	817.59	588.51	229.08	345116	146169.37
阿坝州	60.1	16.28	71.46	56.55	14.91	16186	10141
甘孜州	91.04	26.86	72.43	67.21	5.22	15515	4026.79
凉山州	331.24	122.54	654	461.37	193.03	202510	121292
全省合计	3951.26	2489.76	9979.03	6943.89	3035.13	3661768.00	2614616.73

在四川，不同季节的干旱对农作物的生长影响程度是不同的。一般情况下，春旱会造成小麦结实率下降，籽粒不饱满，油菜也会因生长过快而提前开花，结荚率低，还会影响棉花播种、移栽，从而影响全年产量。夏旱发生时，中稻会无水栽秧或栽下去后秧苗干死，玉米吐雄授粉受到影响。伏旱期间，正值各种作物生长最旺盛的季节，中稻、晚稻、棉花都会损失重大，而且农作季节已过，无法挽回。秋旱虽然对本年农业生产影响不大，但是会减少地表蓄水量，对下一年的春耕生产不利。据统计，1950-2007 年，除 1967 年缺资料外，其余 57 年中，干旱造成的损失粮食产量 50 万吨以下的有 15 年，占 26.3%；50-100 万吨的有 17 年，占 29.8%；100-150 万吨的有 13 年，占 22.8%；150 万吨以上的有 12 年，占 21.1%。

2.2.2 城市干旱暴露性分析

干旱还会对城市供水及农村人畜饮水造成影响。社会经济越发达、人口密度越大，对水资源的需求量也越多，暴露性越明显。在四川省，对于人口密度、人均 GDP 值，城镇大于农村，盆地地区大于山丘区，暴露性相对大。

区域旱灾风险分析中，影响暴露性的主要因子有：人口、资源、社会经济等。根据这些因子的数量和空间分布，可以确定暴露性值。考虑到四川的干旱形势以及数据的代表性和可获取性，选取人均 GDP、人口密度、牲畜密度和单位面积粮食产量作为暴露性的影响因子，计算权重如下：

表 2.3: 四川省暴露性影响因子及权重

	影响因子	指标方向	权重
暴露性 (E)	人均 GDP	+	0.125
	单位国土面积人口	+	0.375
	单位国土面积牲畜数量	+	0.125
	单位面积粮食产量	+	0.375

注：表中，“+” 代表该因子越大，暴露性越大，“-” 代表则该因子越大，暴露性越小。

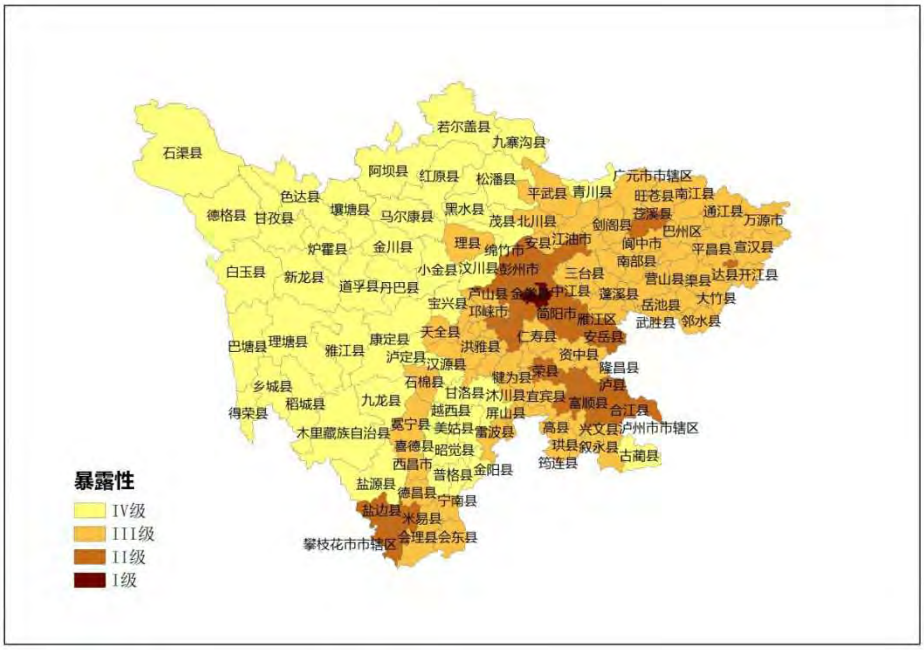
干旱暴露性估算公式如下：

$$E = \sum_{1}^{n} \omega_i y_i$$

其中，E 为干旱暴露性值，y_i 为暴露性影响因子 x_i 经过归一化之后的值，ω_i 为暴露性影响因子 x_i 通过层次分析得到的权重。

由上述方法计算得出四川省各区县干旱暴露性值，并将结果绘制成图，参见图 2-2。由图表可见，东部地区暴露性大于西部。这是由于东部地区经济社会相对发达，人口密度大，是粮食生产的主要地区。

图 2.2: 四川省各区县暴露性分布图



2.3 脆弱性分析

脆弱性为“一个群体、系统或资产易于遭受干旱威胁并造成损失和影响的性质”，脆弱性分析是干旱灾害风险分析的重点，主要从自然环境与社会经济环境两方面考虑，分析受干旱威胁地区抵抗干旱灾害的能力。干旱灾害脆弱性的高低具有“放大”或“缩小”灾情的作用，同时能客观反映对干旱灾害应对、缓冲和恢复能力的差异。一般而言，孕灾环境的脆弱性越高，灾害风险就越大。

2.3.1 社会经济脆弱性分析

经济社会发展水平高低对干旱灾害脆弱性影响十分显著，主要体现在地区经济发展水平、产业结构与布局情况、人口城镇化率、人口密度、人口素质和生活水平等方面。四川省 2007 年总人口 8815.22 万人，其中城镇人口 2143.16 万人，农村人口 6672.06 万人，城镇化率为 24.31%，仅为全国平均水平 47.5%的一半左右。居民收入水平增长明显滞后于经济发展水平。另外，地区之间，城乡之间收入差距很大，经济社会发展很不均衡。中东部地区相对西部人口密度大，城镇化率较高。其中成都和攀枝花两市城镇化率超过 50%，资阳市和凉山州不足 15%，阿坝州和甘孜州也较小。人均 GDP 全省平均为 12164 元，城镇家庭人均收入全省平均为 0.97 万元，其中阿坝州最高为 1.32 万元，其次甘孜州为 1.27 万元；农村家庭人均收入全省平均为 0.37 万元，各市社会经济指标统计情况见表。

表 2.4: 四川省 2007 年社会经济指标情况统计表

市别	人口(万人)			地区生产总值 (亿元)			
	总人口	城镇人口	农村人口	第一产业	第二产业	第三产业	总值
成都	1112.29	595.64	516.65	235.1	1504.0	1585.1	3324.2
自贡	322.45	99.15	223.30	72.3	190.2	132.4	394.9
攀枝花	110.10	59.09	51.01	16.4	246.2	82.6	345.3
泸州	489.20	84.90	404.30	90.7	179.7	133.5	403.9
德阳	385.30	83.89	301.41	122.4	356.1	169.9	648.4
绵阳	537.90	133.20	404.70	144.6	301.8	227.1	673.5
广元	307.40	68.97	238.43	60.5	74.5	73.5	208.5
遂宁	383.70	77.25	306.45	89.9	129.4	85.7	305.0
内江	423.83	82.12	341.71	80.5	184.5	109.7	374.6
乐山	352.45	92.20	260.25	82.9	251.7	118.4	453.0
南充	742.10	151.00	591.10	152.2	202.8	153.1	508.1
眉山	344.51	80.30	264.21	84.6	169.3	89.9	343.8
宜宾	527.81	94.01	433.80	107.5	276.9	144.7	529.1
广安	461.70	70.40	391.30	85.7	131.2	122.0	338.8
达州	662.10	116.50	545.60	163.5	199.7	147.2	510.4
雅安	153.67	34.27	119.40	38.5	84.3	54.0	176.8
巴中	374.20	61.50	312.70	73.3	40.1	62.7	176.1
资阳	493.20	68.90	424.30	110.4	162.4	101.1	374.0
阿坝州	87.39	18.49	68.90	19.6	45.4	40.2	105.1
甘孜州	95.52	15.80	79.72	20.8	27.3	30.8	78.9
凉山州	448.40	55.58	392.82	130.3	186.4	133.8	450.6
合计	8815.22	2143.16	6672.06	1981.6	4943.9	3797.2	10722.7

2.3.2 水利工程抗旱能力分析

四川省供水工程总供水能力 2268546 亿 m^3，其中地表水工程 2209606 亿 m^3，占 97.40%；地下水工程 52855 亿 m^3，占 2.33%；其他水源 6085 亿 m^3，占 0.27%。

2.3.2.1 地表水工程

全省共建成水库 7029 座，其中大型水库 5 座，中型水库 106 座，小型水库 6918 座。水库总库容 95.41 亿 m^3，其中大型水库 28.80 亿 m^3，中型水库 28.22 亿 m^3，小型水库 38.39 亿 m^3；兴利库容 52.28 亿 m^3，其中大型水库 19.00 亿 m^3，中型水库 16.93 亿 m^3，小型水库 16.35 亿 m^3。

全省现有塘坝 46.19 万座，引水工程 4.2 万处，其中大型 17 处，中型 87 处，小型 42138 处，引水能力 100.99 亿 m^3。

现有提水工程 3.2 万处，其中大型 5 处，中型 138 处，小型 32054 处，供水能力 29.19 亿 m^3。

2.3.2.2 地下水工程

四川省现有浅层地下水水井工程 1568729 眼，其中配套机电井 886249 眼。现有深层承压水水井工程 20669 眼，其中配套机电井 2353 眼。

2.3.2.3 其他水源工程

四川省其他水源工程主要指污水回用，矿井利用，海水利用及集雨工程等，全省其他水源工程现状供水能力 6085 万 m^3。

2.3.2.4 抗旱应急备用水源工程现状

全省仅广元市利州区，南充市阆中市，达州市万源市，资阳市雁江区有抗旱应急备用水源工程，主要保障干旱期城镇用水，总供水能力 2660 万 m^3。现状条件下，全省抗旱应急水源工程只限于对城镇的供水备用，农村人饮和灌溉的保障能力还比较脆弱。对于城镇供水的备用供水能力只有 0.576 亿 m3。

2.3.3 脆弱性评估

脆弱性为“一个群体、系统或资产，易于遭受干旱威胁并造成损失和影响的性质”，脆弱性分析是干旱灾害风险分析的重点，主要从自然环境与社会经济环境两方面考虑，分析受干旱威胁地区抵抗干旱灾害的能力。干旱灾害脆弱性的高低具有“放大”或“缩小”灾情的作用，同时能客观反映对干旱灾害应对、缓冲和恢复能力的差异。一般而言，孕灾环境的脆弱性越高，灾害风险就越大。针对四川省，选取第一产业比例、有效灌溉面积比例、水田比例、农村人口比例、水资源开发利用程度、人均收入、单位面积可供水量、抗旱队伍数量、旱情监测系统数量、应急备用水源个数 10 个指标作为干旱灾害脆弱性的影响因子。各因子的指标方向和权重计算结果如下表：

表 2.5: 四川省脆弱性影响因子及权重

组成要素	影响因子	指标方向	权重
脆弱性（V）	第一产业比例	+	0.197
	有效灌溉面积比例	-	0.197
	水田比例	+	0.079
	农村人口比例	+	0.197
	水资源开发利用程度	+	0.079
	人均收入	-	0.031
	单位面积可供水量	-	0.079
	抗旱队伍数量	-	0.079
	旱情监测系统数量	-	0.031
	应急备用水源个数	-	0.031

注：表中，“+”代表该因子越大，脆弱性越大，“-”代表则该因子越大，脆弱性越小。

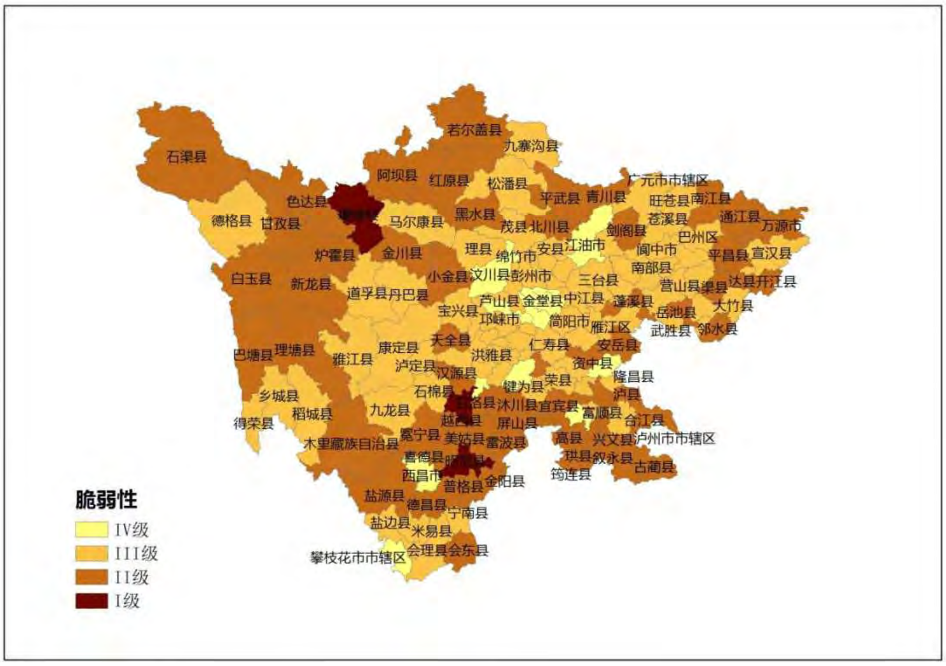
干旱脆弱性估算公式如下：

$$V=\sum_{1}^{n}\omega_i y_i$$

其中，V 为干旱脆弱性值，y_i 为脆弱性影响因子 x_i 经过归一化之后的值，ω_i 为脆弱性影响因子 x_i 通过层次分析得到的权重。

由上述方法计算得出四川省各区县干旱脆弱性值，并将结果绘制成图，参见图 2-3。由图可见，在地域上，干旱灾害脆弱性没有明显的差异。这是由于东部地区为适应其较发达的经济和生产，水源工程和抗旱能力建设也较完善，而西部地区虽然生产和建设较落后，但第一产业比例小，水田比例小，农业受到干旱灾害的影响较小，在一定程度上缩小了地区之间脆弱性差异。

图 2.3: 四川省各区县脆弱性分布图



2.4 风险评估

2.4.1 历史旱灾

1950-2007 年的 58 年中，除 1950、1954、1967 年缺资料外，其余年份，每年都有不同程度的干旱灾害发生。其中，1959、1966、1978、1979、1988、1993、1994、2001、2006 年，发生了特大干旱，发生频次为 15.5%；1961、1968、1969、1977、1987、1998、1999、2000 年，发生了严重干旱，发生频次 13.8%。

干旱灾害虽是每年都有发生，但大范围、长时期的严重干旱灾害的发生仍有一定的周期性。根据 1950-2007 年资料统计，大范围、长时期的干旱 5-10 年就会出现一次。从时间上说，不仅年内有冬干、春旱、夏旱、伏旱，而且还有春夏连旱、夏伏连旱。盆地内不仅有 5-10 年左右出现较大严重干旱的短周期，还有 50 年左右及 100 年左右出现特大干旱灾害的长周期，更有 440 年出现干旱灾害波峰及 880 年出现干旱密集、峰值较高的干旱异常峰的规律。

以 2006 年四川省特大夏、伏旱为例，全省农作物受灾面积达 3287.42 千公顷，成灾面积达 1637.6 千公顷，绝收面积 399.52 千公顷。因旱致使 854.6 万农业人口和 889.6 万头大牲畜发生临时饮水困难。因旱损失粮食 257455.76 万公斤，农业直接经济损失 742929.88 万元。因旱减少城镇供水量 42605 万立方米，影响城镇人口 944.8 万人，影响工业增加值 217167 万元。牧区草场受旱面积 21020 千公顷，受灾牲畜 340.54 万头，牧业直接经济损失 20303.4 万元。

根据四川省多年干旱灾害资料，得出干旱灾害有以下几个特点：

1. 干旱灾害频繁。新中国成立以来的 60 多年中，几乎每年都有不同程度干旱灾害发生，大范围、长时期的干旱 5-10 年就会出现一次。
2. 旱涝灾害交替。四川省容易先旱后涝，洪后又旱；或是先洪后旱，旱后又涝；或是西旱东涝，或是东干西涝，交错为害，对农业生产危害更大，损失更重。
3. 区域性。一般来说，平原、丘陵区干旱灾害重于高原、高山地区，东部盆地干旱灾害重于西部高原，盆地东部重于盆地西部，严重干旱主要发生在盆中丘陵区。

2.4.2 农业旱灾风险图

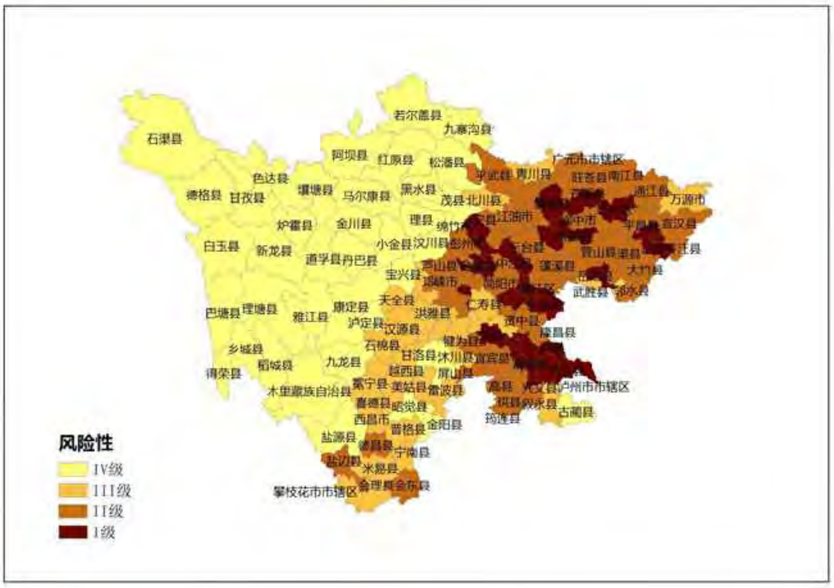
根据区域旱灾理论，干旱风险是危险性、暴露性和脆弱性综合作用的结果。针对四川省，采用下式估算干旱风险：

$$R = H * E * V * 100$$

其中，R 为干旱风险值，H 为干旱危险性值，E 为干旱暴露性值，V 为干旱脆弱性值。

由上述方法计算得出四川省各区县干旱风险值，并将结果绘制成图，参见图 2-4。由图表可见，中东部地区干旱灾害风险性明显高于西部地区。其中，自贡、泸州、德阳、宜宾等市（区）风险性较大。甘孜州、阿坝州、雅安市风险较小。

图 2.4: 四川省各区县风险值分布图



3 旱灾风险管理组织机构及决策过程

3.1 组织机构及职责分工

3.1.1 组织机构

四川省人民政府设立省防汛抗旱指挥机构。负责本省的防汛抗旱日常工作和干旱灾害引起的突发事件的应对工作。四川省人民政府防汛抗旱指挥部是全省防汛抗旱工作的指挥决策机构。办事机构防汛抗旱指挥部办公室设在省水利厅，防汛抗旱指挥部下设抗旱办公室。

四川省人民政府防汛抗旱指挥部由四川省人民政府分管副省长任指挥长，省水利厅厅长任常务副指挥长，省政府分管副秘书长、省军区、省建设厅领导任副指挥长，省发展改革委员会、省经济贸易委员会、省民政厅、省财政厅、省公安厅、省国土资源厅、省交通厅、省农业厅、省卫生厅、省广播电影电视局、省人民政府应急办公室、省气象局、省农机局、省通信管理局、成都铁路局、民航西南地区管理局、省武警总队、省水利厅等委、厅、局负责人和首长为指挥部成员。

县级以上地方人民政府设立地方防汛抗旱指挥机构。负责本行政区域的防汛抗旱日常工作和干旱灾害引起的突发事件的应对工作。有关单位可根据需要设立本单位防汛抗旱指挥机构，负责本单位防汛抗旱突发事件应对工作。

3.1.2 职责

省防汛抗旱指挥部抗旱职责

省防指负责领导、组织全省的抗旱工作，主要职责是拟制省抗旱的政策、法规和制度等，组织制定跨市（州）行政区划的调水方案，及时掌握全省旱情、灾情并组织实施抗旱减灾措施，统一调控和调度全省水利、水电设施的水量，组织灾后处置，并做好有关协调工作。

省防汛抗旱指挥部成员单位抗旱工作分工

省军区：根据汛情需要，协调驻川部队，组织所属部队（含预备役部队）和民兵担负抗洪抢险、营救群众、转移运送物资，稳定秩序及执行其他重大防洪任务。

省委宣传部：把握全省防汛抗旱宣传工作导向，及时协调、指导新闻单位做好防汛抗旱新闻宣传报道工作。

省建设厅：负责城市防洪设施工程建设的管理工作；监督、检查城市排涝的安全运行；指导编制城市山洪灾害的防治规划工作；协助省防办完成当年度分管的行政区域防洪减灾监督、检查工作。

省发改委：协调安排重点防洪建设项目，积极争取将重大防洪工程建设纳入国家基建计划；安排大型山洪灾害的治理；负责计划内防汛抢险物资安排。

省经委：负责所管辖水电站的运行安全及库区的防汛安全；执行防汛指挥部门的防洪调度命令；保障防汛抢险、排涝、救灾的电力供应；负责防汛抗洪、抢险、救灾、能源等重要物资的紧急调度和省药品储备工作，组织实施重大灾情情况下药品器械的紧急调度。

武警四川省总队：根据汛情需要，担负抗洪抢险、营救群众、转移运送物资、稳定秩序及执行其他防洪任务。

省民政厅：负责洪涝灾区群众的生活救助工作，组织协调社会捐赠工作，负责救济款物的发放和管理使用工作，组织灾区开展生产自救。

省财政厅：负责安排防汛报汛及抢险经费；负责监督防汛经费及物资的使用和管理。

省公安厅：负责维护防汛抢险秩序和灾区社会治安工作；遇有紧急汛情，协助防汛部门组织群众撤离和转移；打击偷窃防汛物料、破坏防洪与水利工程设施的犯罪分子，做好防汛的治安保卫工作。

省国土资源厅：负责提供相关地质灾害资料信息，组织应急调查和应急监测工作，并对灾害发展趋势进行预测，提出应急防治与救灾措施建议；组织实施必要的应急治理工程，减缓和排除险情灾害。

省交通厅：负责所辖水路和公路交通设施、工程、装备的防洪安全；汛期督促船舶航行服从防洪安全和航行安全管理的要求；优先组织运送防汛抢险、防疫人员和物资、设备；为紧急抢险和撤离人员及时组织所需车辆、船舶等运输工具。

省农业厅：及时收集、整理和反映全省农业旱、涝灾情信息；指导全省农业防汛抗旱和灾后农业救灾、生产恢复及农垦系统的防洪安全。

省水利厅：归口管理全省防汛抗旱工程。负责组织、指导全省防洪排涝和抗旱工程的建设与管理，督促地方政府完成水毁水利工程的修复；负责组织江河洪水的监测、预报和旱情的监测、管理；负责防洪抗旱工程安全的监督管理；负责建设防汛指挥调度中心，代管省防办。

省卫生厅：负责组织、协调灾区卫生防疫和医疗救护工作。

省商务厅：加强对灾区重要商品市场运行和供求形势的监控，负责协调防汛抗旱救灾和灾后恢复重建物资的组织、供应。

省信产厅：指导协调公共通信设施的防洪建设和维护，根据汛情需要，协调调度应急通讯设施。

省安监局：负责监督、指导和协调汛期安全生产工作。

省广电局：负责组织广播电视防汛宣传工作。

省救灾办：负责组织协调救灾工作，协助防汛抢险；及时掌握灾情，制定抗灾救灾措施，协调安排救灾资金和物资；负责救灾信息的对外发布。

省气象局：负责监测天气形势，及时提供天气预报和降雨量等气象信息，组织实施抗旱人工增雨作业和水利蓄水人工增雨作业。

省水文局：负责及时提供洪水预报、监测站点水雨情等信息。

省农水局：负责指导全省已成水利工程的防洪抢险；组织已成水利工程防洪抢险及水毁水利工程的修复。

省通信管理局：协调组织电信运营企业保障通信设施的防洪安全；优先传递防汛通讯信息，保证防洪抢险通讯信息畅通。根据汛情需要，协调组织电信运营企业调度应急通信设施。

成都铁路局：负责所辖工程及设施的防洪安全；优先运送防汛抢险、防疫人员以及物资、设备。

民航西南管理局：负责所辖机场及设施的防洪安全；优先运送防汛、防疫人员以及物资、设备；为紧急抢险和人员撤离及时提供所需飞机。

省防汛抗旱指挥部办公室职责

四川省人民政府防汛抗旱指挥部办公室，是省防指的常设机构。承办省防指的日常工作，组织全省抗旱工作；组织拟订全省有关抗旱工作的方针、政策并贯彻实施；组织制订重点地区的抗旱预案，并监督实施；指导、推动、督促全省有抗旱任务的县级以上人民政府制定和实施抗旱预案；负责特大防汛抗旱经费、物资的计划、储备、调配和管理；组织、指导抗旱服务组织的建设和管理；组织全省抗旱指挥系统的建设与管理等。

3.2 决策过程

抗旱决策就是为了最大限度地减免干旱灾害损失，经过分析比较，从工程调度、水源配置等安排部署的备选方案中作出选择，并组织领导、付诸实施。指挥决策的依据是经批准的各类水量调度方案、防汛抗旱应急预案、调度规程等。同时，要服从有指挥权的上级防汛抗旱指挥部的统一指挥和调度，严格执行所下达的调度指令。

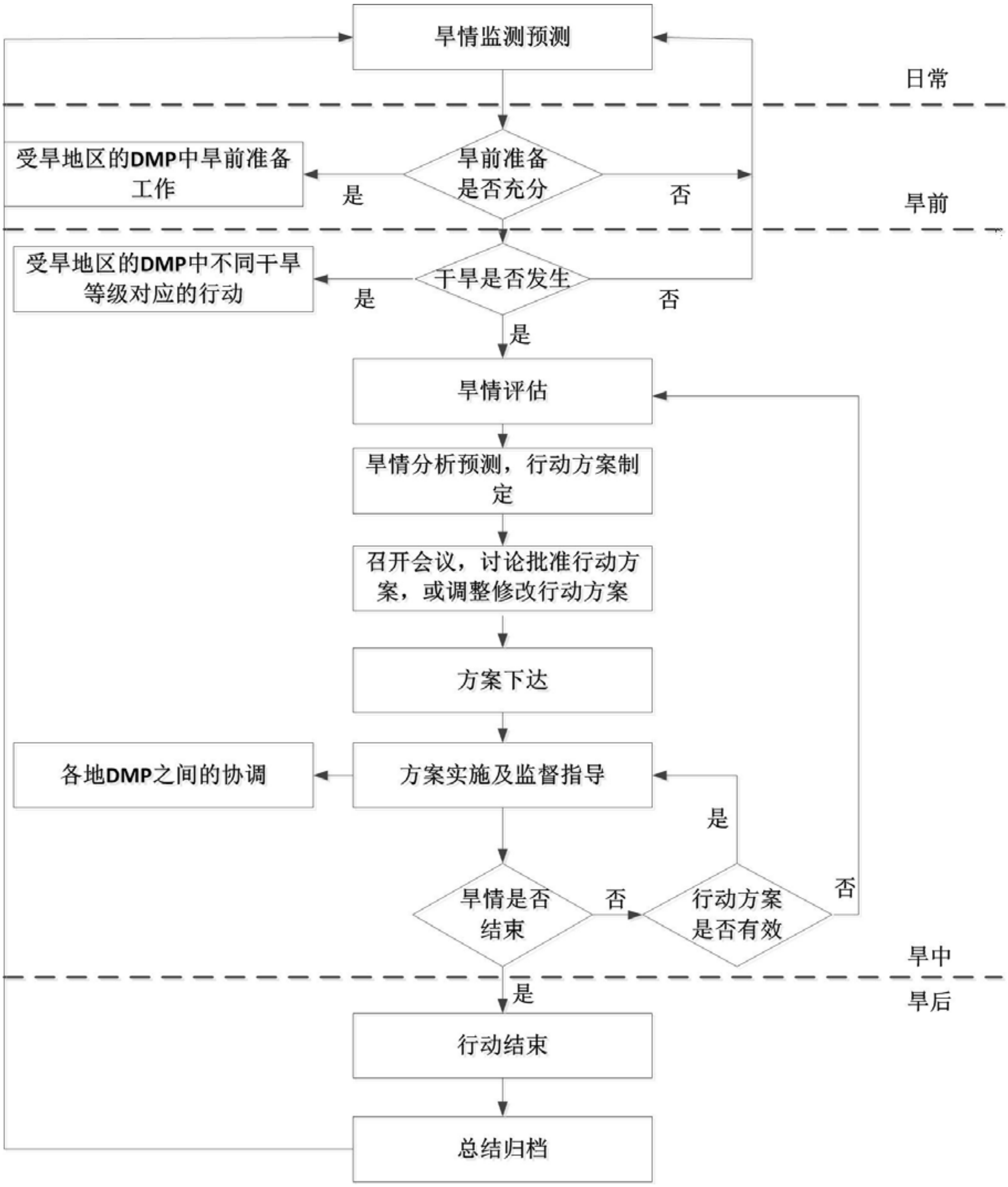
抗旱指挥决策的制定时，需要分析四个方面的问题：一是旱情、灾情现状及其发展趋势；二是可能产生的最不利后果，特别是与群众饮水安全、经济社会稳定相关的因素；三是按照各类预案、方案或规程，所能够运用的工程调度、水量调配等方案、措施，及其各自的利弊分析；四是组织实施最优方案涉及的相关组织机构、工程技术、专家队伍、物资装备、经费支持、运用补偿、生活安置等因素。

抗旱减灾指挥决策的行动方案主要针对如何通过采取措施确保城乡居民饮水安全、如何通过抗旱浇灌减少对农业生产的影响和如何通过水量调度解决城乡供水、生态用水短缺等问题，要坚持统一调度、保证重点、兼顾一般的原则，全力保障城乡居民基本生活用水安全。

决策方案制定完成后，省防汛抗旱指挥部组织召开会议，对行动方案进行讨论和审查，确定最终行动方案。方案经指挥部会议讨论批准后，下达至指挥部各成员单位和下级防汛抗旱指挥部门，并上报至国家防汛抗旱指挥部。成员单位及下一级防汛抗旱指挥部门按照各自职责进行方案实施及监督指导。在行动实施过程中，要实时关注旱情变化情况，当变化较大时，如干旱等级发生变化时，及时上报。成员单位及各级防汛抗

旱指挥部门要对行动方案的实施情况及效果做总结和上报，省防汛抗旱指挥部根据实施效果，可对原方案进行修改调整。

图 3.1: 四川省干旱管理指挥决策过程示意图



4 旱情监测、评估及预测

在考虑四川省现有旱情监测体系和数据可获取性基础上，结合四川省抗旱管理部门前期工作基础和四川省气候地理等自然情况，提出了四川省干旱监测、旱情评估和旱情预测方案，具体如下。

4.1 干旱监测

干旱监测的内容主要包括气象监测、水文监测、土壤墒情监测、饮用水情况监测等。气象监测主要是降水信息的监测，水文监测是河道和水库等地表水的监测和水井等地下水蒋策，土壤墒情监测主要是固定土壤墒情监测站的监测结果。截止目前，四川省有河道水文水 167 处，水库水位站 223 处，雨量站 1100 处（水文部门 695 处，气象部门 405 处），蒸发站 254 处（水文部门 11 处，气象部门 243 处），土壤墒情监测站 103 处（水利部门 17 处，农业部门 86 处）。这些监测站点基本能够支撑目前的旱情监测预警任务。

4.1.1 气象监测

四川省现有降水量观测站 1100 个，其中水文部门 695 处，能够为旱情监测提供稳定的数据支撑，气象部门 405 处，共享情况尚不明确。监测的项目为日降水量。通过降水监测数据，可以计算降水量距平、标准化降水指数（SPI）、连续无雨日数等旱情评估指标。

4.1.2 水文监测

4.1.2.1 地表水监测

地表水监测包括河道水文监测和水库水文监测。

四川省现有河道水文站 167 处。旱情评估中可以利用该监测数据进行河道径流距平的计算。

四川省有水库水位站 223 处，这些数据主要监测水库的水位，通过库容曲线，可以计算各自的蓄水量情况。监测频率分日监测、周监测和旬监测不等。但省水文部门通过这些数据定期生成《水情旬报》，即至少每旬可以获得全省的水资源情况。旱情评估中可以利用该数据进行水库蓄水距平的计算。

由于四川有许多的小水库、小塘坝等水利工程，这些工程在抗旱过程中发挥了立竿见影的作用，对于解决人畜饮水困难具有重要的意义。但是这些小微型水利工程的蓄水情况很难统计，难以汇总如全省水资源情况中。所以，利用河道水文监测和水库水位监测这两类数据计算的河道径流距平和水库蓄水距平等指标在旱情评估中将给予较小的权重，或将其用于旱情发展趋势的比较判断。

4.1.2.2 地下水监测

四川省现有地下水监测井 494 处，但多数为生产、生活用井。现已有 258 处地下水观测井实现自动遥测。地下水监测数据将作为旱情评估和抗旱决策的辅助数据，不直接作为旱情评估的指标。

4.1.3 土壤墒情监测

四川省现有土壤墒情监测站 103 处，其中水利部门有 17 处，农业部门有 86 处。四川省水利和农业部门的数据共享情况较好，因此，这 103 个气象站点均可以用于日常干旱评估。

4.1.4 饮用水情况监测

饮用水水量情况目前尚无全面的、时效的监测手段，主要依靠统计上报的方式获得。

饮用水水质监测方面的站点数量尚不掌握。初步判断，如果存在部分饮用水水质监测站，则大部分的监测站点主要布设在大中城市、重要农业灌区，难以满足全省范围的水质监测需要。并且，由于经费与人员、仪器设备等原因，水源地水质监测频次低，未能实现水质自动监测和移动监测，无法及时掌握水质变化情况，还不能满足抗旱工作的需要。

因此，饮用水监测整体是通过统计上报的方式获得，由各级行政区主管部门逐级上报，上报的内容主要是因旱饮水困难的人口数量。此监测信息将用于因旱饮水困难的评估。

4.2 旱情评估方法及步骤

由于四川省旱情的影响主要体现在农业、人畜饮水困难和城市干旱缺水等方面，因此本方案主要针对这几方面进行旱情评估的设计。

4.2.1 农业旱情评估

农业旱情是指作物受旱状况，即土壤水分供给不能满足作物发芽或正常生长要求，导致作物生长受到抑制甚至干枯的现象。对于一次较大范围的干旱过程而言，不仅不同流域、省（自治区、直辖市）、地（市）、县（区）之间的受旱程度不同，就是同一区域内不同地块之间、不同作物之间的受旱程度也不尽相同。因此，农业旱情监测评估需要分两步进行，第一步是点上农业旱情即耕地或农作物受旱程度评估；第二步是区域农业旱情评估。

4.2.1.1 点上农业旱情评估

点上农业旱情评估的方法主要包括土壤相对湿度法、降水量距平法、标准化降水指数法、作物缺水率法、连续无雨日数法、水库蓄水距平法和河道径流距平法等。

1. 土壤相对湿度

农作物的水分供应主要是靠根系直接从土壤中吸取的，土壤中水分不足会影响农作物的正常发育。土壤相对湿度是衡量土壤水分含量的指标之一，是指土壤含水量占田间持水量的比值。土壤含水量是指一定体积的土壤中所含有水分的百分比，又称土壤含水率，通常有重量含水量和体积含水量两种表示方法，计算土壤相对湿度时通常采用重量含水量。田间持水量是指田间土壤能稳定保持的最高含水量。土壤相对湿度的计算如下：

$$W=\frac{\theta}{F_c}\times 100\%$$ 式 4-1

其中：W —土壤相对湿度（%）；

θ —土壤平均重量含水量（%）；

F_c —土壤田间持水量（%）。

土壤含水量指标是目前研究比较成熟，且能较好反映作物旱情状况的可行指标，对于已建立土壤墒情监测站点的地区，应优先采用土壤相对湿度评估农业旱情。由于不同质地的土壤保墒性能不同，为使评价指标具有通用性和可比性，采用土壤相对湿度作为评估指标。等级划分标准参见表 4.1。

表 4.1: 土壤相对湿度旱情等级划分表

干旱等级	轻度干旱	中度干旱	严重干旱	特大干旱
土壤相对湿度(%)	60>W≥ 50	50>W≥ 40	40>W≥ 30	W<30

2. 降水量距平

降水量距平百分率是指某一时段内降水量与多年同期平均降水量之差占多年同期平均降水量的比值。计算公式如下：

$$D_p=\frac{P-\overline{P}}{\overline{P}}\times 100\%$$ 式 4-2

式中：D_p —降水量距平百分率〔%〕；

P —计算时段内降水量（mm）；

$\overline{P}$ —多年同期平均降水量（mm），一般采用近 30 年的平均值。

降水距平法反映了降水与同期平均状态的偏离程度，具有方法简单、意义明确的优点。对于尚未建立墒情监测站点但已建立雨量监测站点的雨养农业区，可考虑采用降水量距平法评估农业旱情。考虑到降水对农业旱情的影响有持续性，旱情严重程度与前期雨量大小和分布有关，计算时段可根据情况选用月尺度、季尺度和年尺度。对于四川省的旱情评估，推荐采用月尺度和季尺度相结合的方式。等级划分标准参见表 4-2。

表 4.2: 降水距平百分比干旱等级划分表

旱情等级	轻度干旱	中度干旱	严重干旱	特大干旱
Dp（月尺度）	-60＜Dp≤-40	-80＜Dp≤-60	-95＜Dp≤-80	Dp≤-95
Dp（季尺度）	-50＜Dp≤-25	-70＜Dp≤-50	-80＜Dp≤-70	Dp≤-80

3. 标准化降水指数（SPI）

标准化降水指数是表征某时段降水量出现的概率多少的指标之一，该方法是由 McKee 等在评估美国科罗拉多干旱状况时提出的。由于不同时间尺度、不同地区降水量变化幅度很大，直接用降水量在时空尺度上很难相互比较，而且降水分布是一种偏态分布，而不是正态分布，因此，标准化降水指数先求出降水量Γ分布概率，然后再进行正态标准化。计算步骤如下：

假设某时段降水量为随机变量，则其分布的概率密度函数为：

$$f(x)=\frac{1}{\beta^{\gamma}\Gamma(x)}x^{\gamma-1}e^{-x/\beta}\ (x>0)$$ 式 4-3

式中：γ—形状参数，用极大似然估计方法求得，$\gamma>0$；β—尺度参数，用极大似然估计方法求得，$\beta>0$。

$$\hat{\gamma}=\frac{1+\sqrt{1+4A/3}}{4A}$$ 式 4-4

$$\hat{\beta}=\bar{x}/\hat{\gamma}$$ 式 4-5

$$A=\lg\bar{x}-\frac{1}{n}\sum_{i=1}^{n}\lg x_i$$ 式 4-6

式中：$\bar{x}$—降水量多年平均值；x_i—降水量资料样本值；n—计算序列的长度。

确定概率密度函数中的参数后，对于某一年的降水量x_0，可求出随机变量x小于x_0事件的概率为：

$$F(x<x_0)=\int_0^{\infty}f(x)dx$$ 式 4-7

估计降水量为 0 时的事件概率：

$$F(x=0)=m/n$$ 式 4-8

式中：m—降水量为 0 的样本数；n—总样本数。

对Γ分布概率进行正态标准化处理，即将（式 4-7）（式 4-8）求得的概率值代入标准化正态分布函数，即：

$$F(x<x_0)=\frac{1}{\sqrt{2\pi}}\int_0^{\infty}e^{-z^2/2}dx$$

式 4-9

对（公式 4-10）进行近似求解，得到标准化降水指数，即 SPI ：

$$SPI=S\frac{t-(c_2t+c_1)t+c_0}{[(d_3t+d_2)t+d_1]t+1.0}$$

Eq. 4-10

式中：$t=\sqrt{\ln\frac{1}{F^2}}$， F 为（公式 4-8）或（公式 4-9）求得的概率；当 $F>0.5$ 时， $S=1$，当 $F\leq 0.5$ 时， $S=-1$； c_0=2.515517、c_1=0.802853、c_2=0.010328、d_1=1.432788、d_2=0.189269、d_3=0.001308。

该方法适用于月以上尺度旱情监测与评估，能较好地反映干旱强度和持续时间，而且具有多时间尺度应用的特性，因而得到广泛应用。 SPI 的计算只需要降水量资料，资料容易较获取，避免了机理模型繁杂的计算和大量经验性的参数输入。

虽然该指标较降水距平指数复杂，但普遍认为比降水距平指数更好的反映干旱情况，因此，建议在条件允许的情况下，优先选择该指数进行旱情评估，计算的时段为月尺度。等级划分标准参见表 4.3。

表 4.3: SPI 指数干旱等级划分表

旱情等级	正常阶段	预警阶段	轻度干旱	中度干旱	严重干旱	特大干旱
SPI	0≤SPI	0≤SPI＜-0.5	-1＜SPI≤-0.5	-1.5＜SPI≤-1	-2＜SPI≤-1.5	SPI≤-2

4. 作物缺水率

作物缺水率是指某一时段内农作物实际需水量与可用或实际提供的灌溉水量之差占同期农作物实际需水量的比值。计算公式如下：

$$D_w=\frac{W_r-W}{W_r}\times 100\%$$

式 4-11

式中 D_w—作物缺水率（%）； W_r—计算期内作物实际需水量（m^3）； W—同期可用或实际提供的灌溉水量（m^3）。

在用作物缺水率评估农业旱情时，可用或实际提供的灌溉水量可以是河道、蓄水工程、地下水等能供给的水量之和，也可以是单一形式的供水量，不同作物实际需水量可采用作物系数法和彭曼公式计算，也可查阅《中国主要农作物需水量等值线图》确定。等级划分标准参见表 4.4。

表 4.4: 作物缺水率干旱等级划分表

旱情等级	轻度干旱	中度干旱	严重干旱	特大干旱
D_w	5＜Dw≤20	20＜Dw≤35	35＜Dw≤50	Dw>50

5. 连续无雨日数

连续无雨日数是指连续无有效降雨的天数。考虑到不同季节气候以及作物需水量的差异性，一般在春季（3～5 月份）和秋季（9～11 月份），日雨量小于 3 毫米的降雨视为无有效降雨，该日即视为无雨日；夏季（6～8 月份），日雨量小于 5 毫米的降雨视为无有效降雨，该日即视为无雨日。在一些偏远的雨养农业区，农业靠天吃饭，墒情监测基础往往非常薄弱，甚至连雨量站也没有，此时可以考虑用连续无雨日数来大概评判。等级划分标准参见表 4-5。

表 4.5: 连续无雨日数干旱等级划分表

评估时段	轻度干旱	中度干旱	严重干旱	特大干旱
春季(3～5 月)	30	40	50	＞60
夏季(6～8 月)	20	30	40	＞50
秋季(9～11 月)	30	40	50	＞60
冬季(12～2 月)	30	40	50	＞60

6. 河道径流距平

河道径流距平指数是通过河道径流距平百分率来反映区域干旱情况。河道径流距平是指计算期内河道流量与多年同期平均流量的差值；河道径流距平百分率是指河道径流距平值与多年同期平均值的百分比值。河道是指区域内较大河流。计算公式如下：

$$D_F = \frac{F - \bar{F}}{\bar{F}} \times 100\% \qquad \text{式 4-12}$$

其中：D_F —计算期内河道径流距平百分比（%）

F — 计算期内河道流量（m^3/s）

$\bar{F}$ — 计算期内多年同期平均流量（m^3/s），采用近 30 年的平均值

一般情况下，以一段时间内的河道累计流量来计算径流距平，比如过去一个月或几个月内的流量，四川省的旱情评估选择一个月的尺度进行计算。

该指标主要用于主要江河湖泊的监测，可以是一条河流上的多个水文监测站点，也可以是一个区域内的多个河流上的多个监测站点。目前的四川省水文站监测完全可以支撑此指标的计算。等级划分标准参见表 4-6。

表 4.6: 河道径流距平指数干旱等级划分表

旱情等级	正常阶段	预警阶段	轻度干旱	中度干旱	严重干旱	特大干旱
河道径流距平(%)	$0 \le D_F$	$-15 \le D_F < 0$	$-40 \le D_F < -15$	$-65 \le D_F < -40$	$-90 \le D_F < -65$	$D_F < -90$

7. 水库蓄水距平

水库蓄水距平指数是通过水库蓄水距平百分率来反映区域干旱情况。水库蓄水距平是指计算期内水库蓄水量（水位）与多年同期平均需水量（水位）的差值；水库蓄水距平百分率是指水库蓄水距平值与多年同期平均值的百分比值。计算公式如下：

$$D_L = \frac{L - \bar{L}}{\bar{L}} \times 100\% \qquad \text{式 4-13}$$

其中：D_L—计算期内水库蓄水距平百分比（%）；

L— 计算期内水库蓄水量（m^3）/水位（m）；

$\bar{L}$— 计算期内多年同期平均水库蓄水量（m^3）/水位（m），采用近 30 年的平均值。

该指数能够反映区域的水资源情况，与气象指标结合，能够更好的预测旱情的发展趋势，一般采用月尺度进行计算。等级划分标准参见表 4.7。

表 4.7: 水库蓄水距平指数干旱等级划分表

旱情等级	正常阶段	预警阶段	轻度干旱	中度干旱	严重干旱	特大干旱
水库蓄水距平(%)	$0 \le D_L$	$-10 \le D_L < 0$	$-30 \le D_L < -10$	$-50 \le D_L < -30$	$-80 \le D_L < -50$	$D_L < -80$

4.2.1.2 区域农业旱情评估

区域农业旱情评估主要是对县级和县级以上行政区域农业总体受旱状况进行评估。区域农业旱情评估采用区域农业旱情指数法，计算公式如下：

$$I_a = \sum_{i=1}^{4} A_i \times B_i \qquad \text{式 4-14}$$

式中：I_a—区域农业旱情指数（指数区间为 0~4）；

i—点上农业旱情等级（i=1、2、3、4 依次代表轻度、中度、严重和特大干旱）；

A_i—评价区域内 i 级点上农业旱情对应的农作物面积之和与耕地总面积的比值（%）；

B_i—不同旱情等级的权重系数（轻度、中度、严重和特大干旱的权重系数 B_i 分别赋值为 1、2、3、4）。

区域农业旱情指数是一个复合指数，理论上可以选择任意指标进行组合计算，但是通常情况下，需要考虑指标的物理意义，比如，降水量距平指数和标准化降水指数（SPI）都是由降水量数据计算得到的，因此，包含的信息具有一定的重复性，所以，在计算区域农业旱情指数时，尽可能避免同时选择这两个指标。再比如，连续无雨日数属于简单粗放的指标，相比较而言，没有土壤相对湿度、SPI 等指数能更准确地反映旱情，因此，在计算区域农业旱情指数时，如果有更准确的指标，则尽可能不选择准确性较差的指标，避免引入噪声。

鉴于此，本方案建议采用土壤相对湿度、标准化降水指数、作物缺水率、水库蓄水距平、河道径流距平进行区域农业旱情指数的计算。如果该区域降水量数据不充分，没有长序列的逐日降水量数据，而只有是否降水的观测数据，则将标准化降水指数用连续无雨日数代替。如果该区域一直采用降水量距平指数进行旱情评估，或者该区域的技术力量不足，在计算标准化降水指数方面存在一定困难，则将标准化降水指数用降水量距平指数代替。如果该区域在土壤墒情监测、水库蓄水距平监测或河道径流距平监测方面缺少数据，则去掉其中某项指标。等级划分标准参见表 4-8。

表 4.8: 区域农业旱情等级划分表

干旱等级	轻度干旱	中度干旱	严重干旱	特大干旱
I_a	0.1≤Ia＜0.5	0.5≤Ia＜0.9	0.9≤Ia＜1.5	1.5≤Ia≤4

4.2.2 因旱饮水困难评估

因旱饮水困难是指由于干旱造成城乡居民临时性的饮用水困难，不包括长期饮水困难。因旱饮水困难监测评估包括点上因旱饮水困难监测和区域因旱饮水困难监测。四川的相当一部分山区在干旱发生时，尤其容易导致饮水困难情况。

4.2.2.1 点上因旱饮水困难评估

点上因旱饮水困难可根据取水地点的改变或人均基本生活用水量以及因旱饮水困难持续时间来评估。因旱饮水困难必须同时满足表 4.9 中条件一和条件二，其中条件一任意一项符合即可。

表 4.9: 因旱饮水困难判别条件

判 别 条 件			判别标准
条件一	取水地点		因旱改变
	基本生活用水量（L/人.天）	南方	＜35
条件二	因旱饮水困难持续时间（天）		>15

4.2.2.2 区域因旱饮水困难评估

通常，可采用因旱饮水困难人口的绝对数量或因旱饮水困难人口占总人口的比例两个指标，本方案中，对全省因旱饮水困难的评估采用因旱人饮困难人口的绝对数量作为评判指标。

表 4.10: 因旱饮水困难干旱等级划分表

旱情等级	轻度干旱	中度干旱	严重干旱	特大干旱
P_a（万人）	100≤Pa＜200	200≤Pa＜400	400≤Pa＜500	500≤Pa

4.2.3 城市旱情评估

城市旱情指标采用城市干旱缺水率。城市干旱缺水率是指城市日缺水量与城市正常日供水量的比值。计算公式为：

$$P_g = \frac{Q_z - Q_s}{Q_z} \times 100\% \qquad \text{式 4-15}$$

式中 P_g—城市干旱缺水率（%）

Q_z—城市正常日供水量（万立方米）

Q_s—城市实际日供水量（万立方米）

本方案中，城市旱情评估是逐个城市进行判断，对于区域城市旱情评估，通常采用受旱城市的数量比例作为评判标准，比如四川省城市旱情评估通常以三分之一数量的城市达到某一旱情等级作为全省城市干旱的标准。等级划分标准参见表 4-11。

表 4.11: 城市干旱缺水率干旱等级划分表

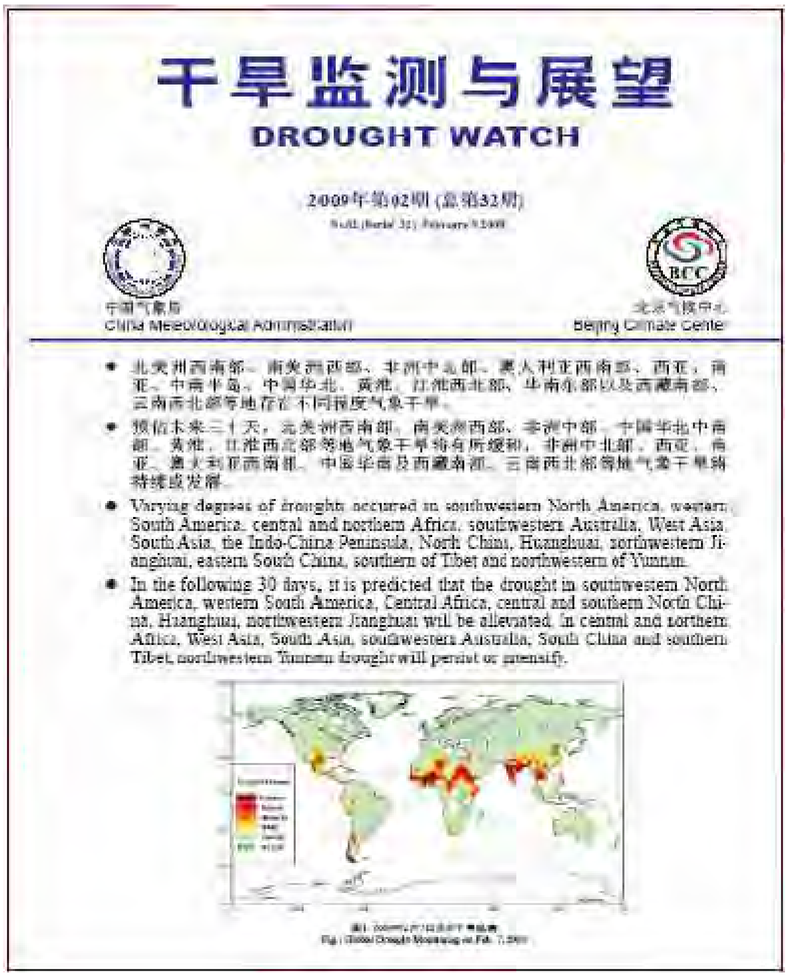
旱情等级	轻度干旱	中度干旱	严重干旱	特大干旱
P_g	5≤Pg＜10	10≤Pg＜15	15≤Pg＜25	25≤Pg

4.3 旱情预测方法

旱情预测既是干旱灾害风险管理的关键，也是难点。根据四川省的工作实际和现有的数据获取渠道，提出了基于气象预报的旱情预测方式。

气象预报旱情预测是通过国家气象中心发布的气象预报进行旱情预测。该气象预报每月发布未来 30 天的天气预报情况，包括干旱的发展趋势等，其预测是全球范围的，四川省可以关注局部地区。如下所示是中国气象局发布的干旱监测与展望。

图 4.1: 中国气象局干旱发布的《干旱监测与展望》月报



干旱监测与展望

DROUGHT WATCH

2009年第02期 (总第32期)

中国气象局
China Meteorological Administration

北京气候中心
Beijing Climate Center

- 北美洲西南部、南美洲西部、非洲中北部、澳大利亚西南部、西亚、南亚、中南半岛、中国华北、黄淮、江淮西北部、华南东部以及西藏南部、云南西北部等地存在不同程度气象干旱。
- 预估未来三十天，北美洲西南部、南美洲西部、非洲中部、中国华北中南部、黄淮、江淮西北部等地气象干旱将有所缓和，非洲中北部、西亚、南亚、澳大利亚西南部、中国华南及西藏南部、云南西北部等地气象干旱将持续或发展。
- Varying degrees of droughts occurred in southwestern North America, western South America, central and northern Africa, southwestern Australia, West Asia, South Asia, the Indo-China Peninsula, North China, Huanghuai, northwestern Jianghuai, eastern South China, southern of Tibet and northwestern of Yunnan.
- In the following 30 days, it is predicted that the drought in southwestern North America, western South America, Central Africa, central and southern North China, Huanghuai, northwestern Jianghuai will be alleviated. In central and northern Africa, West Asia, South Asia, southwestern Australia, South China and southern Tibet, northwestern Yunnan drought will persist or intensify.

5 旱灾风险管理阶段划分和触发点

5.1 管理阶段划分和触发点

受认识所限，长期以来，灾害的危机管理模式在世界各国一直占据着主导地位。干旱危机管理模式是指当干旱发生后才开始作出反应，临时制定应急对策和措施，以期减轻干旱灾害损失和影响。在这种模式下，主要是针对眼前和局部的问题，采取的措施往往是临时性和应急性的，干旱管理也往往局限于实际旱情发生阶段。如此一来，常常是头痛医头、脚痛医脚，完全处于被动应急的局面，很容易陷入“从一个灾害走向下一个灾害”的恶性循环模式。但是，随着对干旱问题的认识的进一步深化，人们已经认识到要实现对干旱的有序、有效管理，应急状态的抗旱管理已无法满足要求，而要实现常态和应急状态的统合管理，即干旱风险管理。干旱风险管理模式是通过监测、分析、预测干旱的发生、发展规律，评估干旱可能造成的损失和影响，优化组合各类抗旱措施，有序、有效应对干旱灾害，并对干旱灾害进行后评价的全过程。在这种模式下，将高效的风险减免机制和理性的控制过程统合考虑，通过博弈应急管理和常态管理各自牺牲一部分利益，实现全局最优。与干旱危机管理相比，干旱风险管理是一种主动、有备、周密和有效的防旱减灾管理模式，干旱管理阶段不再局限于实际旱情发生阶段，而是贯穿于干旱发生发展的全过程，表现为应急管理常态化，常态管理应急化。

从干旱风险管理理念出发，基于对四川省历史旱情旱灾的分析，结合目前的干旱监测状况，将四川省干旱管理阶段划分为正常阶段、预警阶段、实际旱情发生阶段和旱情解除阶段，相应的判别指标及触发条件参见表 5-1。在正常阶段和预警阶段，推荐采用标准化降水指数（SPI）、河道径流距平指数和水库蓄水距平指数为判别指标。在实际旱情发生阶段，采用区域农业旱情指数、因旱饮水困难比例和城市干旱缺水率指标为判别指标。

表 5.1: 四川省干旱管理阶段

管理阶段			判别指标及触发点		可能的干旱影响
			指标	触发点	
旱前	正常阶段		标准化降水指数 SPI	SPI≥0	没有任何旱象
	预警阶段		标准化降水指数 SPI 河道径流距平 D_F 水库蓄水量距平 D_L	-0.5≤SPI<0 -15%≤ D_F <0 -10%≤ D_L <0 以 SPI 指数为主，其他两个指标为辅	尚未造成影响
旱中	实际旱情发生阶段	轻度干旱	区域农业旱情指数 Ia 因旱人饮困难人口 Pa 城市干旱缺水率 Pg	0.1≤Ia<0.5 100 万人≤Pa<400 万人 5%≤Pg<10% 有 1 个条件满足即可	农业用水出现短缺
		中度干旱	区域农业旱情指数 Ia 因旱人饮困难比例 Pa 城市干旱缺水率 Pg	0.5≤Ia<0.9 200 万人≤Pa<400 万人 10%≤Pg<15% 有 1 个条件满足即可	农业用水短缺加剧，部分偏远山区可能发生因旱人畜饮水困难
		严重干旱	区域农业旱情指数 Ia 因旱人饮困难比例 Pa	0.9≤Ia<1.5 400 万人≤Pa<500 万人	农业用水短缺严重，偏远山区因旱人畜饮水困难加重，城市用水

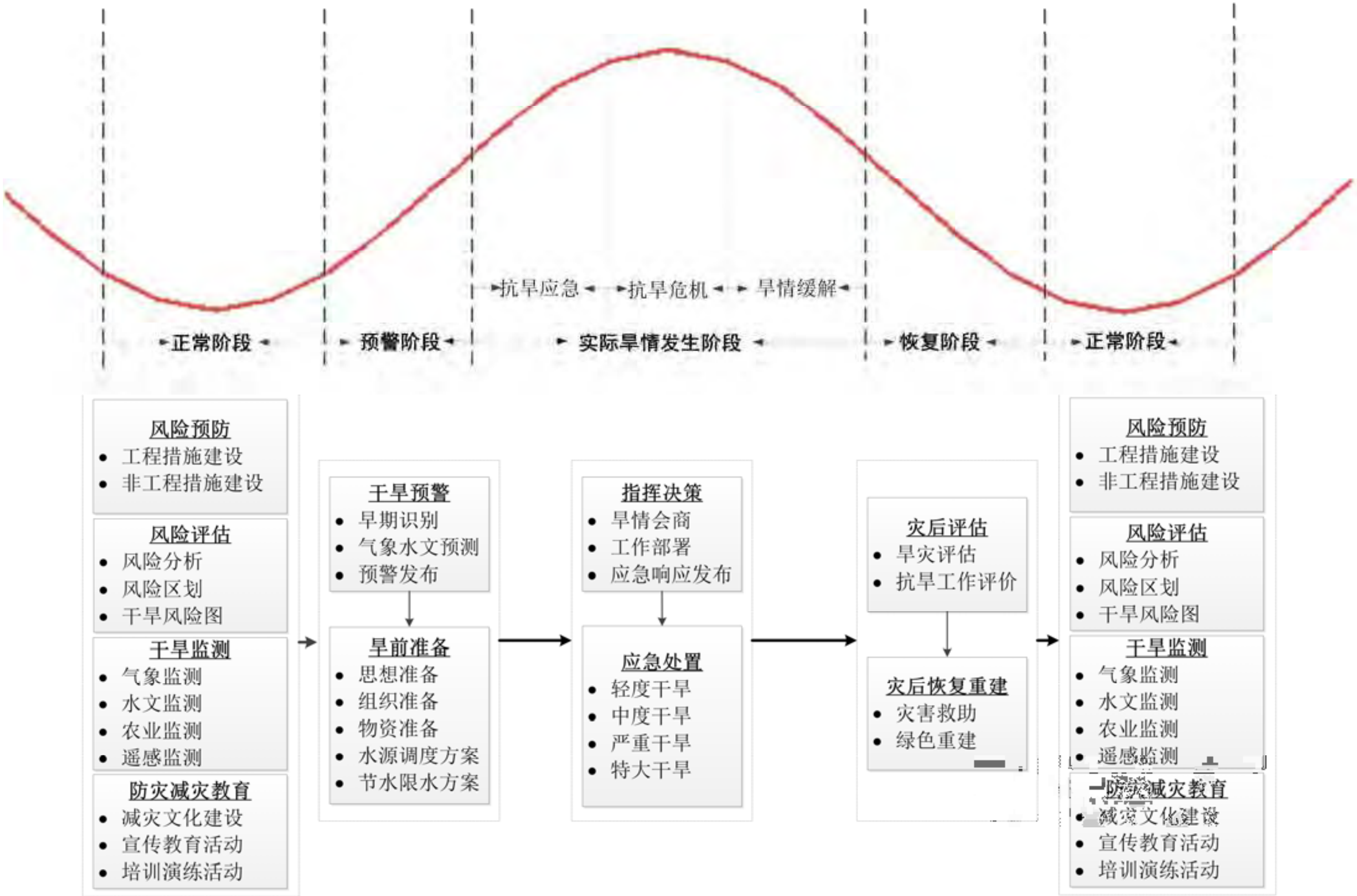
管理阶段		判别指标及触发点 指标	触发点	可能的干旱影响
		城市干旱缺水率 Pg	15%≤Pg<25% 有 1 个条件满足即可	可能受到影响
	特大干旱	区域农业旱情指数 Ia 因旱人饮困难比例 Pa 城市干旱缺水率 Pg	1.5≤Ia≤4 500 万人≤Pa 25%≤Pg 有 1 个条件满足即可	农业用水、农村人畜饮水、城市用水都受到较大影响
旱后	恢复阶段			直接影响解除

注：表中正常阶段、预警阶段的指标计算时段均采用月尺度；城市干旱缺水率是指全省有 1/3 的城市达到此标准。

这里，有两个问题需要特别指出。首先，由于对干旱问题缺乏深入的认识，我国目前大部分省份都将干旱预警和应急响应等同起来，而实际上，这是两个完全不同的概念。干旱预警是指在干旱发生之前，通过选择一组相应的干旱预警指标，对目标区域内的水文和气象因子变化以及来水和用水状况进行监视，对潜在的干旱进行早期识别，并及时将干旱预警信息通过各种途径发布给政府相关部门、各类社会机构和公众，以提早做好应对准备，达到最大限度地减轻干旱损失的目的。而应急响应是指在实际旱情发生之后，为减轻干旱损失而所采取的临时性、应急性行动。为此，在本计划中，将干旱预警和实际旱情发生之后的响应区分开来。其二，包括四川在内的我国大部分地区的现行抗旱预案中旱情等级标准存在不合理之处。各省的抗旱预案大都在 2009 年以前已经完成，基本都是依据 2006 年出台的《国家防汛抗旱应急预案》制定。限于当时的认识，且经实践证明，该国家预案中旱情等级标准存在两个主要的问题：一个是仅用受旱面积单一要素难以客观真实反映区域受旱情况，因为对于一次较大范围的干旱过程而言，不仅不同流域、省（自治区、直辖市）、地（市）、县（区）之间的受旱程度不同，就是同一区域内不同地块之间、不同作物之间的受旱程度也不尽相同，因此需要既考虑受旱面积又考虑受旱程度的区域旱情指标；二是全国不同级别行政区使用同一等级划分阈值是不合理的。鉴于此，我国于 2009 年颁布了第一个规范抗旱减灾工作的行业技术标准《旱情等级标准》，提供了一整套关于农业、牧业、因旱人饮困难、城市旱情评估的方法，以期实现全国各级行政区旱情评估的统一规范、简便易行、快速高效。为此，在本计划中，将依据《旱情等级标准》确定四川省旱情评估方法及标准。

当处于不同的干旱管理阶段时，干旱管理行动措施的重点也是不同的，参见图 5-1。如在正常阶段，重点是进行干旱风险预防、风险评估、干旱监测以及防灾减灾教育等，而在预警阶段，则重点是进行潜在干旱早期识别、预警发布以及旱前准备等。

图 5.1: 四川省各阶段主要干旱管理行动



5.2 正常阶段的干旱管理

干旱管理，从本质上说是对干旱时期缺水问题的管理。但是，这并不意味着干旱管理只在干旱时期才进行，相反，要真正做到有序、有效应对干旱，功夫还须下在平时。换言之，正常阶段的干旱管理是整个干旱管理的奠基石。长期以来，我国干旱管理的关注点主要还是集中在实际旱情发生阶段的应急处置，而忽视了正常阶段的干旱管理。正常阶段的干旱管理之所以如此重要，主要有两方面的原因：一是从干旱风险管理的本质来看，它不是被动地应对干旱风险，而是积极地预防干旱风险。因此，旱期应对和旱后恢复只是风险管理的一部分，而旱前预防才是风险管理的根本所在。二是从干旱成灾机理来看，不同于洪水几天、几小时甚至几分钟就可能成灾，干旱成灾过程较为缓慢，可能是数月、数个季节甚至数年。因此，干旱管理应该向常态化管理发展，重视正常阶段的干旱管理。总的来说，正常阶段的干旱管理应着眼于长远，同时兼顾日常管理，主要包括以下几个方面：

风险预防

工程措施建设

目前，四川省已基本形成以蓄水工程、引水工程、提水工程、调水工程和水井工程等为主的防旱抗旱减灾工程体系。但总的来说，四川的水利工程多以小、微型为主，大、中型等骨干水利工程甚少，水利基础设施薄弱，抵御干旱灾害的能力严重不足，远远不能满足全省经济社会发展和人民生活用水需要。水资源配置格局尚不完善，工程抗旱功能挖潜不足，抗旱供水能力远远不能满足需求，导致一些地区农业抗灾能力低、部分城乡供水安全隐患较多等。因此，为了提高干旱期间的抗旱供水能力，需要长远计划，大力加强水利基础设施的建设。

- 加强控制性水源工程建设。已建水库中，大型水库只有 5 座，总库容 28.64 亿 m3，占全省蓄水能力的 23.7%，抗御较大干旱能力弱。
- 加大病险水库除险加固力度。全省水利工程绝大多数是 20 世纪 50 年代至 70 年代时修建的，工程建设标准低，设施老化严重。
- 加强农田水利工程建设，加快灌区续建配套和节水改造，不断提高蓄供水能力和水资源利用效率。目前全省尚有 900 多万亩设计灌溉面积没有配套，难以发挥应有的效益。
- 在旱山村，加强水池、水窖、山平塘、石河堰等小微型抗旱设施建设、清淤扩建、整修配套等。
- 在充分拓展和挖掘现有水利设施抗旱功能的基础上，以保障干旱期间人畜饮水安全为首要目标，按照先挖潜、后配套，先改建、后新建的原则，因地制宜建设一批规模合理、标准适度的抗旱应急备用水源工程。

非工程措施建设

相比于工程体系来说，我国非工程体系建设一直没有得到足够的重视，滞后较多。近年来，四川省抗旱主管部门也逐渐认识到非工程措施对于防旱、抗旱的重要性，并取得了一定的进展，自上而下的抗旱组织体系已经形成，逐步开展了政策法规制定、抗旱预案及规划编制、抗旱信息化建设等非工程体系建设。

- 进一步充实各级抗旱组织机构职能。在旱情紧急时期，各级抗旱组织机构可以高效有序地指挥和协调相关部门联动响应，但是鉴于干旱灾害具有缓慢发展的特性，这种旱情紧急期的部门联动不能满足经济社会对抗旱工作的要求。因此，除应急抗旱职能外，各级抗旱组织机构还需要强化常规抗旱职能，自上而下突破体制障碍，完善内部组织结构，让各成员单位更多地参与日常抗旱工作，建立多部门的统一协作机制，充分发挥其日常干旱管理的组织和协调作用。
- 加强法规、制度和技术标准体系建设。四川省还没有专门的抗旱方面政策法规，要结合实际，加快建设地方性抗旱法规，如《《四川省〈中华人民共和国抗旱条例〉实施细则》等。加强《旱情等级标准》（SL424-2008）、《抗旱预案编制导则》（SL590-2013）、《干旱灾害等级标准》（SL663-2014）、《抗旱规划编制导则》等技术标准的宣贯和培训。
- 修改完善抗旱预案、抗旱规划的编制。目前，全省大部分县市已经完成抗旱预案的编制，但普遍存在将干旱预警与应急响应混为一谈等基本概念不清、抗旱应急响应触发条件科学性不够、响应行动可操作性不强等问题。
- 进行农业产业结构调整。鼓励发展设施农业、特色农业，推进节水节能的日光温室大棚和畜牧小区，建立高效节水型农业生产结构，提高农业抗灾减灾能力。
- 加强抗旱物资储备和管理。在易旱地区建设规模合理、标准适度的抗旱物资库，同时建立相应的抗旱物资管理办法等。

风险评估

- 以县为单元，全面收集整理历史干旱数据，并进行系统入库。
- 组织相关科研力量，运用基于灾害系统理论的模糊综合评估方法、基于随机理论的概率统计方法、基于干旱频率及潜在损失的旱灾风险评估方法等研究进展开展四川全省干旱风险分析。
- 根据干旱风险分析结果，完成全省干旱风险区划。
- 绘制完成干旱风险图，并定期更新。

干旱监测

- 统一规划，形成覆盖全省、布局合理、信息完备、资源共享的旱情监测站网，包括气象监测、水文监测、土壤墒情监测、水质监测、遥感监测等。
- 加强气象监测，包括降水、蒸发、气温等信息。
- 加强水文监测，包括河流、湖泊、水库的水位、流量、蓄水量等地表水信息和地下水水位等地下水信息。
- 加强土壤墒情监测，分为固定站、移动站和试验站三类监测站。
- 加强水质监测，涉及引水调水控制断面、重要江河、湖泊、区界水体、重要供水水源地的水质监测。
- 加强遥感监测。
- 建立供用水情况监测。
- 建立部门间信息共享机制，形成干旱监测数据信息共享网络。

防灾减灾信息公开及教育

- 加强抗旱减灾文化建设。将抗旱减灾文化建设作为加强社会主义文化建设的重要内容，将抗旱减灾文化服务作为国家公共文化服务体系的重要组成部分，把抗旱减灾纳入国民教育体系，加强中小学校抗旱减灾知识教育。
- 开展抗旱减灾宣传教育活动。结合全国“防灾减灾日”、“国际减灾日”、“世界水日”、“中国水周”等，组织开展多种形式的抗旱减灾宣传教育活动，营造全社会共同参与防灾减灾的文化氛围。开发抗旱减灾系列科普读物、挂图和音像制品等，宣传相关的法律法规、日常节水技巧以及避灾减灾措施等，增强整个社会对干旱的适应能力、提高人们灾害自救能力。
- 组织相关人员进行抗旱应急培训演练。根据发生过的干旱，检验准备工作是否就绪，制定的行动是否存在问题。

5.3 干旱预警阶段的干旱管理

干旱预警阶段的干旱管理，是在干旱发生之前，通过选择一组相应的干旱预警指标，对目标区域内的水文和气象因子变化以及来水和用水状况进行监视，对潜在的干旱进行早期识别，并及时将干旱预警信息通过各种途径发布给政府相关部门、各类社会机构和公众，以提早做好应对准备的过程。简而言之，干旱预警是对可能发生的干旱进行预先的判断，并将准确及时的预警信息传递给相关的机构和人员，以期能作出及时的响应。因此，重视干旱预警的作用，切实提升干旱预警的能力和水平，是降服“旱魔”的重要法宝。

干旱预警

- 早期识别。基于气象、水文、农业等干旱监测数据，进行干旱预警指标值滚动计算，判断是否达到干旱预警触发条件。
- 气象水文预测。基于省气象局短期气候预测以及省水文局水文预测结果，预测并研判未来一段时间内可能的干旱发展趋势。
- 发布预警。如果气象水文预测情况表明未来干旱呈发展趋势，则及时向可能发生干旱的区域发布预警信息，向社会通报旱情，动员全社会做好抗旱准备工作。干旱预警发布单位为当地防汛抗旱指挥机构，特殊情况下由地方人民政府发布。可采用公文、广播、电视、报刊、网络、短信等方式进行干旱预警发布。

旱前准备

- 思想准备。加强宣传，增强全民预防干旱和自我保护的意识，做好抗旱思想准备。
- 组织准备。健全抗旱组织指挥机构，落实抗旱责任制、责任人，加强抗旱服务组织建设。各级防汛抗旱指挥机构应当加强抗旱服务网络建设，鼓励和支持社会力量参与抗旱服务组织建设。
- 抗旱检查。实行以组织、工程、预案、物资、监测为主要内容的分级检查制度，发现薄弱环节要明确责任，限时整改。重点检查组织领导、责任制、水源工程、抗旱措施等是否到位。
- 物资准备。按照分级负责的原则，合理储备必须的抗旱物资。
- 抗旱水源调度初步方案制定。受旱地区要按照“先生活、后生产，先地表、后地下，先节水、后调水”的原则，进行抗旱水源的调度。抓住有利的气候条件，加大人工增雨力度。

- 限水初步方案制定。农业生产推广节水灌溉技术和耕作技术，制定限水方案；制定城乡生活及工业节水、限水方案，限制缺水地区发展高耗水、高污染项目，着力发展节水型工业和服务业。

5.4 实际旱情发生阶段的干旱管理

根据旱情评估方法、步骤，进行区域旱情评估。根据旱情的严重程度不同，划分为轻度干旱、中度干旱、严重干旱和特大干旱四个等级。不同旱情等级的干旱管理重点和主要管理行动也是不同的。

轻度干旱

- 召开会商会议。由省防汛抗旱指挥部办公室主任主持旱情会商会议，分析旱情发展动态，视情况启动Ⅳ级响应。
- 加强旱情监测和预报工作。水文、气象、农业等部门密切配合，及时掌握旱情变化趋势，为抗旱主管部门指挥决策提供依据。同时，通过网络、信息、媒体等渠道，及时向旱区农民提供准确的雨情、水情等旱情信息。
- 加强对农业生产的指导。通过媒体或农业技术下乡等方式，向农民介绍耐旱作物信息，各种农产品的市场供求状况和价格信息，耐旱耕作技术等，使农民根据自身的生产条件做出应对干旱的具体办法选择。
- 做好旱区计划用水。在确保农村人畜饮水的前提下，积极组织抗旱水源及临时设施抢灌受旱农田。
- 做好节水宣传工作。鼓励用水户主动节水，减少或停止没必要的用水。
- 持续关注干旱变化情况，为可能出现的中度干旱做好准备。

中度干旱

当发生中度干旱时，雨养农业出现严重缺水，灌溉农业出现缺水，少量偏远山区可能出现农村人蓄饮水困难。当旱情评估结果显示为中度干旱时，触发中度干旱响应行动。

- 召开会商会议。由省防汛抗旱指挥部副指挥长主持召开正式会议或电视、电话会议，分析旱情发展动态，视情况启动III级响应。并将旱情上报省委、省政府、国家防汛抗旱总指挥部办公室。
- 加强旱情监测和预报工作。水文、气象、农业等部门密切配合，及时掌握旱情变化趋势，为抗旱主管部门指挥决策提供依据。同时，通过网络、信息、媒体等渠道，及时向旱区农民提供准确的雨情、水情等旱情信息。
- 加强抗旱水源的统一调度和管理。确保居民生活用水，干旱严重地区，启动农村自备水源，保证农村人畜饮水。适当压缩农业供水，适当限制洗车、洗浴等高耗水服务行业用水。适时实施人工增雨作业。
- 加强农业水利技术指导。通过媒体或技术下乡等方式，指导旱区农民开展缺水灌溉、节水灌溉，减少农业用水。
- 适时开展抗旱浇灌。发动抗旱泵站、机井、小口井、各类抗旱流动机械，适时开展旱区抗旱浇灌。渠道淤积严重地区，要发动劳力及时清淤疏浚，保证输水畅通。
- 持续关注干旱变化情况，对可能出现的严重干旱做好准备。

严重干旱

发生严重干旱，农业用水短缺严重，偏远山区因旱人畜饮水困难进一步加重，城市用水可能受到影响。当旱情评估结果显示为严重干旱时，触发严重干旱响应行动。此时抗旱重点是保障城镇生活用水和农村人畜饮用水、重点工业企业生产用水、种子生产用水、高效经济作物用水等。

- 召开会商会议。由省防汛抗旱指挥部常务副指挥长主持召开正式会议，分析旱情发展动态，启动Ⅱ级响应，部署抗旱工作。并将旱情上报省委、省政府、国家防汛抗旱总指挥部办公室。
- 加强旱情监测和预报工作。水文、气象、农业等部门密切配合，及时掌握旱情变化趋势，为抗旱主管部门指挥决策提供依据。同时，省防汛抗旱指挥部定期发布旱情通报，并通过网络、信息、媒体等渠道，及时向旱区农民提供准确的雨情、水情等旱情信息。
- 加强抗旱指导工作。派出由省防汛抗旱指挥部成员单位组成的工作组、专家组赴旱区指导抗旱。
- 保障抗旱物资。由省防汛抗旱指挥部办公室统一安排抗旱交通运输和物资供应，统一调度抗旱用电，省经济委员会保障旱区提水所需电力、成品油等供应。
- 保障抗旱经费。省财政厅落实抗旱经费并及时下拨。
- 加强农业抗旱指导。省农业厅负责农业抗旱指导，指导农民做好农作物的田间管理和病虫害防治，负责农业生产自救、恢复等工作。
- 启动抗旱水量调度方案。实行地表水、地下水统一调度。坚持供水工程统一指挥，统一调度。组织应急抗旱水源工程建设，严重缺水城市启动抗旱备用水源和应急供水方案。调配各类临时抗旱设备，启用临时性措施，如临时设置抽水泵站，开挖输水渠道；应急性打井、挖泉、建蓄水池等；应急性跨流域调水；在保证水工程安全的情况下，适量抽取水库死库容；临时在江河沟渠内截水；依法适时实施人工增雨作业；对饮水水源发生严重困难地区临时实行人工送水。
- 制定并实施用水量紧急限制方案。在确保居民生活用水的前提下，根据干旱期供水紧缺状况，确定用水优先次序，限定供水量。压缩农业供水量，适当缩小农业灌溉范围。控制工业用水。限制洗车、洗浴等高耗水服务行业用水。严重缺水地区，居民生活用水实行定量、定时供应。
- 加强社会宣传和动员。组织、协调新闻媒体向社会公众及时报道旱情、灾情，宣传抗旱工作，动员社会各方面力量支援抗旱救灾工作。
- 持续关注干旱变化情况，对可能出现的特大干旱做好准备。

特大干旱

发生特大干旱，将出现社会经济严重缺水，农业干旱持续加重，工业用水受限加剧，部分城市发生居民生活用水困难。当旱情评估结果显示为特大干旱时，触发特大干旱响应行动。此时，抗旱重点是保障城镇生活用水和农村人畜饮用水。

- 召开会商会议。由省防汛抗旱指挥部指挥长主持召开正式会议，分析旱情发展动态，启动Ⅰ级响应，部署抗旱工作。将旱情上报省委、省政府和国家防汛抗旱总指挥部，必要时请示省委常委会、省政府常务会听取汇报并作出决策和部署。
- 加强旱情、灾情监测。省防汛抗旱指挥部做好旱情预测、预报，做好旱情、灾情及抗旱工作情况的统计和报送，及时发布旱情。省气象局加强天气监测和预报，及时向省防汛抗旱指挥部提供相关的气象信息、土壤墒情和卫星遥感监测信息，适时组织人工增雨作业。

- 加强抗旱救灾指导工作。省防汛抗旱指挥部在发布预警后 24 小时内派专家组赴受旱地区技术指导，派出抗旱检查组、督导组，检查指导抗旱救灾工作，并动员受旱地区群众紧急抗旱。
- 保障抗旱物资。由省经济委员会协调抗旱物资的生产和调度，省交通厅优先运送抗旱物资，为抗旱物资提供运输保障。
- 保障抗旱经费。省财政厅落实特大抗旱经费，及时下拨抗旱专项资金。
- 加强农业抗旱指导。省农村经济委员会负责农业抗旱指导，指导农民做好农作物的田间管理和病虫害防治，负责农业生产自救、恢复等工作。
- 启动抗旱水量调度方案。实行地表水、地下水统一调度。坚持供水工程统一指挥，统一调度。实行全省水库联合调度，为满足城乡生活及重点行业需水要求，可适当超采地下水。增加应急抗旱水源工程建设，严重缺水城市全部启动抗旱备用水源和应急供水方案。调配各类临时抗旱设备，启用临时性措施，如临时设置抽水泵站，开挖输水渠道；应急性打井、挖泉、建蓄水池等；应急性跨流域调水；在保证水工程安全的情况下，适量抽取水库死库容；临时在江河沟渠内截水；依法适时实施人工增雨作业；对饮水水源发生严重困难地区临时实行人工送水。
- 根据更严重的缺水情况，制定并实施用水量紧急限制方案。在确保居民生活用水的前提下，根据对国民经济发展的影响程度及干旱期供水紧缺状况，确定用水优先次序，限定供水量。缩小农业灌溉范围，减少农业供水量。严格控制工业用水。对于高耗水的企业，必要时停止供水。停止洗车、洗浴等高耗水服务行业用水。限制城乡生活用水。对于严重缺水地区，居民生活用水实行限额、定时供应。人畜饮水严重困难的地区组织临时人工送水。
- 宣传动员。各级防汛抗旱指挥部根据国家有关规定，统一发布旱情、灾情及抗旱信息，组织、协调新闻媒体向社会公众及时报道旱情、灾情，宣传抗旱工作，动员社会各方面力量支援抗旱救灾工作。

5.5 恢复阶段的干旱管理

当全省旱情解除之后，进入恢复阶段的干旱管理。

灾后评估

- 干旱灾害等级评估。省防汛抗旱指挥部办公室根据各市上报情况及评估组的评估结果组织灾情核查组，深入灾区进行调查核实，最后将核查结果与省救灾应急指挥部办公室（设在省民政厅）协调一致后上报省政府及国家防汛抗旱总指挥部。同时，根据《干旱灾害等级标准》（SL663-2014）确定全省干旱灾害等级。
- 抗旱工作评价。进行抗旱工作效果评价，并总结实际抗旱工作中取得的经验和存在的问题。

灾后恢复重建

- 灾民救助。灾情核实后，各级防汛抗旱指挥部对受灾地区救助对象进行登记，实施救助。
- 恢复灾后生产。各级人民政府、有关主管部门帮助受灾群众尽快恢复生产，做好灾后自救。

- 水利工程修复。水行政主管部门应当对水利工程进行检查评估，并及时组织修复遭受干旱灾害损坏的水利工程，或优先列入年度修复建设计划。受旱灾损毁的水利工程一般包括农业灌溉渠系、小型水库坝体、塘坝、扬水泵站设施、输水管线、机电井等。
- 物资、设备等归还。有关地方人民政府防汛抗旱指挥机构应当及时归还紧急抗旱期征用的物资、设备、交通运输工具等，并按照有关法律规定给予补偿。

Appendix L. Generic Local Level Drought Management Plan

L.1 Introduction

This appendix provides details of the current plans and recommendations for future drought management plans. It is structured as follows:

- L.1 Introduction
- L.2 Current Approaches for Drought Relief Plans
- L.3 Strategic Framework for Provincial DMP and Local DMP Relationships
- L.4 Proposed Prototype Municipal or County Level DMP
- Annex 1 Contents of an Example Municipal (or County) Level Drought Management Plan

The TA is recommending a long term strategy based on IWRM and drought management best practice to tier drought management decision making and allow local decision makers to implement appropriate risk reduction and mitigation measures. Given this long-term concept, the TA team reviewed some existing municipal level drought relief plans in all three pilot provinces. The following sections provide summaries of the planning processes used in this sampling of municipal plans.

L.2 Current Approaches of Local Plans in Provincial Drought Relief Plans

L.2.1 Liaoning Province

The TA project has cited a drought management plan produced under the DFID WRDMAP project in Chaoyang as a good example of a local drought management plan for the PRC. In reality, this Chaoyang DMP was merely a research effort and the Chaoyang municipality has prepared a drought relief plan in normal PRC practice.

According to the city's specific situation, drought classification as follows:

Table L.1: Chaoyang City Drought classifications

Drought Level	Alert Level	Arable land affected by the drought situation		Situation of rural drinking water		City water rate (%)
		Area (*Mu*)	Proportion of arable land (%)	Water (10 000)	Proportion of total rural population (%)	
Severe drought	Level Ⅰ Red	540	80	150	> 60	30
Severe drought	Level Ⅱ Orange	400	51-80	125	41-60	20-30
Moderate drought	Level Ⅲ Yellow	280	31-50	100	21-40	10-20
Mild drought	Level Ⅳ Blue	200	30	5 0	20	10

In drought occurs, the Municipal Flood Control and Drought Relief Headquarters According to statistics drought information to determine the appropriate level of drought and drought early warning level, the approval of the Municipal People's Government, Municipal Flood Control and Drought Relief Headquarters issued a formal text mode corresponding drought early warning information. Grade I – IV drought early

warning level followed by the color with red, orange, yellow, blue. Specific response actions are specified for the four drought levels.

L.2.2 Gansu Province

The Baiyin Municipal drought relief plan was reviewed in Gansu province. The following section summarizes their planning process. The Baiyin classification of drought is divided according to the type of drought arid between agricultural drought and urban categories. Based irrigation characteristics of the agricultural drought area, it is divided into rainfed agriculture and irrigated agriculture areas. The Agricultural Drought Disasters class is divided into: mild drought (Ⅳ grade), moderate drought (Ⅲ level), severe drought (Ⅱ grade) and droughts (Ⅰ level) four levels (with a tabular reference). Main agricultural indicators are:

- number of consecutive days without rain,
- rainfall and drought-hit area.

Reference indicators are:

- relative humidity of the soil,
- irrigation water deficiency,
- difficulty in drinking water,
- river runoff, and
- damage to several disaster areas.

Urban or city related drought classification use the following main indicator of water levels. The reference indicators are:

- reservoir levels,
- lowering of groundwater levels.

Drought class is divided into: mild drought, moderate drought, severe drought and severe drought in four levels. (standard PRC levels)

L.2.3 Sichuan Province

The Liangshan municipal drought contingency plan was reviewed. In agriculture drought measures, Liangshan uses the following agricultural drought classification:

Table L.2: Agricultural drought classification in Liangshan Municipality (prefecture), Sichuan Province

Evaluation Standard			Light Drought	Medium Drought	Severe Drought	Extreme Drought
Main indicator	Precip. Quantity	Cont. Days≥10 days	≤10			
		Cont. Days ≥15 days		≤10		
		Cont. Days ≥25 days			≤10	
		Cont. Days ≥50 days				≤10
	area affected by drought（%）		10--30	31--50	51--70	>70
Reference Indicator	area with actual damage (%)		10--20	21--40	41--50	>50
	production reduction (tenth)		<1	1--2	2--3	>3
	irrigation water deficiency (mm)		<50	50--100	100--200	>200

Standard soil relative humidity (%)	60-51	50--41	40--30	<30
Note : The consecutive day without rain (Cont. Days) refers to the number of days with ineffective rain less than 5mm.				

For the urban water situation in Liangshan, there is one major surface water intake that has regularly run dry and planning all revolves around assuring adequate intake water for the Xichang City. Various measures are proposed to maintain urban water requirements in dry season.

L.3 Strategic Framework for Provincial DMP and Local DMP Relationships

As outlined in Appendix K on the provincial DMPs, the provincial drought management plan has been developed under a presumed future tiering of drought management responsibilities with linked and specific roles and responsibilities at each layer of the process. Detailed water management decisions in IWRM are made at the lowest practical water management level. Given this framework, the provincial plan and local plans are part of an overall hierarchy of drought planning. The lowest level would be water companies, industries and agricultural interests. Their drought management activities are coordinated by county level and municipal level drought planning. The county and municipal level drought planning is managed and coordinated by these provincial plans, and the entire process has had guidance and oversight from the national level drought management process.

Since the PRC practice has been to develop drought response or relief plans at various levels, there will need to be some phasing in of the concept of drought management planning at all times, even during normal conditions. There may be an interim period where drought management and drought relief plans exist simultaneously for the local level, with the idea that the drought management plans should eventually supersede the need for separate drought relief plans.

L.4 Proposed Prototype Municipal or County Level DMP

Based on this tiered approach, the project team has assembled a prototype local level drought management plan applicable at municipality or county level, using a template from the United States as well as lessons learned from the WRDMAP project and the municipality drought management plan produced for Chaoyang Municipality in Liaoning Province.

This prototype or template form of drought management plan provides examples and ideas for the contents of such plans using approaches that are common in the USA and the UK while taking into account PRC institutional arrangements. Although this municipal/county level DMP was not a requirement of the project TOR, the TA team considers it a vital link in the risk based drought management planning process proposed for the PRC. In general, drought management should be undertaken at the lowest practical level, which would give the primary responsibility to the county level, operating under the guidance of the municipality. However, initially the municipality is likely to have a greater responsibility for implementation of the plan, gradually into a more supervisory role as capacity at the county level is built up. The precise details will need to be developed to suit local requirements and capacity in each municipality

Annex 1 – Contents of an Example Municipal (or County) Level Drought Management Plan

Notes:

1. *The Primary Reference for the Prototype is the Chaoyang DMP, WRDMAP Project, but examples from a USA municipal drought plan are also included.*
2. *It is recognized that municipal and county levels in the PRC already have Drought Response Plans for measures when the drought is in place. The concepts in this model plan will ultimately need to be integrated into the existing drought response plans. This integration of plans at local level was beyond the project scope of work. For the three pilot provinces new integrated drought management and drought response plans are being prepared.*
3. *This prototype contains some suggested contents from Chaoyang DMP and USA model, as ideas for consideration in any local level DMP in the PRC.*
4. *No actual municipal or county level DMPs will be produced by the TA team*

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Executive Summary

Plan Objectives
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Historical Drought and Impacts
Drought Vulnerability
Drought Risk Reduction and Mitigation
Drought Stages, Trigger Points and Response Targets
Drought Team and Responsibilities
Drought Public Information Campaign
Implementation and Monitoring
Formal Plan Approval and Updates

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Annex 2 – Outline of a Sample Municipal or County Level Drought Management Plan

1.0 INTRODUCTION

1.1 Plan Objectives

1.1.1 Process of Setting Goals and Objectives

Describe stakeholder and public processes used to set goals. Provide details of meetings and findings

1.1.2 Plan Objectives

The Plan objectives and operating principles are reflective of Municipality's water use priorities and played an important role in guiding the development of the Plan. The Drought Committee allocated and prioritized **Municipality XX's** water usage into the five categories shown in Table XX.

Table XX Typical USA Water Use Priorities

Priority	End Use	Description
1	Health and Safety	Single-family residential, multi housing, water treatment plant, hydrants (for emergency use), wastewater treatment plant, and hospital
2	Business	Indoor use by the commercial and public sector including schools, stores, offices, hotels, restaurants, etc., and outdoor use on golf courses.
3	Public outdoor irrigation	Parks, sports fields, and open spaces.
4	Construction water	Water used for construction purposes.
5	Outdoor irrigation	Outdoor irrigation in the single- and multi-family residences, and public and commercial sectors.

Table XX Example of Water Supply Priorities From Chaoyang DMP

Priority	Description
Top	Domestic water use for basic needs (urban and rural), hospitals, schools, livestock
	Minimum flows for the environment and basic needs for downstream water users
	Pillar industries e.g. power stations
	Irrigation for vegetable crops
	Industry
	Supplementary irrigation of field crops
	Mining and other industries needing large quantities of water and discharging polluted waste water
Bottom	Non-essential or 'luxury' use

Essential uses for the health and safety of the community were given the highest priority. Water uses for existing businesses were assigned a second priority, and construction and outdoor irrigation were assigned lower priorities.

Box XX. Typical US Municipal DMP Goals

- Preserve essential public services during any level of drought severity from mild to critical emergency conditions.
- Minimize the adverse drought-related impacts on public health and safety, economic activity, environmental resources, and individual lifestyles during a drought event.
- Provide a comprehensive yet flexible framework to guide **Municipality XX** staff on the drought risk reduction, mitigation and monitoring efforts at early stages of drought, followed by drought relief actions once drought has developed to serious levels.
- Effective communication of drought awareness and response information to water customers.
- Provide an efficient means to monitor and improve the effectiveness of the Plan over time.
- Closely coordinate the drought mitigation and response with **Municipality XX**'s water supply reliability planning efforts as well as with other **Municipality XX** and regional level policies and planning efforts. This includes Municipality and Provincial policy as well as **Municipality XX**'s Conservation Plan and multi-hazard mitigation and emergency operations plans.
- Provide sufficient contextual information in the Plan to convey the importance of drought preparedness and management to the public and how the actions in this Plan are relevant to reducing future drought-related impacts.

Box XX. Chaoyang DMP Goals: Example from WRDMAP Project

- Reduce the impacts of drought disaster through building awareness of drought management and undertaking effective measures to deal with droughts;
- Structure the framework of drought management organization for drought risk management, improve the cooperation and coordination between government drought management departments at all levels;
- Set out a system of monitoring and reporting to identify and track the onset, progress and recovery from droughts;
- Provide more information for drought management through drought prediction with appropriate new methods;
- Set out specified drought management plan and measures targeted on different water users to make a sure of equal/effective/ sustainable water use in drought condition;
- Pay more attention to environment in drought condition;

1.2 Introduction to Drought Risk Reduction, Mitigation and Response Planning

The drought management plan is based on an underlying premise that drought management activities are conducted at all times in order to avoid and minimize impacts to humans and the economy when a drought is imminent or occurs. As such, the Normal scenario defines the roles of the drought management team and institutions during non-drought situations. As the early information system provides meteorological trend information on the potential onset of a drought, the roles of the institutions switch into Pre-Drought scenario, with increased efforts and beginning of the drought risk reduction and mitigation measures. Once the drought is in full effect (according to PRC Level IV up to Level I), the team have another set of operating procedures (mainly now defined in existing drought relief plans). The Post-Drought roles are one of recovery and return to the Normal mode.

Drought risk reduction and mitigation refers to actions taken in advance of a drought that reduce potential drought-related impacts when the event occurs. Drought risk reduction and mitigation measures continue in a more comprehensive fashion once the condition moves from Pre-Drought into actual Drought levels, in a hierarchical fashion with ever more aggressive measures being employed. Each municipality or county will need to assess the range of international examples of such measures provided in the project and assess and employ a hierarchy of measures appropriate to their local conditions and context. Refer to ANNEX A for examples.

Box XX Chaoyang Example Drought Issues

Major issues that currently affect the Upper Daling River Basin and require careful management during periods of drought include:

Water Supply Companies (WSCs)
- High transmission losses (pipe leakage)
- Limited pumping and transmission capacity
- Water quality often associated with rotational supply and pipe fractures
- Weak demand management
  - Meters
  - Tariffs/Cost Recovery
  - Water value awareness
  - High leakage losses within households with no or broken meters
  - Recycling of grey water

Industrial Enterprises
- Highly consumptive processes
- Compliance shortcomings with recycling regulations
- Compliance shortcomings with discharge controls
- Water charges transmit no need for conservation
- Imposition of polluter pays principle needs improved enforcement

Irrigation
- Loss of rain-fed crops in poor rural areas
- Creeping loss of peripheral irrigated crops as water supply reduces
- High transmission losses in many irrigation systems (canals, pipes)
- High field losses owing to old irrigation practices
- Inefficient surface water infrastructure (dams, reservoirs)
- High crop water requirements for some crops that are grown
- Need for more deficit irrigation and technical support to farmers

The main purpose of drought mitigation and response planning is to preserve essential public services and minimize the adverse effects of drought on public health and safety, economic activity, environmental resources, and individual lifestyles during a drought event. Effective drought management plans remove the “crisis” from drought response efforts, reduce the hardship caused by water shortages, and raise public confidence in the actions taken to address the water supply shortage. Drought mitigation refers to actions taken in advance of a drought that reduce potential drought-related impacts when the event occurs. This Drought Management Plan (Plan) includes both drought mitigation and response planning; however, it does not address emergency water shortage events as a result of acute catastrophes such as an unexpected failure of a major raw water conveyance facility. It is also important to note that this Plan is effective in drought and non-drought years. Drought mitigation, monitoring of drought indicators, and drought public education are implemented on an annual basis regardless of whether it is a dry or wet year.

Summary of past plans if any

1.3 Drought Planning and Water Conservation

Water conservation and drought planning both involve a combination of strategies for reducing water demand. However, the main objective of a water conservation plan is to achieve continuing, long-term improvement in water use efficiency while reducing overall water demands. A drought management plan focuses on long-term drought mitigation in addition to response strategies that provide short-term responses to temporary drought-related water supply shortages. Nevertheless, conservation measures that

result in an ongoing reduction in water demand can provide long-term drought mitigation benefits and can be considered as both conservation and drought mitigation measures.

Table XX Typical USA Conservation Measures

Conservation Measures
Outdoor watering only allowed 6:00 pm to 9:00 am
Toilet rebate program
Washer rebate program
Dishwater rebate program
Loan program for installation of xeriscape
Historic water usage provided on water bills
Water wasting ordinance
Incentives for water efficient fixtures and/or appliances on house resale or remodeling
New landscape ordinances that promote wise water use
Xeriscape loans
Promote indoor water audits
Public education program promoting conservation
Provide acoustical meters to assist customers in identifying leaks
Provide instructional resources on developing a business/office specific conservation plan

These conservation measures also provide drought mitigation benefits by providing water savings that can extend into subsequent years. For example, savings achieved through the installation of water efficient toilets provide water savings for the service life of the toilet. These savings may reduce stress on **Municipality XX**'s system during drought years. A portion of the water saved through these conservation measures is stored as drought reserves in each of **Municipality XX**'s reservoirs.

1.4 Water Abstraction Permits

Water abstraction permits come under the regulations as required by State Council Decree 460. SCD460 allows for reallocation of abstraction permits under drought conditions. This will become a much stronger lever for making drought planning risk reduction and mitigation over time.

Summarize abstraction permits in local jurisdiction

2.0 DROUGHT VULNERABILTY ASSESSMENT

A vulnerability assessment is the process of identifying, quantifying, and prioritizing (or scoring) the vulnerabilities in a system. Vulnerability from the perspective of drought planning includes an assessment of the threat from potential drought hazards to various sectors across social, economic, environmental, and political fields. Vulnerability assessments are typically performed according to the following steps:
1. Cataloguing assets and resources in a system and across sectors
2. Assigning quantifiable value (or at least rank order) and importance to those resources
3. Identifying the vulnerabilities or potential threats to each resource
4. Mitigating or eliminating the most serious vulnerabilities for the most valuable sectors/assets

Vulnerability assessment has many things in common with risk assessment. Risk assessment for natural hazard planning is principally concerned with investigating the risks surrounding infrastructure (or some other object) and people. Such analyses tend to focus on causes and the direct consequences for the studied object. Risk assessment thus involves determination of vulnerabilities and hazards to establish risks and risk probabilities in terms of frequency of occurrence, magnitude and severity, and consequences.

A **drought vulnerability analysis serves to categorize sectors and assets in order to drive the risk management process**. It is necessary for a comprehensive vulnerability assessment to be conducted prior to starting a risk assessment. The vulnerability of a local area can be approximated by looking at previous impacts due to drought and identifying existing conditions, or metrics, that would cause a local area to be more or less impacted during future droughts. These metrics are determined on a sector-by-sector basis.

Examples from both USA and Chaoyang DMP included.

2.1 Profile of Municipality (or County)

Municipality XX is located XXXX. **Municipality XX** provides treated water and wastewater services to a xx km^2 service area with approximately XXXX people. The current population is expected to grow as **Municipality XX**'s xxxx increases.

Municipality XX typically relies on a combination of surface flow water rights and storage water allocation. **Municipality XX** typically diverts water directly from xxxx. **Municipality XX** also has a groundwater supply that is used to xxxxx.

Water resources in **Municipality XX** consists of

INSERT MAPS AND TABLES AND GRAPHS

Municipality XX's water supply systems in various sectors consist primarily of

INSERT MAPS AND TABLES AND GRAPHS

Meteorological conditions in **Municipality XX** affect the frequency and effects of drought. They consist of

INSERT MAPS AND TABLES AND GRAPHS

2.2 Existing Water Demands

A detailed summary of the growing demand for water in **Municipality XX** is presented in Appendix XX.

2.2.1 Water Supply Companies (WSCs)

The water supply companies (WSCs) who operate within **Municipality XX** in the XXXX Basin are:

INSERT MAPS AND TABLES

Appendix XX contains maps showing their location and the sub-catchments affected. As part of the Municipal drought management procedures, each of these water supply companies will be required to prepare, maintain and operate a Water Supply Drought Management Plan approved by **Municipality XX**. The purpose of these plans will be to minimize the impact of droughts on water supplies to customers of the water companies by minimizing consumption and leakage in order to maintain supply.

2.2.2 Industrial Enterprises

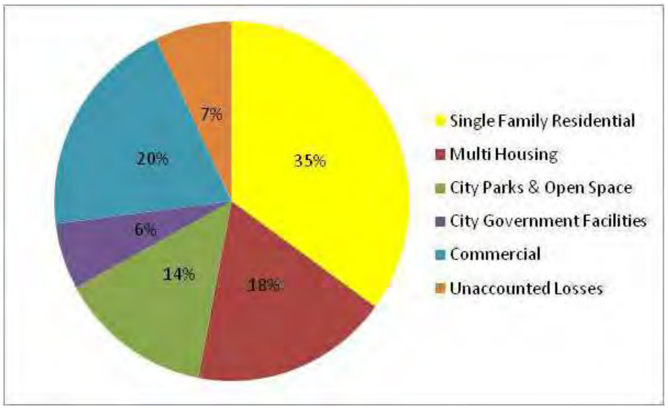
A list and location map of industrial enterprises that use large quantities of water is provided in Appendix XX. Each enterprise that consumes more than XXXX m^3/year will be required to maintain and operate an Industry Drought Management Plan approved by **Municipality XX**. The purpose of these plans will be to minimize the impact of droughts on industrial production by minimizing waste and maximizing recycling. Progressive reduction of non-essential production will be included in these plans.

2.2.3 Irrigation

A list and location map of the main irrigation areas, dams and reservoirs in the XXXX River Basin is provided in Appendix XX. The managers (Water Management Stations WMSs) of large (INSERT CRITERIA FOR SIZE) irrigation schemes that are will be required to maintain and operate an Irrigation Drought Management Plan approved by **Municipality XX**. The purpose of these plans will be to minimize the impact of droughts on agricultural production by minimizing supply and field losses and using drought resistant crops. Progressive reduction of low value production will be included.

Figure xx 20xx-20xx Average Customer Water Use

Need sectoral use by sector by local area (municipality or county)



2.3 Historical Assessment of Drought, Available Supplies and Demands

USA Example

Droughts **are** a natural phenomenon of xxx's climate. The xxxx drought was by far the worst drought year on record Province wide in terms of surface water. While Municipality XX's storage rights were of sufficient seniority to allow for the legal filling of both reservoirs, there was a shortage of physical supply. Snowpack above xxxx and xxx Reservoirs was 50% of normal in late April and, as shown in Figure XX and Figure XX, storage in xxxx and xxxx reservoirs was xx% and yy% of normal, respectively, by July 1, XXXX.

Figure XX Storage in xxxx Reservoir

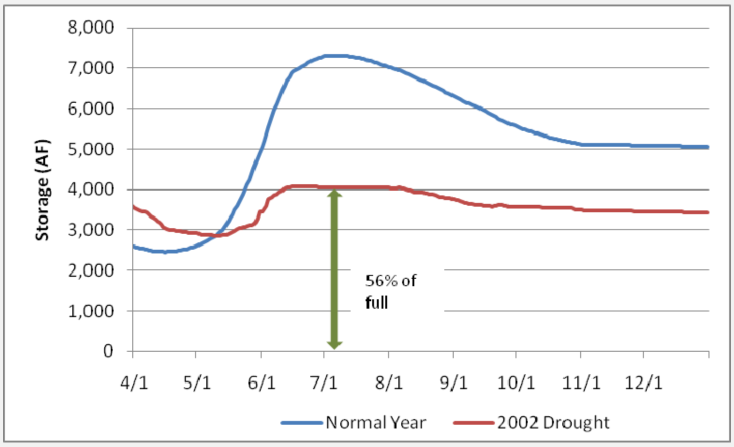
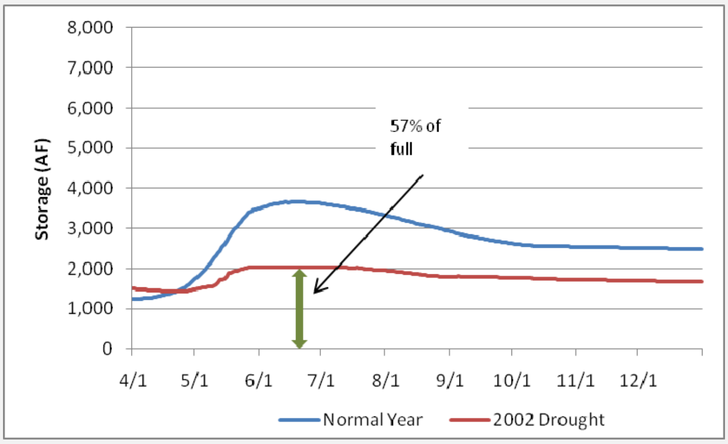
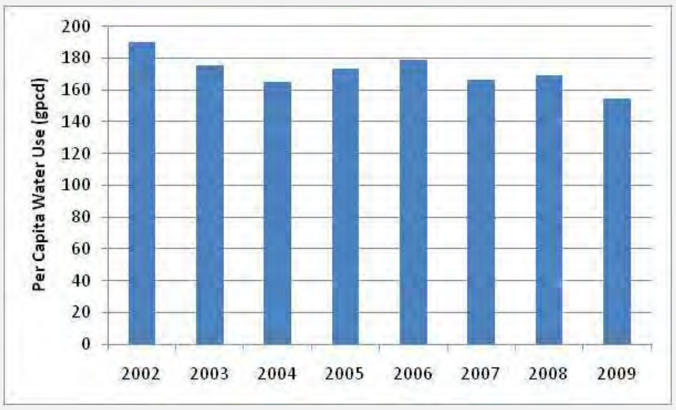


Figure XX Storage in xxxx Reservoir



While **Municipality XX** had sufficient supplies to meet demands in XXXX, water restrictions were enforced as a precautionary response in recognition that the drought could extend into the following year and drought response would be essential to meeting future XXXX demands. Figure XX shows **Municipality XX**'s per capita water usage from XXXX to XXXX. Per capita water demands in the years following the drought were noticeably lower with an average 5-year per capita water usage of XXXX (20XX -20XX). This post-drought reduction in per capita water usage is a common trend observed by many municipalities throughout the Province and is likely attributed to behavioral changes in response to regional public drought campaigns promoting increased water conservation. A portion of **Municipality XX's** reduction may also be attributed to new long-term water conservation measures initiated in XXXX, as well as above average rainfall during the irrigation season. **Municipality XX** typically uses five-year running average per capita water usage values for operational and annual planning purposes.

Figure XX Municipality XX Per Capita Water Demands



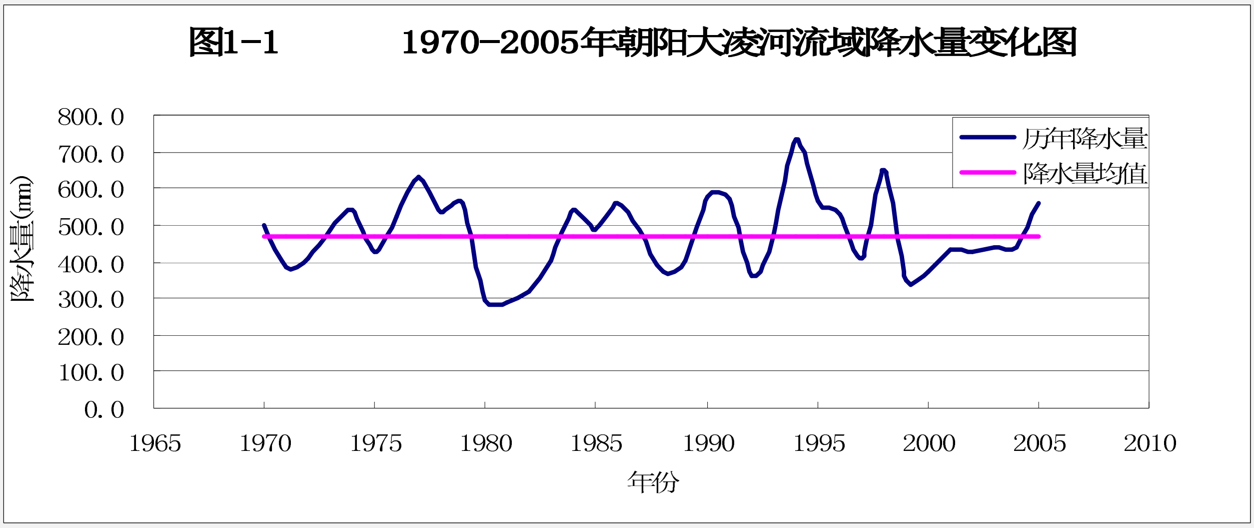
The XXXX drought emphasized the importance of effective water supply reliability and drought planning and provided the following lessons:

- In XXXX, **Municipality XX** received customer complaints regarding taste and odor as a result of algae growth in xxxx Reservoir. While this is a normal occurrence near the end of the summer, reservoir levels are such that this usually does not result in a water quality issue. However, in XXXXX, the abnormally low reservoir level resulted in less water to dilute the organic material, exacerbating the problem. Management should reserve supplies in the xxxx Reservoir reducing the need to use the poor quality water in **xxxx** Reservoir.
- **Municipality XX**'s efforts to educate the public on drought during the XXXX drought were generally well received and most customers were responsive to water restrictions. However, a sufficient number of water restriction infractions were found, suggesting that enforcement via utility staff neighborhood patrol and fines were necessary.
- **Municipality XX** is projected to almost double in population over the next 40 years. While demand management is an important component of drought planning, the XXXX drought confirmed that additional supplies are needed to not only meet increasing demands, but to also provide insurance for the uncertainty of climate change and increased drought protection.
- Water rates were restructured in XXXX to compensate for the reduction in revenue from water sales and increased treatment costs during the drought. An increasing block rate structure was adopted where the water users at the highest two tiers of water usage are charged significantly higher water rates. A portion of the funds generated from these higher rates are put into a drought response reserve account to compensate for drought related reductions in retail sales and costs associated with implementation of the drought response plan.
- In November of XXXX, a variety of temporary leasing arrangements with downstream farmers were being discussed as a potential means to provide needed supplies to **Municipality XX** if necessary in XXXX. While **Municipality XX** did not need to utilize any of these arrangements, these discussions highlighted the benefit of working with the agricultural community and possibly neighboring municipalities in finding synergistic beneficial arrangements during a drought.

Chaoyang DMP Example

The historical record of monthly average precipitation from 1970 to 2005 is given in Appendix XX. The average value of precipitation was calculated by arithmetic average method using 33 rainfall gauging stations in Chaoyang. Figure XX presents the change in inter-annual precipitation in Chaoyang within the Daling River Basin. It shows that the inter-annual average precipitation in the period **1970 to 2006 was 471.3mm**. The inter-annual average precipitation from **1980 to 1983 was only 326.2 mm**. The minimum of annual average precipitation was by **289.9 mm in 1981**.

Figure XX: Long Term Annual Rainfall Series in the Upper Daling Basin (33 station average).



The average rainfall profile in the Upper Daling Basin is given in Figure XX. The runoff pattern at Chaoyang gauging station is shown in Figure XX. It indicates that the precipitation during May to September in Chaoyang area of the Upper Daling Basin can have a great impact on drought severity. The continued low rainfalls for several years will lead to the occurrence of extreme and long-term hydrological / socio-economic drought conditions. The runoff process of Daling river in Chaoyang, based on historical record, is presented in Figure XX.

Figure XX: Average Rainfall Profile in the Upper Daling Basin

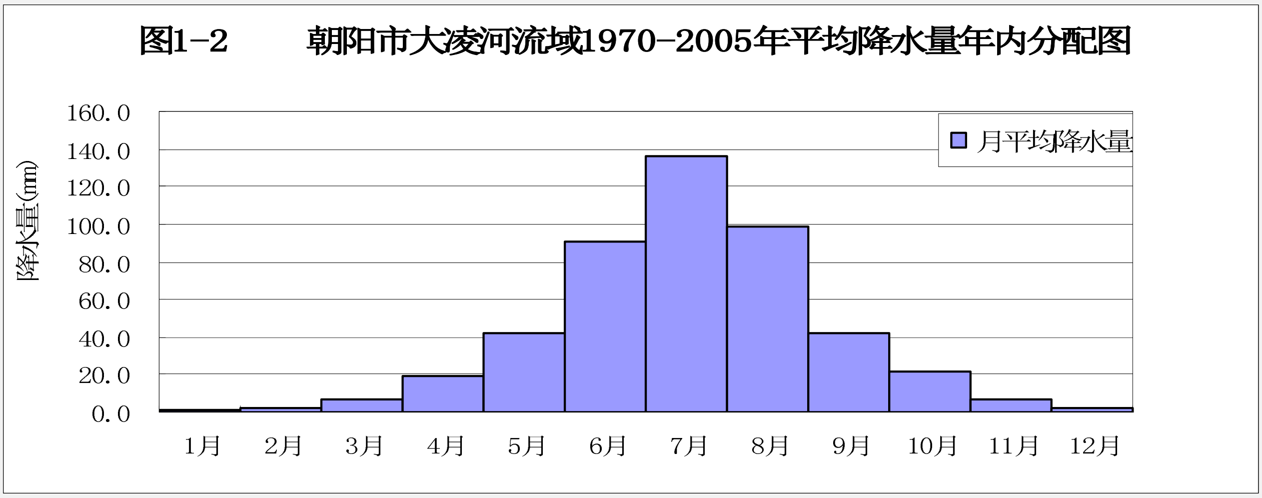


Figure XX: Typical River Daling Discharge Hydrograph at the Chaoyang Gauge Station

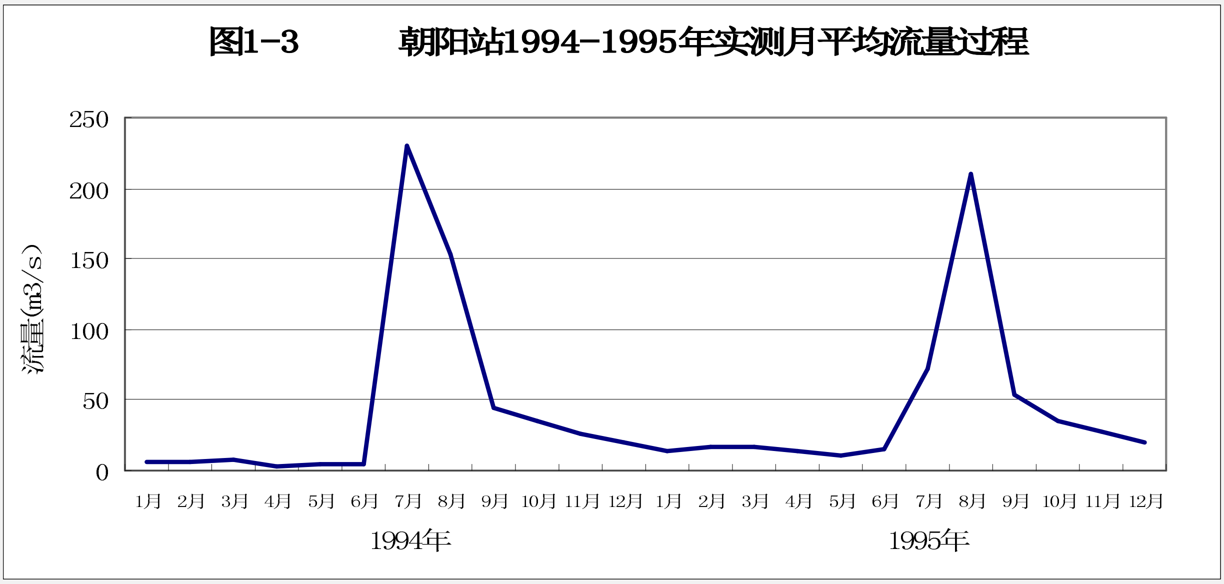
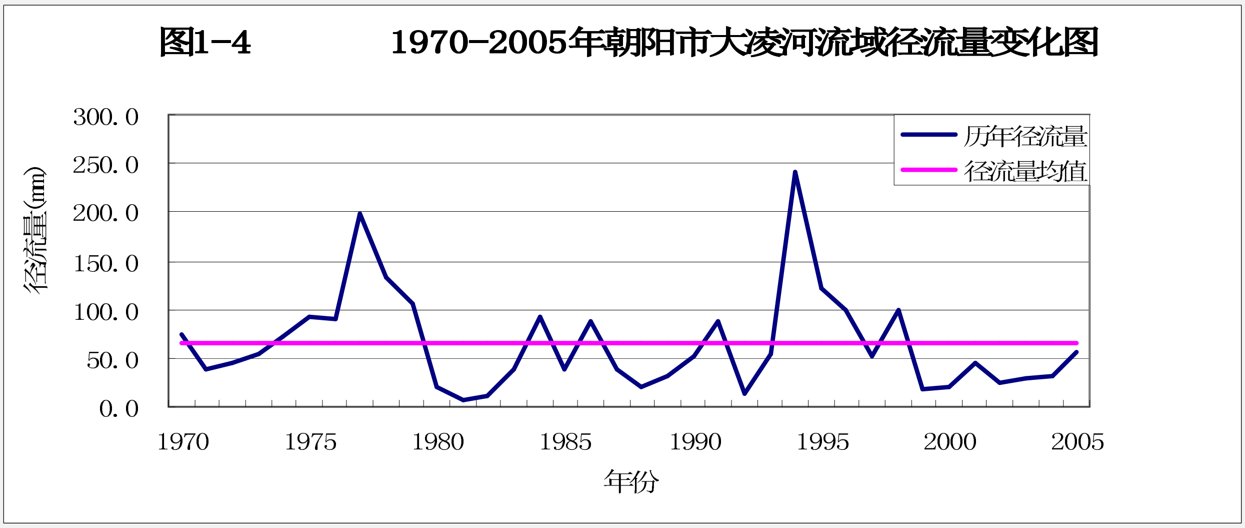
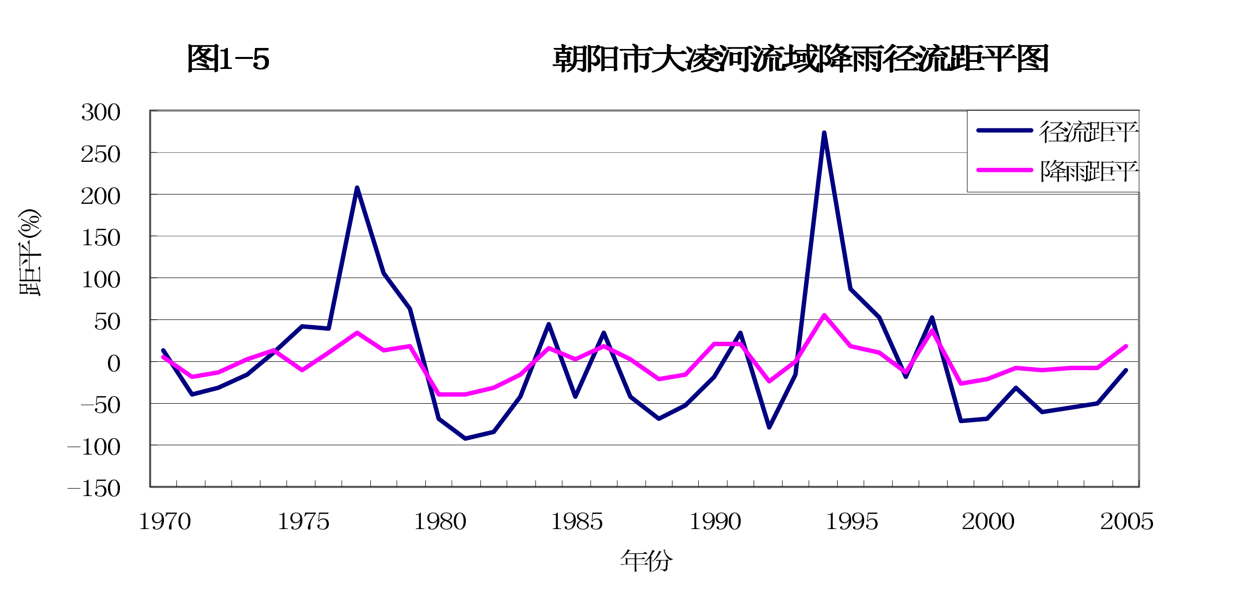


Figure XX: Long Term Discharge Hydrograph at the Chaoyang River Gauge



Finally, it is important to take into account that below average rainfall conditions when they become significantly below the average conditions can result in extreme deterioration in the availability of surface water flows. This is demonstrated by Figure XX.

Figure XX: Variability in rainfall and discharges related to average values



A summary of the droughts, of various severities are presented in Appendix XX. In relation to monthly rainfall records over the last 35 years or so, the extremes are summarized in the Table XX.

Table XX: Average and Maximum Rainfall Values in Chaoyang 1970-2005

Month	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Mean (mms)	6.56	2.70	1.63	2.25	7.05	19.38
Max (mms)	31.96	17.73	10.14	6.61	29.76	83.4
The number of years that amount of monthly precipitation is less than 25mm	1	0	0	0	2	7

Additionally, periods of low rainfall imply low levels of recharge to aquifers whilst at the same time as extended dry periods result in an increased demand for irrigation thereby exasperating ground water level declines. The drought management plan will need to pay particular attention to assessing drought severities and the different responses that will need to be associated with each. Water demand is increasing, particularly for industry, public water supply and agriculture. This combination of unreliable resources and growing demand creates an urgent need to closely manage the Municipality's water resources and consider the needs of downstream municipalities.

2.4 Drought Hazard Analysis and Drought Exposure Analysis

USA Example

Municipality XX experienced a variety of drought-related impacts during the XXXX drought. These impacts and level of severity are outlined in Table XX. These impacts were generally moderate to minor in nature and did not extend beyond the XXXX drought.

Table XX Historical Impacts on the Municipality XX Urban Water Supply

Historical Impact	Severity
Loss of revenue from reduction in water sales	Moderate
Reduction in storage reserves	Moderate
Degraded water quality	Moderate
Higher water treatment costs	Moderate
Increased costs and staff time to implement the drought response	Moderate
Increased data/information needs to monitor and implement drought response	Minor
Public favorable/unfavorable perception of provider regarding drought response	Minor

The **Municipality XX** community also experienced a variety of impacts. The lack of rainfall stressed the surrounding environment resulting in increased risk of wildfire, lower surface waters and reservoir levels, stress to wildlife, and overall reduction in the aesthetics of the area. This significantly impacted recreational activities such as tubing and fishing and impacted the local tourist industry (hotels, restaurants, shops) in the Municipality. The nearby agricultural community was also impacted. Farmers with junior water rights had very limited water to grow crops and several landscaping companies relying on summer as their busy season were forced out of business.

Historically, **Municipality XX** was a small town and had not experienced water shortages, and prior to the XXXX drought **Municipality XX** did not have a formal drought plan or designated drought mitigation measures. However, during the XXXX drought, such dramatic reductions in reservoir storage justified the necessity for a drought response. The drought response measures included: watering restrictions starting in June XXXX and continuing through September XXXX; a public drought campaign to educate the public about drought; and some low-cost adjustments to the water treatment to address the taste and odor issues.

While the water restrictions and public education program proved to be effective in lowering demands, the treatment adjustments were not very successful. An increasing block rate structure was also adopted in XXXX in which a portion of the additional revenue generated by the top two tiers of water users is set aside in a drought reserve account for future droughts.

2.5 Water Supply Reliability and Drought Management Planning

USA Example

Municipality XX's water supply reliability planning efforts focus on the ability of the Municipality's water supply system to meet the needs of its customers during times of stress. This reliability depends on a multitude of factors including the Municipality's water source(s), seniority of water rights, storage capacities, and rate of customer demand growth. Water supply reliability planning is an important component of ensuring sufficient supplies during times of drought and, to some extent, overlaps with this drought management planning process. However, this Plan focuses on drought within the context of drought monitoring, mitigation actions, and drought response to lessen drought impacts. Consequently, this Plan does not take the place of water supply reliability planning but rather is closely coordinated with Municipality's water supply reliability planning efforts.

A thorough assessment of **Municipality XX's** water supplies was last conducted in XXXX when **Municipality XX** updated their Raw Water Master Plan. Since XXXX, **Municipality XX** has gained further insight as a result of the XXXX drought and has purchased additional water rights. **Municipality XX** is currently leading an effort to update the outdated XXXX Raw Water Master Plan which is scheduled for completion by XXXX including:

- New water rights purchased and projected to be purchased since XXXX.
- Updated water demand projections assuming build-out in XXXX.
- Evaluation of whether **Municipality XX's** current water supply planning approach.
- Evaluation of new water supply options to meet future growing demands and to provide additional drought reserves.
- Climate change influences on **Municipality XX**'s future demands and supplies.
- Reconnaissance level evaluation characterizing the potential impacts to **Municipality XX's** water supplies if a lower basin water resources priority emerges.

2.6 Drought Impact Assessment

USA Example

Municipality XX could experience a variety of future drought-related impacts. These potential impacts and level of severity are outlined in Table XX. The potential severity of many of these impacts could be significant depending on the magnitude and duration of the drought as well as how effectively the drought mitigation and response efforts reduce the impact.

Table XXHistorical Impacts of the Utility

Potential Future Drought Impacts	Potential Severity
Loss of revenue from reduction in water sales	Moderate
Reduction in storage reserves	Significant
Disruption of water supplies	Significant
Degraded water quality	Significant
Higher water treatment costs	Moderate
Sediment and fire debris loading to reservoirs following a wildfire	Significant
Increased costs and staff time to implement drought plan	Minor
Increased data/information needs to monitor and implement drought mitigation plan	Minor
Increased costs of acquiring additional supplies during times of drought	Significant
Favorable/unfavorable public perception of provider regarding drought response	Moderate
Capacity of equipment and other water related services (i.e. contractors to repair wells)	Moderate

The **Municipality XX** community could also experience a variety of future drought-related impacts. Some of the more significant impacts include:

- Damage to public and private landscaping.
- Degraded drinking water quality similar to the taste and odor issues experienced during the XXXX drought.
- Unequal impacts of water restrictions and other drought response measures upon certain businesses/individuals.
- Reduction in surface waters and reservoir levels could impact the tourist and commercial industry.
- Increased risk of wildfire that not only threatens the water supply but the safety and overall environment of the surrounding area.
- Loss of agricultural irrigation could reduce farm income and impact agricultural-related businesses in the Municipality.
- Increased public awareness on drought response efforts, importance of water conservation and positive reduction in water usage.
- Loss of use of public and private swimming pools.

While some of these impacts are beyond the immediate control of **Municipality XX**, drought mitigation activities and daily operational adjustments during future droughts may be made to alleviate some of these impacts.

3.0 DROUGHT STAGES, TRIGGER POINTS AND RESPONSE TARGETS

3.1 PRC Standard of Classification for Drought Severity, SL424-2008

Drought risk reduction and mitigation refers to actions taken in advance of a drought that reduce potential drought-related impacts when the event occurs. Drought risk reduction and mitigation measures continue in a more comprehensive fashion once the condition moves from Pre-Drought into actual Drought levels, in a hierarchical fashion with ever more aggressive measures being employed. This hierarchy forms the basis of the technical responses at various levels, with associated institutional and monitoring requirements.

The drought management plan is based on an underlying premise that drought management activities are conducted at all times in order to avoid and minimize impacts to humans and the economy when a drought is imminent or occurs. As such, the **Normal scenario** defines the roles of the drought management team and institutions during non-drought situations. As the early information system provides meteorological trend information on the potential onset of a drought, the roles of the institutions switch into **Pre-Drought scenario**, with increased efforts and beginning of the drought risk reduction and mitigation measures. Once the drought is in full effect **(according to PRC Level IV up to Level I),** the team have another set of operating procedures (mainly now defined in existing drought relief plans). The Post-Drought roles are one of recovery and return to the Normal mode.

According to the tiered drought management framework in this project, the move from Normal to Pre-Drought mode would occur at the municipal or county level based on the provincial drought management plan early warning system, based on meteorological indices. At that stage, the local drought management plan moves into Pre-Drought scenario and the local drought indices are carefully analyzed. The PRC tool for evaluation of existing drought levels is a comprehensive suite of sectorial drought indices located in the Standard of Classification for Drought Severity, SL424-2008. This document describes a methodology to calculate drought indices and classification for the following:

- Agriculture
- Pasture
- Urban
- Drinking water supply

Regional drought indices and classification (for different levels of administration) are also provided for the following:

- Regional agriculture droughts
- Regional pasture droughts
- Regional drinking water supply stress
- Comprehensive agriculture and pasture droughts
- Comprehensive regional droughts

3.2 Drought Stages and Trigger Points

USA Example

Droughts can vary significantly in spatial extent, severity, and duration. The drought stages in Table XX were developed to capture this variability and identify an appropriate level of response, according to drought severity. The four stages increase in intensity from watch, to warning, to critical, to emergency. The response target (targeted water savings) also increases with each stage, with a 10% water savings target under the watch drought stage and a 50% water savings target under the emergency drought stage.

Table xx US Example Drought Stages, Trigger Point Guidelines, and Response Targets

Drought Stage	Drought Trigger Point Guidelines			Response Targets[1]
	Measured Snowpack near the end of April	Projected Reservoir Storage on July 1		
		Storage Level	Approximate Supply[2]	
Watch	90% of normal	Storage less than 90% of full	2 years of unrestricted total demand	10% water savings
Warning	75% of normal	Storage less than 80% of full	1 year of unrestricted total demand	25% water savings
Critical	50% of normal	Storage less than 65% of full	1 year of total demand with mandatory outdoor restrictions	40% water savings
Emergency	30% of normal	Storage less than 50% of full	1 year of unrestricted indoor demand	50% water savings

[1]Percentage water savings is measured as annual total retail water sales divided by a 5 year average of retail water sales.

[2]Based on XXXX projected demands. Unrestricted implies no drought response or water restrictions.

The drought trigger points are based on the measured snowpack near the end of April and the projected percentage of storage on XX. **Municipality XX** staff begins to develop these storage projections using **Municipality XX's** xxxx water supply model in early March taking into consideration snowpack measurements and other hydrologic data. It is important to note that the xxxx modeling assumes a single-drought year scenario and consequently, while these trigger points provide a general means to gage drought, droughts are unpredictable and can significantly vary (as described in Section xxxx).

The drought triggers in Table XX are simply general guidelines. Sustained multi-year droughts could require a significant modification to the drought triggers based on the duration and severity of the drought and the **Municipality XX** staff's historical experience managing **Municipality XX's** water supply system. The declaration of a drought, timing of the declaration, and corresponding drought stage will ultimately be a real-time decision. The real-time decision will be based on a combination of the drought trigger guidelines in Table XX, historical staff experience, and other drought indicator data

Chaoyang DMP Example

The Chaoyang DMP was based on three indices: a rainfall based index the SPI, a groundwater level index, and Relative Water Content in Soil as shown in Table XX. The Standardized Precipitation Index (SPI) from the USA is used to quantify the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of the different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, stream flow, and reservoir storage reflect the longer-term rainfall anomalies. The SPI calculation for any location is based on the long-term precipitation record for a desired period, e.g., SPI (24) for 24-months, SPI (18) for 18-months etc.

SPI value for chosen period:

2.0 and above	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and less	extremely dry

The Chaoyang groundwater level index was based on 19 observation wells. Recommendations were made in the DMP to increase this number and to improve the spread of locations to provide a more representative sample. The relative moisture

content of soil 'R' is calculated following standard guidance in 'Meteorological Drought Classification' GB/T20281-2006. The data to calculate the index is obtained from the 9 station soil moisture monitoring network.

Table xx: Proposal of Drought Classification for Chaoyang of Upper Daling Basin

Potential Drought magnitude	Potential Drought intensity	Colours - present drought intensity	Potential Negative Impacts	Drought indices
i	**Extreme** drought	**Red**	Socio-economic development in extreme water shortage, some of cities have a lot of stress to access to domestic water supply	**Composite SPIs** for the latest 12, 24 and 36-month periods < -1.0 Average depth to groundwater is increased to 7.6 m
ii	**Severe** drought	**Orange**	Water shortage to socio-economic development, it is difficult for people and livestock in remote rural areas to access to drinking water	-1.0 ≤ **Composite SPIs** for the latest 12, 24 and 36-month periods < -0.5; Average depth to groundwater is increased to 7.0 m
iii	**Moderate** drought	**Yellow**	Water shortage to some of irrigated agriculture, and rain-fed agriculture has a severe water shortage	During the crop growth period, the SPI for the latest 6-month period < -1.0; Relative soil moisture (R) that is 10cm to 20cm below the soil surface ≤ 50%
iv	**Slight** drought	**Blue**	Water shortage to rain-fed agriculture	During the crop growth period, -1.0 ≤ SPI for the latest 1-month period < -0.5; 50% < R that is 10cm to 20cm below the soil surface ≤ 60%

Notes:
1) Composite SPI = $SPI_{(12)} * 0.6 + SPI_{(24)} * 0.3 + SPI_{(36)} * 0.1$
2) Groundwater depth averaged over 19 observation boreholes
3) $R_{(10\text{-}20cm)}$ calculated following standard guidance 'Meteorological Drought Classification' GB/T20281-2006
4) Chaoyang DMP slightly modified to show potential drought levels, so as not to be confused with actual drought levels I-IV in PRC DRR.

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3.3 Drought Management under Various Scenarios

Chaoyang DMP Example

Drought management is part of the range of water resources management activities. Therefore this DMP is consistent with the Integrated Water Resources Management (IWRM) Plan for the upper Daling River Basin.

Drought impact varies from minor to very severe. Therefore the DMP covers the whole range of drought management activities and decisions required. As droughts severity increases, more time and effort is needed to manage drought management activities. The DMP comprises three stages of drought management:

Stage	Activity
Normal	Drought planning and routine monitoring
Potential Drought	Drought teams assemble, additional monitoring and reporting
Drought	Drought teams work to manage the drought; other activities may be reduced or stopped.

Drought triggers identify drought actions that may need to be taken. They do not mean that the action must automatically be taken: the drought team make decisions on whether or not action is needed based on a range of factors, including the present and forecast conditions and how effective the action would be. Local judgment is an important part of drought management.

Actions and Triggers during Normal Conditions

Actions	Schedule	Responsibility	Resp. Follow-Up
Review and update the DMP and WAB Drought Management Team Membership	January		
Annual Area Drought Management Team Meeting	February		
Review water resources situation	March		
Confirm links with key water users	March		
Update abstraction and discharge databases and scenario tables	March		
Routine monitoring of weather forecasts, rainfall, SMD, river flows, reservoir levels, groundwater levels	Continuous (by Hydrology Bureau)		
Publish monthly situation reports	Monthly		
Consider move to 'Potential Drought' conditions based on Effective Rainfall, Groundwater or river level	See triggers below		

Routine hydrometric monitoring continues at all times and provides the data required to detect the onset of potential drought conditions which will trigger. There are three potential drought triggers:

- effective rainfall
- groundwater level
- surface water flows/levels.

Low effective rainfall in spring provides an early indication of a potential rain-fed agricultural drought. Continued low rainfall in spring and summer indicates potential surface water drought conditions that might affect supply to some irrigation schemes and river water quality. Therefore groundwater levels and surface water flows are also monitored to ensure that potential drought conditions that might affect irrigation, industry and urban water supply are detected. Monitoring data provided by water users (water supply companies, industry agriculture) is important for early warning of difficulties in managing water. The detailed reasoning behind the decision to select these as triggers is available in Appendix XX.

Actions and Triggers during Potential Drought Conditions

Actions	Schedule	Responsibility	Resp. Follow-Up
Place Drought Team on standby	If triggered		
Identify budget required to manage potential drought	If triggered		
Check and update drought communications plan	If triggered		
Activate additional hydrometric monitoring by Hydrol. Bureau	If triggered		
Nominate key specialists and confirm their TOR	If triggered		
Notify stakeholders of potential drought status	If triggered		
Coordinate meetings with Municipality and key water users	If triggered		
Draft abstraction and discharge permit variations for non-essential uses	If triggered		
Publish weekly situation reports	Weekly		
Consider move to 'Drought' conditions based on monitoring of effective rainfall, groundwater or river levels or reports from stakeholders of water stress	See triggers below		
Consider return to 'Normal' status	See triggers		
Wash-up meetings after normal conditions have resumed to learn lessons	If drought is over		

Actions and Triggers during Drought Conditions

Actions	Schedule	Responsibility	Resp. Follow-Up
Place Drought Team in operational mode	If triggered		
Activate key specialists if necessary	If triggered		
Check and update drought communications plan	If triggered		
Activate additional hydrometric monitoring by Hydrology Bureau	If triggered		
Notify stakeholders of drought status	If triggered		
Coordinate meetings with Municipality and key water users	If triggered		
Implement abstraction and discharge permit variations for non-essential uses	If triggered		
Implement drought management plans/re-allocations of essential water users	If triggered		
Publish weekly situation reports	Weekly		
Intensify monitoring of effective rainfall, ground-water or river levels and incidents of water stress	See triggers below		
Consider return to 'Normal' status	See triggers		
Wash-up meetings after normal conditions have resumed to learn lessons	If drought is over		

4.0 DROUGHT TEAM AND RESPONSIBILITIES

The Normal scenario defines the roles of the drought management team and institutions during non-drought situations. As the early information system provides meteorological trend information on the potential onset of a drought, the roles of the institutions switch into Pre-Drought scenario, with increased efforts and beginning of the drought risk reduction and mitigation measures. Once the drought is in full effect (according to PRC Level IV up to Level I), the team have another set of operating procedures (mainly now defined in existing drought relief plans). The Post-Drought roles are one of recovery and return to the Normal mode.

This entire chapter is directly from Chaoyang DMP under WRDMAP.

4.1 Brief Description of DMP Structure and Connection to Provincial DMP

As per prototype provincial DMP description.

4.2 Drought Team, Responsibilities and Provincial Coordination

4.2.1 Introduction

A coordinated approach is required to drought management. Although there is a necessity for the Chaoyang Municipality to have a specific Drought Management Plan, co-ordination with the provincial drought management command center will be necessary.

4.2.2 Provincial Drought Management Center

The 'Flood and Drought Management Command Headquarter' of The People's Government of Liaoning Province has a structure with three main parts including Director General, assistants of Director General and group of members:

Position	Position held by:
General Director	Deputy Governor of Liaoning Province with responsibilities of water resources management.
Assistants of General Director	Deputy Commanding Officer of Military in Liaoning province. Vice Secretary of People's Government in Liaoning province. Director of Water Resources Department in Liaoning province
Group of Members	Directors or managers from several governmental departments

The responsibilities of the 'Flood and Drought Management Command Headquarter' are:

- Leading and organizing drought management within the boundary of Liaoning province;
- Implementing national rules, policies, decrees, formal documents relating to drought management;
- Collecting timely information of drought event development and drought impacts/disasters, distributing and publishing information on forecasting, warning through newsletters;
- Organizing drought relief, resettlement after drought (if required) and undertaking coordination between different areas.
- Overseeing the activities of provincial organizations in their drought planning, monitoring and responses (see Annex XX for the responsibilities of these other organizations).

There are similarly structured 'Flood and Drought Management Command Headquarter' at local levels. They have responsibilities for organizing and directing flood and drought management in local areas under the lead of Flood and Drought Management Command Headquarter of Government at high level. The operational office (Standing Office) is assigned to the water resources administrative departments/bureau at the respective levels.

The Standing Office of Flood and Drought Management Command Headquarter of the People's Government of Liaoning Province has responsibilities for flood and drought management for overall areas in Liaoning Province. Its members generally come from staff working in the Water Resources Departments in Liaoning province. Their Roles and Responsibilities being are:

- Undertaking routine works relating to flood and drought management;
- Providing the Flood and Drought Management Command Headquarter of The People's Government of Liaoning Province a recommendation to initiate a 'drought contingency plan' in accordance with the development of drought event;
- Providing a Specialists' Team

The Water Resources Department and other allied departments/organizations at the respective levels assign teams consisting of specialists in drought management. Their Roles and Responsibilities are:

- Based on the development of drought situations, meteorological and hydrological forecasting as well as assessments of the condition of infrastructure, the specialist teams formulate drought management plans and evaluate level of responsiveness to drought management actions.
- The team provide to the Flood and Drought Management Command Headquarter of the People's Government of Liaoning Province suggestions and recommendations for drought management for the specific drought situation.

4.2.3 Chaoyang WAB Drought Management Team and Responsibilities

The Framework of a Drought Management Organization and its Roles and Responsibilities was specified in the 'Chaoyang Drought Management and Water Saving Implementation Plan in 2001.' The document states that Chaoyang Drought Management Command and Water Saving Headquarter (CDMCWSH) is the authorized organization to lead Drought Management in Chaoyang Municipality.

The members of the Headquarters are:

- General Director: Mayor;
- Assistants of General Director: deputy mayor, vice secretary to government;
- Group members. (Further details are presented in Appendix XX.)

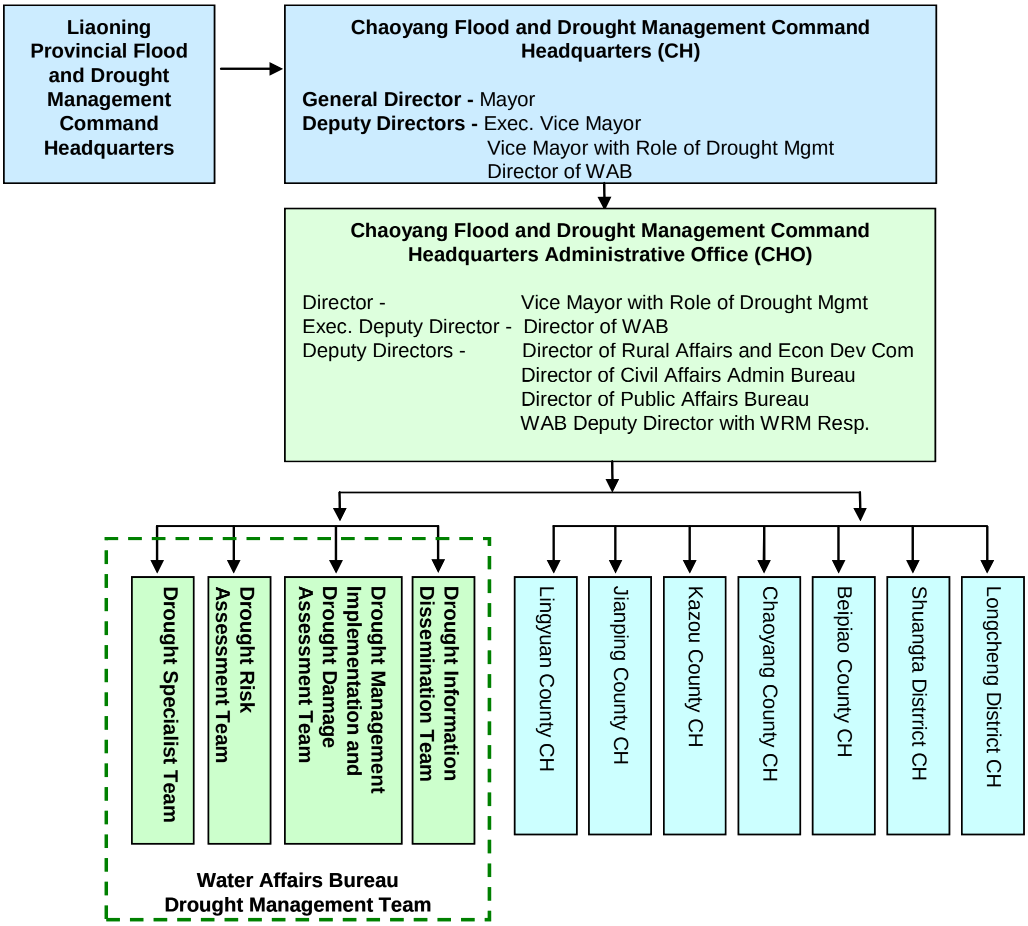
However, it is recommended that a specific Drought Management Office is established that is separate from the Water Saving Headquarters. The two water management activities are considered to be sufficiently different to justify separate organizations. A Drought Management Headquarters should be set up in Chaoyang. It will have a similar structure with current drought management headquarters at provincial/municipal/county level. (See Appendix XX).

Table XX Proposed Drought Management Headquarters Office:

Positions	Roles and Responsibilities
Director General: Mayor	Agricultural and water resources works
Assistants to the Director General: Executive Vice Mayor Vice Mayor in charge of drought management, Director of WAB. Plus Group Members.	Providing guidance for drought management, providing supports for coordination and decision-making of drought management

Group of Members: (leaders and managers from following departments):

Development and Reform Committee of Chaoyang
Publicity and Information Department in Council of Chaoyang Government,
Planning Committee of Chaoyang,
Agricultural Committee of Chaoyang,
Economic Committee of Chaoyang,
Financial Bureau of Chaoyang,
Water Affair Bureau (WAB) of Chaoyang,
Rural Affairs and Economic Committee in Chaoyang
Urban Construction in Chaoyang,
Civil Administrative Bureau (&Poverty Alleviation Office) in Chaoyang
Construction Bureau of Chaoyang,
Environment Protection Bureau of Chaoyang,
Chaoyang Bureau of Power Supply to Agriculture,
Chaoyang Agriculture Bureau,
Forest Management Bureau in Chaoyang,
Agricultural Bank, Rural Credit Service Joint – Offices.
Meteorological Bureau in Chaoyang
Hydrological Bureau in Chaoyang
Food Administrative Bureau in Chaoyang,
Broadcasting and TV Administrative Bureau



Group Member	Role
Development and Reform Committee	Examining and approving long-term drought management plans, supervising the implementation of plans
Financial Bureau	Allocating budget for drought management and rehabilitation of damage after droughts
Water Affair Bureau	Working together with both the Meteorological Bureau and the Hydrological Bureau to undertake the monitoring, forecasting and assessment of meteorological/ hydrological/ socio-economic factors relating to drought condition assessments; Providing information of monthly drought intensity as well as drought forecasting and providing warnings to the Drought Management Headquarter and the general public; During droughts, the preparation of specific Drought Management Action Plan based on this Drought Management Plan. This is submitted to the Drought Management Execution of the Drought Management Action Plan together with the herein specified departments or organizations with specific attention to urban domestic water supply, conducting the management of wastewater treatment plants; Summarizing and evaluating the reports / Drought Logs (drought damage assessments) drafted by each water use category; Reviewing drought action plans and the Drought Management Plan together with relevant departments; Undertaking routine works as directed by the Drought Management Headquarter.
Meteorological Bureau	Undertaking weather monitoring and forecasting; Assessing changes to climate and weather, providing continued real-time weather forecasting Providing timely meteorological drought information to the Drought Management Headquarters and other organizations
Hydrological Bureau	Undertaking hydrological monitoring and forecasting; Working together with WAB, undertaking the evaluation and forecasting of hydrological droughts and socio-economic droughts; Providing hydrological drought information to the Drought Management Headquarters and other organizations;
Economic Committee	Work with WAB to undertake the supervision and management of restricted industrial water use; Investigation and evaluation into the impact of restricted water availability on industrial; Organizing a drought mitigation interventions and relief within industrial sector.
Rural Affairs and Economic Committee	Providing technological information on drought-resist crops to local farmers in accordance with the development or severity of the anticipated drought event and the season(s) affected; Working together with the WAB and the Poverty Alleviation Office assist people and livestock in remote mountain areas in securing assess to drinking water in accordance with the decisions made by the Drought Management Headquarters; Undertaking the supervision and management of agricultural water use; Undertaking the investigation and assessment of drought damage to agriculture; Working together with Civil Administrative Bureau and Poverty Alleviation Office assist local farmers though drought mitigation and relief interventions;
Environment Protection Bureau	Working together with WAB undertake urgent water pollution management;
Urban Construction Bureau	Working together with WAB, undertake the supervision of restricted water use in urban areas; Undertake water supply and use management in urban areas under the drought conditions;
Civil Administrative Bureau (&Poverty Alleviation Office)	Working together with specialized organizations, assess drought damage and provide drought mitigation and relief;
Food Admin. Bureau	Providing local farmers with information on agricultural production marketing.
Broadcasting and TV Administrative Bureau	Publishing information on drought conditions and management approaches being adopted to the general public through coordination with relevant organisations in the process of drought management;

Group Member	Role
Forest Administrative Bureau	Working together with WAB, undertake the supervision and management to water use by forestry activities; Investigate and evaluate the impact of drought damage on forests; Undertake drought mitigation and relief to forestry sector as agreed by the Drought Management Headquarters.

The following will be the **Administrative Office** of the Drought Management Headquarters Office:

Positions	Roles and Responsibilities
Leader: Vice mayor with responsibilities for agricultural and water resources works	
Assistants to the Leader: Vice secretary of Chaoyang Municipal Government, Vice director of Agricultural Committee in Chaoyang, Vice director of Construction Bureau in Chaoyang, Vice director of Water Affair Bureau in Chaoyang.	The overall coordination of drought management and water saving, routine works. (Would have strong administrative officer support-from the respective departments)

A Drought Operations Team (DOT) will exist in the WAB Offices. The main roles and responsibilities of the WAB Drought Management Team are basically to:

- Plan for and manage any drought event;
- Keep the drought action plan up-to-date;
- Liaise with Hydrology Bureau and others to ensure drought monitoring is adequate to assess the impact;
- Implement WAB drought management actions;
- Communicate with the Municipality Drought Management Headquarters and thereby other stakeholders involved in drought management.

The WAB **Drought Operations Team (DOT)** will comprise of the following sub-teams:

Sub-Teams	Role
Drought Specialist Team	Review and assessment of reports/information provided by each 'General Member' organizations; Provide the Drought Management Headquarter support to decision-making on drought management
Drought Risk Assessment Team Members: Meteorological Bureau, Hydrological Bureau, WAB (WAB will take the lead)	Undertake long-term monitoring, assessment, warning and forecasting on drought risk; Providing Drought Management Headquarter and relevant organization information of drought risk
Drought Management Implementing and Drought Damage Assessment Team Members: Executive Vice Mayor as leader, Directors from Development and Reform Committee, Financial Bureau, WAB, Economic Committee, Rural Affair and Economic Committee, EPB, Forest Administrative Bureau, Urban Construction Bureau, Civil Administrative Bureau (including Poverty Alleviation Office), Food Administrative Bureau, Broadcasting and TV Administrative Bureau.	Coordinating and supervising the implementation of drought management decisions; Providing resolutions to water use conflict during droughts.
Drought Information Dissemination Team	Dissemination of information on drought risk, drought risk response/management, drought damage assessment, drought mitigation and relief.

A leading role is played by the Water Affairs Bureau and any Drought Management Plan needs to have one organization providing the main driving force. However, it is necessary to both have the top level direction and drive of the Mayor and Vice-mayor and also the committed involvement of other organizations. Also, it is necessary to have roles and responsibilities assigned to individuals. Organizational responsibility is one thing, but individuals need to have defined roles and assume leadership. Other staff will be co-opted to the WAB Drought Team to provide specialist advice (e.g. legal, financial and technical) as the need arises.

The names of the current WAB Drought Team are available in Appendix XX. The activities matrix in Appendix XX summarizes their roles and responsibilities. The master hard copy of the WAB Drought Plan is located in XXXX. A second paper copy of the document will be held by the Chaoyang Drought Management Headquarters Office (Administrative Office).

During a drought it may be necessary to setup the Municipal and WAB Incident Room. Telephone numbers and other communication details are provided in Appendix XX.

4.2.4 Administrative Procedures

It is important that accurate records are kept during a drought event. This includes work undertaken prior to a drought. Records are needed for auditing purposes and for producing post drought reports. The DST should be responsible for the management of all administrative procedures. The following procedures have been set up to create a record of events:

- Filing
- Logs
- Drought Meetings
- Drought Reporting

4.3 Final Responsibility for Decisions

Describe the decision making processes referring to drought indices

4.4 Resourcing

4.4.1 The Need for Extra Resources

As droughts are frequent in Chaoyang Municipality, many routine activities (e.g. low flow, groundwater monitoring etc) for water resources management are the same as, or similar to the activities required for drought management. As drought conditions worsen, much can be achieved by re-prioritizing existing workloads and redirecting staff efforts. For more prolonged droughts, additional resources may be required. Impact on normal work and operational targets needs to be recognized and planned for.

The following is a list of extra work, which might be required prior to and during a drought:

- Additional hydrometric, chemical, biological and/or ecological monitoring in the field;
- Additional monitoring and analysis of data to forecast and respond to developing situation;
- Enhanced level of water resources enforcement;
- Enhanced level of abstraction license management including the need to impose restrictions etc.;
- Increased level of applications for new/varied license;
- Additional internal and external meetings;
- Increased liaison with customers (water companies and other abstractors, conservation bodies etc.);

- Increased liaison with general public (e.g. well failures, other concerns about specific sites or activities, generally higher level of interest);
- Preparation and issue of appropriate messages
- Responses to media interest.

This extra work can be covered by:
- Re-prioritizing work within existing teams;
- Assignment of staff from other teams (with appropriate training);
- Provision of extra resources (e.g. staff/consultants - with appropriate training);
- A combination of any of these.

It is expected that there will always be a period of transition when extra work will have to be absorbed pending the provision of extra resources, but these periods will be kept to a minimum by clear and appropriate planning.

4.4.2 Financial Resources

The appointment of extra staff/consultants or the need to purchase equipment both have financial implications which should be raised with budget holders at the earliest opportunity. If resources are likely to be required in the next financial year, forecasts of expenditure should be provided so that sufficient resources can be allocated. Approvals will need to be sought in accordance with the financial scheme of delegation.

4.4.3 Appointment of Consultants

In times of drought it may be necessary to appoint consultants either to carry out drought work itself or to backfill for staff transferred from other duties. Prior to the need to appoint consultants (at potential drought stage) WAB will first ensure that other avenues, such as redeployment of existing resources, have been fully explored.

5.0 DROUGHT MONITORING

This section is entirely from Chaoyang DMP.

5.1 Introduction

The collection of hydrometric and water quality data is a routine task of the Provincial Hydrology Bureau and Municipal EPB. They will be required to produce drought monitoring plans for additional data collection, analysis and reporting to detect and monitor onset of drought, its progression and return to normal conditions.

Water supply companies, large industrial and agricultural water users are also required to produce drought plans. These plans identify specific monitoring that they will undertake to support and assess the impacts of their specific drought actions.

5.2 Hydrometric Monitoring

This section describes the arrangements for hydrometric monitoring, which is primarily undertaken by the Provincial Hydrology Bureau. Monitoring occurs during regular conditions under what is called “Normal” operations. During a potential drought situation based on provincial meteorological indices and information dissemination, monitoring moves to “Potential Drought” operations. Once the drought has been formally declared and in place, monitoring moves into “Drought” operations.

5.2.1 Hydrometric Monitoring under Normal Conditions

The hydrometric network, including groundwater observation boreholes, river gauging stations and rain gauges is routinely monitored and this will continue at all times. A number of sites have been identified as key drought indicator sites. These key sites are listed below.

Key Drought Indicator Sites (Rainfall)

Sub-Catchment	Rain gauge Reference	Coordinates

Key Drought Indicator Sites (Groundwater)

Sub-Catchment	Borehole Reference	Coordinates

Key Drought Indicator Sites (Surface Water)

Sub-Catchment	River-gauge Reference	Coordinates

The operation of abstraction and discharge license conditions are typically linked to surface water flows or groundwater levels, and are largely reliant on information sourced from the hydrometric network. The Regulatory Water Resources Officer responsible for cessation conditions routinely monitors the available hydrometric data to ascertain the need to implement cessations.

5.2.2 Hydrometric Monitoring under Potential Drought Conditions

Under potential drought conditions, additional monitoring will be required to detect the onset of drought conditions, trigger abstraction and discharge permit restrictions.

5.2.3 Hydrometric Monitoring during Drought Conditions

Under actual drought conditions additional monitoring will be required to monitor the impacts of the drought, the efficiency of the drought management procedures and the recovery from drought conditions to the point where normal conditions have resumed.

5.2.4 Ecological Monitoring

<Ecological monitoring may not be practicable in the foreseeable future, but in the long-term the DMP (& IWRM plan) should include it>

5.2.5 Drought Monitoring by Water Users and Stakeholders

Water Supply Companies (WSCs)

Urban Centre	Supply source	Normal Use. m3/mth	Monitoring station for resource			Frequency of measurement	Who holds the data?
			Reservoir level (m AOD)	River level (m AOD)	GW Level (m AOD)		
Chaoyang							
Lingyuan							
Jiancang							
etc							

<Describe water supply company data needed to help detect the onset of a drought and the additional data needed during and following a drought. This might include demand data, abstraction data, leakage data, outage data, supply/demand scenario forecasts>.

Industrial Enterprises

Industrial Centre	Supply source	Normal Use. m3/mth. (Reuse %)	Monitoring station for resource			Frequency of measurement	Who holds the data?
			Reservoir level (m AOD)	River level (m AOD)	GW Level (m AOD)		

<Describe industrial company data needed to help detect the onset of a drought and the additional data needed during and following a drought. This might include demand data, abstraction data, leakage data, outage data, supply/demand scenario forecasts>.

Irrigation

rrigation/ Water Management Station	Supply source(s)	Normal Use. m3/mth. (GW %)	Monitoring station for resource			Frequency of measurement	Who holds the data?
			Reservoir level (m AOD)	River level (m AOD)	GW Level (m AOD)		

<Describe irrigation data needed to help detect the onset of a drought and the additional data needed during and following a drought. This might include demand data, abstraction data, leakage data, outage data, supply/demand scenario forecasts>.

Schools, etc

Similar tables if appropriate

6.0 DROUGHT RISK REDUCTION AND MITIGATION AND RESPONSE STRATEGIES

Refer to ANNEX A for more complete examples in matrix form.

6.1 Drought Risk Reduction and Mitigation Measures

USA Example

Drought risk reduction and mitigation and response strategies that focus on the management of the water supply system are generally referred to as supply-side actions; whereas demand-side mitigation and response strategies focus on actions that **Municipality XX** can take to promote or enforce reductions in customer water demands. This section presents the mitigation and response strategies selected following a screening process.

The drought risk reduction and mitigation measures were selected by developing a preliminary list of potential measures and conducting a screening process to select the measures most conducive for **Municipality XX**. The preliminary list was developed using **Province XX** Drought Management Guidance Document and accompanying worksheets, as well as incorporating **Municipality XX**'s water supply reliability and conservation planning efforts. Potential impacts were also used to generate new ideas for risk reduction and mitigation options. The preliminary mitigation list was screened and further refined using the following criteria:

- *Technical feasibility* – Is the selected risk reduction or mitigation or response strategy technically feasible and will it work as intended? Can implementation occur in a timely manner? Is there staff to implement the action?
- *Perceived benefits* – Will the selected risk reduction or mitigation or response strategy provide an adequate amount of water supplies and/or water savings?
- *Cost effectiveness* – How does the implementation cost compare with the benefits? This may simply be a qualitative assessment or quantitative comparison of ratios of implementation costs to the water savings cost benefit.
- *Public acceptance* – How favorably will the public react to the select risk reduction or mitigation strategy? A review process of alternative means to engage the public would be beneficial to assess general public acceptance.
- *Environmental sensitivity and other impacts* – What are the environmental benefits/costs to implementing the risk reduction or mitigation and/or response strategy? Is there an environmental issue or other impacts that should be further considered?

The final step of the screening process assessed the selected group of risk reduction or mitigation actions to ensure that the final combination collectively met the following criteria:

- Compatible with Municipality's water supply system and is feasible from an implementation standpoint;
- Consistent with the operating principles and objectives of the drought management plan;
- Fairly represents the needs of affected individuals and groups; and
- Sufficiently addresses potential water shortages and future impacts.

The final risk reduction or mitigation measures are provided below.

- *Drought risk reduction and mitigation planning* – The major components of this Plan provide an effective means for **Municipality XX** to prepare for drought. When done in advance of a drought, planning is considered drought risk reduction and mitigation. These components include the objectives and operating principles; assessment of historical and potential drought impacts; drought-related monitoring; drought stages, trigger points and response targets; declaration of a pre-drought and drought levels; development of drought-related ordinances; and the public drought education campaign.
- *Ongoing monitoring of drought indicators* – **Municipality XX**'s monitoring plan is outlined in XXX
- *Development of new water supplies* – **Municipality XX** is planning to develop additional water supplies for drought protection and meet the growing water demands through the XXXX. A portion of these new supplies will be designated for growth while the remainder will be reserved for use during periods of drought.
- *Develop cooperative sharing agreement opportunities with neighboring communities during periods of drought* - **Municipality XX**'s water supply yields may be increased by making some adjustments to how water rights are traditionally managed and through other synergies developed via cooperative agreements with other local water users. Where possible, these agreements will be established in advance of a drought as part of the mitigation effort and

activated during drought periods. Agreements may include exchanges, agricultural leases, trades, temporary fallowing, etc.

- *Existing operation and maintenance activities that improve water distribution efficiency* – **Municipality XX** currently conducts annual audits on their urban water distribution system, routinely repairs leaks on an as-needed basis, monitors and replaces inaccurate meters, and strategically operates its water supply system to avoid reservoir spills (releasing reservoir water when not necessary for water supply purposes).
- *New operation and maintenance activities that improve water distribution efficiency* – The addition of new water supplies to **Municipality XX**'s system will require modifications to current daily operations. Such operational changes are being evaluated through XXXX.
- *Conservation measures specified in the Conservation Plan* – Many of **Municipality XX**'s conservation measures serve the dual purpose of conserving water while also providing drought protection. A portion of the water saved through these conservation measures is stored as drought reserves in each of **Municipality XX**'s reservoirs.
- *Standard practices of **Municipality XX** Staff* – **Municipality XX**'s management and operations reflect the Municipality's values of sustainability and environmental stewardship. Many of **Municipality XX** standard operations focus on water conservation, providing multi-year water savings, and drought mitigation during dry periods.

6.2 Supply-Side Strategies

USA Example

The final supply-side risk reduction or mitigation or response strategies in Table XX consist of technical and financial assistance opportunities, water rights management and cooperative agreements, and improvements to water distribution efficiency.

Table XX Supply-Side Response Strategies

Category	Response Strategy
Seek technical and financial assistance opportunities	▪ Identify Province, federal, county, and private entity assistance. This could include grants or loans for emergency drought related planning, ▪ drought relief, water use efficiency improvements, etc.
Execution of existing water rights management and cooperative agreements and development of new opportunities	▪ Purchase or lease water from other entities (i.e. neighboring cities, federal projects). ▪ Arrangement and/or execution of exchanges. ▪ Utilize emergency interconnections with other providers' systems. ▪ Lease irrigation rights from farmers. ▪ Negotiate purchases or "options". ▪ Jointly develop water transfers with other entities. ▪ Trade water supplies with other entities to increase yield. ▪ Pay upstream water user to allow diversion of more water.
Improvements to water use efficiency	▪ Change pattern of water storage and release operations to reduce net evaporation, optimize efficiencies in Municipality XX's water supply system, and reduce drought related impacts.

Note that China has been significantly focused on supply side water infrastructure improvements so a PRC focused list of measures can be developed.

6.3 Demand-Side Response Strategies

The final demand-side risk reduction or mitigation or response strategies shown in Table XX consist of actions taken by Municipality staff to conserve water and place water use limitations on residential and commercial customers. These strategies are refined into specific drought response measures in Section XX. Each of these strategies is reflective of the operating principles disclosed in Section 1.2 and is refined into a staged drought management program in Section XX.

Table XX Demand-Side Response Strategies

Category	Response Strategy*
Municipality operations and maintenance activities (actions taken by Municipality staff to conserve water)	▪ Implement drought surcharges. ▪ Eliminate/reduce irrigation on Municipality-owned parks and landscaping. ▪ Educate Municipality staff on how to save water. ▪ Prohibit watering during fall, winter, and early spring. ▪ Limit/prevent washing of Municipality fleet vehicles. ▪ Limit hydrant washing and flushing. ▪ Limit use of water for fire training. ▪ Eliminate all fire hydrant uses except those required for public safety. ▪ Turn off ornamental fountains in Municipality-owned buildings and parks. ▪ Conduct indoor water audits.
Residential	▪ Enforce landscape watering restrictions. ▪ Limit number of watering days per week and the duration of watering time. ▪ Prohibit lawn watering during fall, winter, and early spring. ▪ Limit watering to hand-held hose or no-volume non-spray device. ▪ Limit/prohibit installation of new sod, seeding, and/or other landscaping. ▪ Enforce restrictions on spraying of impervious surfaces. ▪ Prohibit/limit vehicle washing. ▪ Prohibit/limit non-recirculating fountains. ▪ Prohibit/limit filling and use of swimming pools. ▪ Enforce indoor water restrictions. ▪ Promote/enforce reduction of water-cooled air conditioning
Commercial	▪ Prohibit/limit use of construction water. ▪ Enforce policy guidelines/limitations for installation of new sod and/or other landscaping. ▪ Enforce outdoor landscape watering restrictions. ▪ Promote/require indoor and outdoor water audits where applicable. ▪ Turn off indoor and outdoor ornamental fountains. ▪ Prohibit/limit filling and use of swimming pools. ▪ Turn off public drinking fountains. ▪ Prohibit/limit dealership washing of vehicles. ▪ Enforce water use restrictions on commercial car washes ▪ Promote/enforce service of water in restaurants only upon request. ▪ Promote/enforce reduction in frequency of linen and towel washing in hotels.

*The response strategies listed in Table XX are activities Municipality staff can perform during drought periods to save water in addition to the standard practices and conservation measures specified in the Conservation Plan.

In the China system, a municipal plan may include reallocations from agriculture or other sectors to domestic use by changing abstraction permits.

USA Example

The staged drought response program defines the specific response measures to be taken according to drought stage. This section outlines the mitigation, supply and demand-side measures and associated enforcement levels by drought stage. It is important to note that crucial components of this program include the implementation, enforcement and monitoring which are discussed in Sections xxxx, respectively. Some water providers may find it more conducive to put this detailed description of the staged drought response program into a separate accompanying document such as an appendix.

Watch Drought Stage

Drought Trigger Points: Storage less than 90% of full on July 1 and measured snowpack 90% of normal by 30 April.

Drought Stage and Trigger Summary: The Watch drought stage is triggered when the actual or forecasted storage on July 1 is less than 90% of full. The drought response is to primarily focus on voluntary measures with the objective of reaching a water use reduction target of 10% during the irrigation season.

Supply-Side Response Measures

The following two supply-side measures may be implemented regardless of the drought severity and stage. The specifics on how each measure would be implemented and timing would be identified at the onset of the drought.

- Seek technical and financial assistance opportunities – This may include assistance from the public sector at the federal, Province, or county level or include assistance from private entities such as non-profit organizations promoting water conservation and drought awareness. Assistance may include grants, loans, technical assistance (i.e. water use efficiency improvement), education, etc. **Municipality XX** plans to be aware of the technical and financial opportunities before a drought enabling the Municipality to take advantage of the opportunities quickly and efficiently when a drought occurs.
- Water rights management and cooperative agreements – **Municipality XX's** water supply yields may be increased by making some adjustments to how water rights are traditionally managed and through other synergies developed via cooperative agreements with other local water users. Where possible, these agreements will be established in advance of a drought as part of the mitigation effort and activated during drought periods. However, the activation of these agreements and identification of new arrangements during drought periods will be a component of the drought response. Appropriate Substitute Water Supply Plans will be filed to ensure that the agreement/arrangement(s) are viable under the province Water Law. These agreement/arrangement(s) may include the following:
  - Acquire water from other entities – **Municipality XX's** water supply system is situated in such a manner that it could divert and utilize water from other entities via exchange. Purchase, lease, trade, temporary fallowing, and water transfer arrangements with downstream agricultural users and nearby water providers will be explored as an option during drought periods.
  - Pay upstream water users to divert less water – This would include **xxxx** who can significantly reduce stream flows in November and December during snow making periods.

Demand-Side Response Measures

Municipality XX Departments

- Irrigation of Municipality-owned property (parks and open spaces) – enforce standard practices which includes water audits at the beginning of the irrigation season and efficient water use.
- Washing of Municipality-owned vehicles – Washing of Municipality-owned field vehicles is limited to once every two weeks and washing of all other vehicles is limited to once per a month.
- Fountains – Ornamental and drinking fountains in Municipality-owned parks are turned off from 10:00 am to 4:00 pm.

Residential Voluntary Restrictions

- Outdoor water restrictions – residents are encouraged to follow the voluntary outdoor water restrictions according to the following schedule:
  - Impervious surfaces (driveways, sidewalks, patios, etc.) – recommend minimizing power washing and spraying on impervious surfaces. A broom or mop may be used as a replacement.

- Personal vehicles – should only be washed with bucket and hand-held hose with automatic shut-off nozzle.
- Private swimming pools – all swimming pools should be covered when not being used to reduce evaporation. Regular maintenance should minimize leaks and reuse the water for irrigation when emptying the pool.
- Water cooled air conditioning, swamp coolers, and humidifiers – adjust room temperatures to reduce use of water-cooled air conditioning. Use room size humidifiers and swamp coolers in most utilized rooms as opposed to whole house units.

Commercial and Institutional

- Construction water – appropriate best management practices should be employed to conserve and prevent wastage
- Outdoor water restrictions – commercial businesses are encouraged to follow the voluntary outdoor water restrictions according to the following schedule:
  - Outdoor water audits – **Municipality XX** has partnered with a natural resources conservation non-profit organization that promotes efficient water use. This non-profit organization provides free water audits for an unlimited number of customers during drought periods. Commercial businesses are encouraged to sign-up for a free outdoor water audit through the **Municipality XX** website.
  - Commercial swimming pools and hot tubs – all swimming pools and hot tubs should be covered when not being used to reduce evaporation. Regular maintenance should minimize leaks and reuse the water for irrigation when emptying the pool/hot tub.
  - Commercial car washes – all commercial car washes are encouraged to implement best management practices to reduce water use by 10% where technically feasible.
  - Car dealership vehicles – should only be washed using a bucket and hand-held hose with an automatic shut-off.
  - Restaurants – all restaurants are encouraged to not serve water unless asked for it.
  - Lodging – all lodging establishments are encouraged to place water conservation cards in every room promoting water conservation (i.e. short showers) as well as not changing linens and towels unless a customer specifically requests the service.

Public Campaign

Outlined in Section xxxx. Details of the public drought campaign are to be developed at the onset of a drought.

Enforcement Procedures

Provided in Section xxxx.

Similar set of trigger points and responses for Warning Stage, Critical Stage, Emergency Stage.

Chaoyang DMP Example

Drought Triggers and Responses of Water Users

Water Supply Companies (WSCs)

Water Supply Companies must have their own Drought Management Plans. Drought plans are required to set out how a water company will continue to meet its duties to supply adequate quantities of wholesome water during drought periods with as little recourse as possible to drought orders or drought permits. Depending upon the severity of the drought this might include campaigns to encourage reduced consumption by the public, enhanced leakage control and pressure reduction.

The WSC Drought Management Plan should be held by the Regulator assigned with regulating the performance of the WSC whilst a copy of the WSC DMP should be held by the Drought Management Headquarters.

Industrial Enterprises

All major industries, holding a water abstraction permit of more than XXXX m^3/month should have a simple document explaining how the organization will operate during droughts of different level of severity. A copy of this document should be sent to the Drought Management Headquarters on March 1st each year even if the document remains unchanged from previous years.

Irrigation

All major irrigation areas, holding a water abstraction permit of more than XXXX m^3/month should have a simple document explaining how the organization will operate during droughts of different level of severity. A copy of this document should be sent to the Drought Management Headquarters on March 1st each year even if the document remains unchanged from previous years.

6.4 Drought Public Information Campaign

USA Example

Municipality XX's water demands were significantly reduced in XXXX as a result of the public's awareness and responsiveness to reduce water consumption. The public drought education campaign (public drought campaign) will be one of Municipality's largest drought management efforts. Messages will be delivered in both Spanish and English to reach the majority of demographics within **Municipality XX's** service area.

The public drought campaign will be closely coordinated with **Municipality XX's** current conservation education programs and other related programs providing information on sustainability, weather, climate change, etc. When reasonable, these programs may be integrated into a single program by the Public Affairs Department to integrate efforts and enhance efficiencies. These program(s) will promote the importance of conserving water and achieving water savings in both normal and drought years. During non-drought years the drought campaign component will simply provide a general overview on drought and the importance of drought preparedness. During a drought, the drought messages will increase in frequency and intensity and will be expanded to include information on the staged drought response program and the necessity to conserve supplies.

The objectives of the public drought campaign are:

- Provide concise effective drought information to **Municipality XX** customers and the media.
- Adjust the intensity of the public outreach effort in accordance to the severity of the drought (drought stage).
- Coordinate campaign efforts with nearby municipal entities and other conservation oriented entities to capitalize on synergistic opportunities and convey, where appropriate, a consistent drought message.

The public drought campaign will provide the basic foundational drought information during non-drought (Normal) periods. **Municipality XX** will monitor the drought messages and information conveyed by other local providers to ensure that differences in drought-related messages may be explained, if necessary. Information from other providers may also serve as a means to generate new ideas of how Municipality **XX'**s public drought campaign and overall drought response could be improved.

Table XX Public Drought Campaign Messages (Normal, Pre-Drought and Continuing During Drought Periods)

Drought Information	Coordination With Other Entities
Status of current drought conditions and corresponding drought stage	Be aware of messages conveyed by neighboring providers in order to explain, if necessary, why there are differences in the messages as well as in the overall drought response.
Long-term sustainability of water supply system	n/a
Location of where customers may access the Drought Management Plan	n/a
Factors that could influence water supply services and cost of services	n/a
Water provider's actions to save water and/or acquire new water	Be aware of other local providers' drought mitigation efforts. This may be helpful to generate new ideas to improve the Municipality's public drought campaign and overall mitigation efforts.
Drought policies, requirements, and penalties	n/a

During drought periods, the intensity of both the conservation public education program and public drought campaign will

increase. Particular messages as well as the means in which the information is conveyed to the public will be customized to the severity of the drought and public informational needs at that time. Information **Municipality XX** intends to convey to the public during drought periods, as shown in Table XX, consists of educating customers of drought policies (i.e. water restrictions), enforcement, landscaping tips, and an expansion of the **xxxx** Program established via the Conservation Plan. The **xxxx** Program advertises and promotes businesses that practice a strong water conservation ethic. This may encompass installing water efficient appliances/fixtures, xeriscape landscaping, water conservation education to staff, etc. During droughts, this program will be expanded to advertise and promote businesses that are going the extra mile to conserve water and adhere to voluntary drought response measures.

Coordination with other entities will be an important component of the public drought campaign during periods of drought. Efforts will be made to take advantage of synergies associated with consistent drought-related messages shared among neighboring providers and collectively contributing to a regional drought outreach effort. During this period it will also be important to be aware of neighboring providers' drought-related response activities, water use restrictions, and means of enforcement. This will enable **Municipality XX** to explain any differences among their drought response efforts and maintain integrity with the public.

Table XX Public Drought Campaign Response Information to Convey During a Drought

Drought Information	Coordination with other Entities
Measures and/or impacts that customers can expect if drought continues or intensifies	Be aware of the drought response measures implemented by other local providers. This will assist in addressing public concerns and questions.
Increase advertisement of water conservation promotion and incentives specified in the conservation and drought plans	Identify synergies/benefits of working with other entities on this advertisement campaign.
Landscaping tips during a drought (i.e. which plants to convert to drip, which to save, which to let die)	Research information that is currently available and identify whether there are other entities that can assist with this effort.
Post-drought landscape revival information	Research information that is currently available and identify whether there are other entities that can assist with this effort.
Encourage intense public discussion and media involvement concerning ways to reduce water use while minimizing impacts (i.e. landscaping impacts)	n/a
Explanation of rate increases/drought surcharge (this can apply to both drought and post-drought years)	Be aware of other provider's rates and drought surcharges and be prepared to explain why Municipality XX's rates/drought surcharges are different.
Publicize efforts of individuals and businesses as examples of how to reduce water use Expand the Water Star Program developed through the Conservation Plan)	n/a

Municipality XX will coordinate efforts to ensure that accurate information is being conveyed to the media and to customers. **Municipality XX** will develop regular action plans detailing the specific drought-related messages delivered to the targeted audiences both prior to and during a drought. This will be an evolving process that could change on a seasonal basis depending on weather and public concerns. The basic targeted audiences and communication tools are shown in Table XX. Outreach will mainly consist of website communications, social networking media, and informational emails during non-drought periods. Communication tools will likely be expanded to newspaper articles, television ads, bill inserts, emails targeted to specific water users, booths at special events, and school programs during a drought.

Table XX Public Drought Campaign Audiences and Communication Tools

Targeted Audience	Communication Tools	
	Long-term Mitigation	Short-term Response Strategy
Decision/policy makers, Municipality departments (i.e. parks, finance, etc.)	▪ Email	▪ Email ▪ Meetings
Media	▪ Website ▪ Social networking media ▪ Interviews	▪ Website ▪ Newspaper articles ▪ Social networking media ▪ Interviews ▪ Television ads
Water Customers (Single and multi-family, HOAs, commercial)	▪ Website ▪ Broadly distributed emails ▪ Social networking media	▪ Website ▪ Broadly distributed emails ▪ Social networking media ▪ Public meetings ▪ Bill inserts ▪ Newspaper articles ▪ Billboards ▪ Booths at special events
Targeted business owner customers (recreation facilities, nurseries, health facilities, schools)	▪ Website ▪ Social networking media	▪ Website ▪ Emails targeted for business owners ▪ Social networking media
Large water users (golf courses, water-intensive industrial customers)	▪ Website ▪ Social networking media	▪ Website ▪ Emails targeted for large water users ▪ Social networking media ▪ Meetings
Commercial business employees	▪ Website ▪ Broadly distributed emails ▪ Social networking media	▪ Website ▪ Broadly distributed emails ▪ Social networking media
School children	▪ Water educational curricula for teachers ▪ Water educational programs for students ▪ Water festivals	▪ School programs ▪ Booths at special events for children

Chaoyang DMP Example

Communications play a key role in drought management by establishing trust in the key stakeholders and encouraging conservation of water. The Drought Communications Plan deals with the additional communications created as a result of a drought such as media releases, direct communications with stakeholders and staff using mail, internet and telephone.

The Drought Communications Plan includes the following deliverables:

- Key messages;
- Links to Provincial and National drought plans;
- Sensitive or problem areas in Chaoyang;
- Positive action undertaken by WAB since the last drought;
- Key communications links and activities.

The main external communications are with:

- The Municipal Government
- Water supply companies;
  - Water Management Stations and Farmers groups;
  - Fish farmers;
  - Industry managers
- The Media:
  - Chaoyang Television and Radio
  - Shenyang Television

7.0 IMPLEMENTATION MECHANISMS

This section would include information on SCD460, inter river basin transfers and increased supply mechanisms, and drought permits from UK system as potential future.

7.1 Introduction

Drought permits are intended to enable additional supplies to be provided to certain users during droughts. These would be almost totally related to meeting human needs with particular attention being given to such key establishments as supply areas serving hospitals.

Drought orders on the other hand are official directives for the curtailment of certain uses of water. Normally, the introduction of such measures is undertaken in stages:

- Stage 1: Drought Orders
- Stage 2: Drought Permits
- Stage 3: Emergency Drought Orders

It should be appreciated by all concerned that drought permits may not be possible to issue owing to the water resource situation. Both drought permits and drought orders must be supported by regulation/ legislation to enable enforcement.

However, Water Supply Companies can impose a ban on the use of domestic hosepipes and sprinkler systems. They do not need permission from the Drought Management Headquarters (or WAB) to impose such a ban, and they do not need to explain their reasons or discuss water reserves in their area.

7.2 Drought Orders

Drought orders are instructions from the Drought Management Headquarters, under the Mayor's authority, to restrict waster use in certain areas of the municipality for various forms of water use. A Drought Order could be put in place for a specified period for the cessation of the following uses:

- Car washes, particularly mechanical car washes in Urban Centers should terminate business;
- Washing any vehicle except for reason of safety or hygiene;
- Garden sprinklers by the general public and commercial enterprises should be terminated;
- Sprinklers for landscaping use by government bodies should be terminated or limited to a set number of hours per day;
- Water to clean any premises, apart for safety or hygiene reasons;
- Authorities should terminate using tankers for the 'wetting' of roads to curb dust nuisance;
- All public fountains and water features should be closed;
- Filling privately-owned swimming pools (other than for medical treatment) and ornamental ponds other than fishponds;
- Running automatically-flushing toilet cisterns at times when buildings are unoccupied

Emergency drought orders may go further than ordinary drought orders. They are intended to deal with a situation in which the deficiency of supplies resulting from or threatened by an exceptional shortage of rain is likely to impair the economic or social well-being of persons in the area. They allow water companies to limit the use of water for such purposes as it thinks fit.

This could include rationing supplies in the water distribution system with supply hours being reduced. Customers would be directed to make significant efforts to save water. Drought Orders can be put in place for 6 months, a year or longer if need be.

7.3 Drought Permits

Drought permits, which are granted by the WAB, can authorize a water company to take water from new sources or to alter restrictions on existing abstractions. In regulating water abstraction the WAB would seek to balance water supply needs and the environmental implications of abstracting water.

However, the issuance of a drought permit should only be issued after the approval of the Drought Management Headquarters. A Drought Permit Proposal would need to be prepared for the approval of the DMH and should fully explain the reasons for the request, the amount and duration of the drought permit and clear evidence that the issuance of the drought permit will not impact on others or seriously impact on the environment.

7.4 Emergency Drought Orders

Emergency drought orders may go further than ordinary drought orders. They are intended to deal with a situation in which the deficiency of supplies resulting from or threatened by an exceptional shortage of rain is likely to impair the economic or social well-being of persons in the area. They allow water companies to limit the use of water for such purposes as it thinks fit.

This could include rationing supplies in the water distribution system with supply hours being reduced. Customers would be directed to make significant efforts to save water. An emergency drought order could include the action of water supplies to homes being shut off and standpipes being set up in streets and water being rationed by cutting off supplies to homes and businesses at certain times of day.

8.0 FORMAL PLAN APPROVAL AND UPDATES

This section is entirely from USA example.

8.1 Public Review Process

Prior to finalization of the Plan, the **xxxx** facilitated a public review process educating and providing the public an opportunity to review and provide feedback on the Plan. This process was important in developing an effective Plan that was reflective of the community's values and could mitigate potential conflict during a future drought event.

A 30-day public review process is stipulated for all Municipality planning documents by **xxxx**. The public was informed of this review process and of two public open houses on the Plan via the Municipality's website, general mass email distribution, **xxxx**, a newspaper ad, and through a water bill insert distributed a month in advance of the public review process. The two open houses were held on **xxxx** and **xxxx** to present the main components of the Plan and provide a question and answer feedback forum. During the 30-day period from **xxxx**, the draft Plan was posted on the Municipality's website and was available in hard copy at Municipality Hall. Members of the public could provide comments via email, verbally at the open houses, or deliver hard copies of their comments to the main receptionist at Municipality Hall. The **xxxx** was responsible for consolidating all comments and providing these to **Municipality XX** for review and consideration for incorporation into the Plan.

The majority of public comments generally focused on the following:

8.2 Adoption of Ordinances and Official Agreements

The following drought-related policies were adopted as a means to implement the Plan:

- *Ordinance xxxx, Drought Declaration* – Outlines the process in which a drought declaration is to be officially declared. This is described in **xxxx** and authorizes the Mayor to officially declare a drought and corresponding stage.
- *Ordinance xxxx, Authorization for Implementation and Enforcement of the Staged Drought Response Plan* – Gives the **Municipality XX** Director the authority to conduct the actions laid out in the enforcement policy in order to enforce the measures specified in the staged drought response program and the flexibility to make changes if necessary to address specific problems and/or improve overall effectiveness of the staged drought response program.
- *Ordinance xxxx, Enforcement Policy* – Specifies the infraction, penalty, and fee structure outlined in Table 14.
- *Ordinance xxxx, Emergency Drought Declaration* – Gives the Mayor the authority to officially declare a drought and corresponding stage when there is not sufficient time to follow the process outlined in **xxxx**. This is limited to circumstances when the safety and health of the community are at risk due to stressed drought-related water supply conditions. A thorough review of supply conditions and implementation of the drought response program shall be conducted by **Municipality XX** following such declaration.

Municipality XX currently does not have any official agreements with other entities related to drought. However, these agreements may be an important component of drought mitigation and/or response in the future.

8.3 Drought Management Plan Approval

Municipality XX's Drought Management Plan was approved by Municipality Council at the **xxxx** Municipality Council meeting. Each member had the opportunity to review the Plan and comment prior to finalization of the Plan and formal approval.

8.4 Periodic Review and Update

Drought management planning is most effective when viewed as an ongoing process rather than a discrete process that results in a shelved document only reviewed at the onset of a drought. **Municipality XX's** Plan will be updated every five years. The next update is scheduled for **xxxx**. The **Municipality XX** Director will be responsible for initiating the update with **Municipality XX** staff responsible for the majority of facilitation. The update will consist of a similar stakeholder process outlined in Section 1.0 and the stakeholder group will be responsible for reviewing the Plan objectives and operating principles in light of the Plan monitoring data and conclusions presented in the annual monitoring reports. This group will be charged with providing recommended changes to the goals and operating principles as well as identifying key changes necessary to improve the overall effectiveness of the revised Plan.

9.0 ANNEXES

ANNEX A - Example Risk Reduction and Mitigation Measures

The drought management plan is based on an underlying premise that drought management activities are conducted at all times in order to avoid and minimize impacts to humans and the economy when a drought is imminent or occurs. As such, the Normal scenario defines the roles of the drought management team and institutions during non-drought situations. As the early information system provides meteorological trend information on the potential onset of a drought, the roles of the institutions switch into Pre-Drought scenario, with increased efforts and beginning of the drought risk reduction and mitigation measures. Once the drought is in full effect (according to PRC Level IV up to Level I), the team have another set of operating procedures (mainly now defined in existing drought relief plans). The Post-Drought roles are one of recovery and return to the Normal mode.

Drought risk reduction and mitigation refers to actions taken in advance of a drought that reduce potential drought-related impacts when the event occurs. Drought risk reduction and mitigation measures continue in a more comprehensive fashion once the condition moves from Pre-Drought into actual Drought levels, in a hierarchical fashion with ever more aggressive measures being employed.

Each municipality or county will need to assess the range of international examples of such measures provided in the project and assess and employ a hierarchy of measures appropriate to their local conditions and context.

Examples of Possible Mitigation Measures to Reduce Drought Impacts by Sector

Short-term	Sector	Long-term	Sector
Supply management			
Mixing fresh and low quality waters	U,A,I,R	Increase water collection and storage opportunities	U,A,I,R
Exploiting high-cost waters	U,A,I	Desalination of brackish and saline water	U
Over-drafting aquifers	U,A,I	Treatment and reuse of wastewater	A,I
Diverting water from given uses	U,A,I	Water transfers	U,A,I,R
Decreasing transport and distribution losses	U,A,I	Artificial precipitation	U,A,I,R
Adjust legal and institutional framework	U,A,I,R	Locate potential new resources (standby supplies)	U,A,I
Etc.		Aqueducts and canals	U,A,I
		Groundwater recharge	U,A,I
		Monitoring and forecasting	U,A,I,R
		Adjust legal and institutional framework	U,A,I,R
Demand management			
Restricting agricultural uses (rationing, subjecting certain crops to stress, …)	A	Adopting supplementary and deficit-irrigation	A
		Water saving irrigation techniques (drip, sprinkler,)	A
Restricting municipal uses (lawn irrigation, …)	U	Incentives to invest in water saving technology	U,A,I
		Water recycling	U,I
Review operations of reservoirs	U,A,I	Dual distribution networks for drinking water supply	U
Water metering and pricing	U,A,I	Inventory private wells and negotiate their public use	U,I
Water rationing	U,A,I		
Education and awareness creation	U,A,I	Assess vulnerability and advise water users	U,A,I
Provide permits to exploit additional resources	U	Elaborate alert procedures	U,A,I,R
		Carry-over storage	U,A,I
Provide drilling equipment	U	Conjunctive use	A,I
Adjust legal and institutional framework	U,I,A,R	Adjust legal and institutional framework	U,A,I,R
Negotiate transfer between sectors	U,A		
Etc.			
Impact Minimisation			
Temporary reallocation of water resources (on the basis of assigned use priority)	U,A,I	Development of early warning system	U,A,I
		Reallocation of water resources on the basis of	U,A,I

Short-term	Sector	Long-term	Sector
Restrict uses	U,A,I	water quality requirements	
Emergency supplies	U	Use of drought resistant plants	A
Public aid to compensate loss of revenue	U,A,I	Development of a drought contingency plan	U,A,I,R
Tax relief (reduction or delay of payment deadline)	U,A,I	Mitigation of economic and social impacts through voluntary insurance, pricing and economic incentives	U,A,I
Rehabilitation programmes	U,A,I		
Resolving conflicts	U,I,A,R	Education activities for improving preparedness to drought	U,A,I
Postpone payment of credits	U,I,A		
Implement set-aside regulations	U,I,A,R	Elaborate set-aside regulations	U,A,I,R

Note: A = Agriculture, I = Industry, R = Recreation, U = Urban

Source: Bazza, M (2002)

Some additional examples of potential mitigation measures to reduce drought impacts.

Short Term Mitigation Measures (suitable for consideration in drought management plan)	Long Term Mitigation Measures (suitable for river basin plan, integrated water resources plan etc)
Improve the accuracy of seasonal runoff and water supply forecasts	Reduction in leakage in canals and main pipelines
Develop early warning systems	Reduction in leakage in distribution pipe network
Establish new data collection networks and data sharing arrangements	Agricultural extension to advise farmers on more efficient irrigation, more drought resistant crops, rotations, deficit irrigation etc.
Emergency limitation on abstraction permit holders (prioritised list of users) in accordance with SCD 460	Introduce more efficient water use in industrial processes by introduction of new technologies
Rotational cuts in water supply	Introduce new technology for clean up of process effluent to improve quality of return flow
Public education and awareness of water saving actions	Take marginal land out of production
Advice to farmers on cropping before planting based on drought forecast	Implement waste water re-use where water quality permits
Avoid high water use crops	Review development plans to avoid new industry with high water use unless committed to new technologies for recycling etc
Revise reservoir operating rules	Establish protection zones above reservoirs to maintain runoff potential and minimise sediment ingress
Waste water reuse where water quality permits	Artificial recharge
Maintain and use cloud seeding capability	Conjunctive use of surface and groundwater
Emergency borehole drilling	Water transfer from outside (inter-basin transfer)
Step up leakage control activities in urban areas	Construct new storage (dam) or transfer infrastructure
Change any subsidies that promote greater water use (eg subsidised electricity for pumping)	Develop water grid to allow internal transfers between sources
Inventory of industrial users with own source of supply to see if this supply could be used for domestic water supply in an emergency	Establish charging mechanisms that discourage wasteful use of water but protect low income users' water for living

Example Using Typical Drought Actions to Illustrate Hierarchy Of Actions As Drought Worsens

Drought Management Actions / **Drought Severity Class**	Normal	Slight IV	Moderate III	Severe II	Extreme I
Information to support decision making					
Drought monitoring specified in Section 4	✓	✓	✓	✓	✓
Additional monitoring during drought to guide mitigation measures		✓	✓	✓	✓
Regular drought forecasts	✓	✓	✓	✓	✓
More frequent forecasts during drought to guide mitigation measures		✓	✓	✓	✓
Publish monthly situation reports	✓	✓	✓	✓	✓
Additional reporting during drought to guide mitigation measures		✓	✓	✓	✓
Situation analysis to support decision making					
Review the situation of water supply infrastructures, water abstraction permit, water consumption	✓	✓	✓	✓	✓
Undertake water deficit analysis and scenarios analysis to emergency limit to water abstraction permit for all 30 individual units / sub-catchments in Chaoyang of Upper Daling Basin by Mike Basin Model;					
Long term measures to increase society's resilience to drought					
Adopt water tariff policy (progressive water price) in order to reduce water demand;	✓				
Strengthen water metering management	✓				
Strengthen regulation of waste water treatment management;	✓				
Drill on drought management (review the historical drought condition to make a preparation for drought management and find out the problems of DMP implementation)	✓				
Develop training events and capacity building on drought management.	✓				
Develop training events on water saving for different sectors.	✓				
Build awareness of water saving in households by dissemination and promotion of water saving;	✓				
Public awareness of drought severity and actions that they should take as individuals					
Build awareness of water saving in households by dissemination and promotion of water saving;				✓	✓
Assistance to agricultural water users (especially rainfed agriculture)					
Forecasts targeting agricultural users		✓	✓	✓	✓
Provide local farmers information related to existing/potential price of crops by agricultural economist, particularly providing the price of drought resistant crops and products;		✓			
Provide local farmers trainings related to planting crops techniques with high economic value during drought condition by agricultural specialists or experienced local farmers;		✓			
Produce TV programmes to show drought resistant crops or how to plant these crops by agricultural specialists, agricultural economists, local experienced farmers (or by other medias);		✓			
Advice water saving irrigation to local farmers or irrigation management staff in villages by staff from Hydraulic Stations at townships;			✓	✓	✓
Assistance to industrial, commercial and institutional water users					
Improve water saving in governmental organizations, industrial enterprises, undertaking units, for example, running automatically-flushing toilet cisterns at times when buildings are unoccupied;	✓	✓			
Measures to reduce agricultural water use during the drought					
Set out water saving irrigation norms in drought condition in order to limit water irrigation to crops with high water consumption. Supervise water saving irrigation in drought condition by irrigation management organizations at all levels;			✓	✓	
Maintain and keep logs and filings related to irrigated water volume in drought condition, and examine their compliance. Under existing irrigated water metering, it requires to provide detailed records of irrigation from groundwater (such as the			✓	✓	✓
Measures to reduce industrial, commercial and urban domestic water use during drought					
Supervise units/individuals compliance with the emergency limit to water abstraction permits and the controls to waste water discharge;				✓	✓
Undertake strictly emergency limit to water abstraction permit to ensure urban/rural domestic water supply and important economic sectors water use by limit water uses in low priorities;				✓	✓
Reduce water supply hours in order to reduce amount of water supply;					✓
Emergency measures to mitigate drought impacts on vulnerable communities					
Supply water for basic needs of local farmers and livestock, who suffer from water shortage			✓	✓	✓
Undertake emergency measures by WSCs in order to provide water to hospitals and schools;					✓
Undertake effective emergency measures to deal with domestic water shortage in some cities;					✓

10.0 Appendices

Example Appendices from Chaoyang DMP

Appendix A	Maps
Appendix B	Rainfall Data
Appendix C	Historical Drought Conditions in Chaoyang
Appendix D	Summary of Estimated Water Use in the Upper Daling River Basin
Appendix E	Drought Severity Indexes and Triggers
Appendix F	Drought Management Measures
Appendix G	Flood and Drought Management Headquarters, Shenyang
Appendix H	Chaoyang Drought Management and Water Saving Implementation Plan of 2001
Appendix I	Drought Monitoring Sites
Appendix J	Water Affairs Bureau Drought Management Team
Appendix K	Main Water Users

Others to consider:

- Communication plan
- Public involvement plan
- etc

Appendix M. Background Materials to Drought Guidelines

M.1 Current PRC Drought Management Guidelines

In 2004, the Ministry of Water Resources proposed "two transformations on flood control and drought relief", i.e., shifting from flood control to flood management and changing from single drought relief to comprehensive drought relief. Comprehensive drought relief referred to expanding the scope and content of drought relief according to requirements of social and economic development. In the past, drought relief mainly served agriculture and rural economy. Comprehensive drought relief requires covering the whole social and economic society, not only focusing on agricultural benefits but also considering social, economic and ecological benefits. This is a new strategy of drought management in China that requires to changing from passive drought relief to proactive drought prevention in order to minimize economic losses and impacts on environment.

Long term drought relief in China has mainly relied on structural measures and administrative measures. As of 2011, there are more than 88,000 reservoirs with total storage capacity of 720 billion cubic meters, of which there are 567 large reservoirs, 3,346 medium reservoirs and 84,700 small reservoirs. However, due to lack of relevant regulations and legislations, water allocation, drought relief decision making, emergency response and water regulation are mainly by administrative tools. The FCDRHs and other water resources agencies have coordinated many major structural projects over the past few years for drought relief such as diversion water from Luan River to Tianjin, Dongjiang-Shenzhen water supply project, diversion water from Yellow River to Qingdao in Shandong province, diversion water from Yellow River to Shanxi province, Water Diversion Project from Biliu River to Dalian City and diversion water from Songhuajiang to Changchun in Jilin Province. Pre-planning for drought relief is common, but flood prediction and proactive drought risk assessment and mitigation to minimize drought impacts are not as well established.

In recent years, in addition to further improving drought-resistant engineering systems in China, the use of legal, economic, scientific, and non-engineering means has greatly enhanced drought relief capability. In terms of legislation and regulations, Anhui, Zhejiang, Yunnan and Chongqing went ahead of other provinces and issued "Anhui drought relief regulation", "Zhejiang flood, typhoon and drought relief regulation," "Yunnan drought relief regulation" and "Chongqing flood control and drought relief regulation." Most noteworthy is the "PRC Drought Relief Regulation" enacted on February 26, 2009, filing the gaps in drought legislation in China and marking the drought relief work has entered into a new phase.

On application of economic instruments, water tariff reform and water right transfer are used to promote the rational distribution and efficient use of water resources. On aspects of technologies, there are attempts and explorations to establish drought monitoring and evaluation system. "Drought level standard[1]" and "Meteorological drought level classification[2]" and a series of drought-related technical standards were issued. In addition, technologies, such as artificial rainfall, sea water desalination, as well as agricultural drought resistant and water saving technologies are used. Guidelines were published in 2013 on the preparation of drought response plans at the provincial level.

The concept of a water saving society has been strongly promoted in China since 2000, reflecting the severe water shortage in many regions which has become a bottleneck for economic development and has resulted in serious environmental degradation. The concept was introduced in recognition of the fact that

[1] Standard of Classification for Drought Severity, SL 424-2008

[2] Classification of Meteorological Drought, GB/T 20481-2006

there appears to be considerable waste of water, and many opportunities for increasing the productivity of water. For this reason, MWR has promoted a programme for establishing a water saving society throughout China. The water saving society implementation plans are prepared at municipality level. Goals for the program for establishing a water-saving society included that by 2010:

- all systems (preliminary) of legislation, administration, economic and technical policies, and advocacy and education for a water-saving society would be established;
- good progress will be achieved in water saving technologies and management levels;
- water-saving awareness of all the people will be significantly improved;
- wastage of water resources will be effectively controlled;
- the water use per 10,000 yuan of GDP will be reduced by 20%,
- agricultural irrigation water efficiency will be increased from 0.45 to 0.5, and there will be no increase in total agricultural irrigation water use;
- the water use per unit of added industrial water output will be reduced by 30%; and
- water use efficiency of service trades will approach the level of world best practice.

Under this program numerous pilot projects have been set up, including in Gansu and Liaoning province. The National Development and Reform Commission, Ministry of Science and Technology, Ministry of Water Resources, Ministry of Construction and Ministry of Agriculture have jointly worked out the China Water Conservation Technology Policy Outline (2005) to provide guidance to the development and application of water conservation technology, push forward the progress of water conservation technology, enhance the efficiency of water use and its benefits, and promote the sustainable utilization of water resources. This Outline provides technological policy support in order to realize water conservation goals. With the guidance of the Outline, China strived to achieve "micro-growth" in industrial water consumption, "zero-growth" in agricultural water consumption and a gradual reduction in overall per capita water consumption in urban cities between 2005 and 2010.The progress and results of the above described initiatives will be reviewed.

Table M.1 provides a summary of China laws, regulations and standards for drought management.

Table M.1 Summary of China Laws and Regulations and Standards for Drought Management

Name	Date/agency	Major content
Provisional Rules of the Use of Subsidy for Major Flood Control and Drought Fighting	Dec 1994 Ministry of Finance, Ministry of Water Resources	Sets forth the use of subsidy for major flood control and drought resistance, the approval and application procedure, supervision methods etc. The subsidy will mainly be used for purchase of materials for construction of simple drought relief facilities and tools for water pumping and transfer.
Provisional Rules on Management of Organisation and Construction of Drought Fighting Organisations	10th May 1996 Ministry of Finance, Ministry of Water Resources	Defines the nature of drought relief service organisation, its function, goal, service method, capacity building etc, to guide the drought relief organisation to develop in a formal way.
Rules of the Use of Subsidy for Major Flood Control and Drought Resistance (Revision)	1st January 1999 Ministry of Finance, Ministry of Water Resources	It makes amendment to the Provisional Rules of the Use of Subsidy for Major Flood Control and Drought Resistance and expands the usage of the subsidy. The subsidy will be used to support construction of emergency drought relief facilities, purchase of water pumping and transferring equipment and to cover the running costs.
Flood and Drought Disaster Statistical Form System (Revision)	2004 The State Flood Control and Drought	It makes amendment to the 1999’s Flood and Drought Hazard Statistical Form System and adds regulation on urban drought hazard statistics. The additional statistical forms include: statistics on status of

Name	Date/agency	Major content
	Relief Headquarters The State Statistics Bureau	urban water shortage and water sources, statistics on urban water shortage and drought relief situation, basic information of water shortage cities and water usage statistics and basic information of water sources of water shortage cities.
China National Flood Control and Drought Relief Emergency Plan	11th Jan 2006 The State Council	Sets forth the structure and function of flood control and drought relief organisation, prevention and alarm system (prevention and alarm information, prevention and alarm actions, alarm supporting system), emergency response (four-level emergency response start up, action and completion, information release etc), emergency security (communication and information exchange security, emergency support and equipment security, technology security etc) and after-disaster work etc.
Terms of Reference for Drought Relief Plan Formulation	27th Feb 2006 State Flood Control and Drought Relief Headquarters Office	Provides guidance on principle and scope of drought relief plan, organisation system, prevention and alarm, emergency response, guarantee measures, approval and revision of plan.
Classification of Meteorological Drought Category	1st November 2006 China Meteorological Bureau	Presents the calculation method and classification criteria of some meteorological drought indicators such as precipitation anomaly percentage, relevant humidity index etc, and identification of drought process and evaluation method.
Soil Moisture Monitoring Standards	1st June 2007 Ministry of Water Resources	Presents the monitoring elements, plan and spread of soil moisture monitoring station network, site visit to and construction of the monitoring stations, monitoring method of soil moisture, soil moisture measurement system and reporting method, aiming at standardising soil moisture monitoring.
Standard of Classification for Drought Severity SL424-2008	29th December 2008 Ministry of Water Resources	Presents the drought assessment indicators and corresponding classifications for agricultural drought, pasture drought, urban drought and drinking water difficulty caused by drought. Regional drought can also be evaluated.
Drought Mitigation Regulation of the People's Republic of China, Decree No.552	26th February 2009 The State Council	Presents the requirements (Article 14) for the development of drought management master plans with mitigation measures for different severities of drought. Sets out activities, roles and responsibilities in the event of drought and post drought restoration. Sets out the legal obligations and responsibilities of organisations and individuals in complying with the regulations for drought mitigation and penalties for non-compliance.
Compilation Guidelines for Drought Response Plan	22nd April 2013 Ministry of Water Resources	Provides guidance on principle and scope of drought response plan, organisation system, prevention and alarm, emergency response, guarantee measures, approval and revision of plan.
Cartographic symbols for flood control and drought relief maps	Forthcoming/ Ministry of Water Resources	Provides specifications on symbols, classifications and scale of maps for flood control and drought mitigation.

Annex 1 contains a translation of the Compilation Guidelines for Drought Response Plan (SL 590-2013), issued by Ministry of Water Resources on 2013-01-22 and came into force in 2013-04-22. This guidance is very new and has yet to be fully implemented in the existing provincial drought relief plans. Eventually, the concepts and ideas put forth in the guidelines produced in the TA would have to be codified by amending Regulation 552 above and revising the SL590 guidelines. This work to integrate the concepts and ideas of drought risk management into existing China regulations and guidelines is beyond the scope of the TA.

M.2 Basic Theory of Drought Risk Management Versus Drought Response

The TA team believes that the implementation of drought risk theory in China must be performed in such a manner that is cognizant of drought management institutions and constraints. As such, the TA activities have been prepared based on this understanding. This includes recognition that water related risk mitigation and water conservation measures are more properly managed in China at the municipal; and county level drought management plans, including their major local water suppliers. Provincial drought management plans should provide an overview of historical drought-related vulnerabilities throughout the province, guidance on the use of risk based proactive approaches to drought prior to the drought actually beginning, tools to assist in the production and implementation of the local DMPs, and a regional perspective and oversight when droughts extend to multiple local jurisdictions.

Based on the size and complexity of water institutions and sources in a province, provincial DMPs in China cannot be “command and control” drought management plans which attempt to outline detailed risk reductions and water conservation and control programs at the local scale. Such issues are intrinsically connected to water abstraction and control programs that are part of local water management control systems. As was shown in the DFID WRDMAP program, municipal level drought management plans can contain the detailed triggers and actions necessary to manage drought proactively as it is occurring, rather than merely a response to drought after it is underway. However, this will mean a major change in the way FCDRHs view their mandates and standard operating procedures at all levels. Provincial DMPs can also contain requisite early warning triggers for action at the local level, but not at the micro-scale involving changes in water supply, abstraction licenses or water conservation measures. These are the proper domain of local government and water supply institutions, with guidance from the local FCDRHs.

The provincial DMPs produced under this TA will incorporate international best practices, current Chinese institutional and regulatory processes, and the recognition that these provincial DMPs are catalysts to the production and implementation of locally-driven DMPs to make appropriate risk based water management and water conservation measures before droughts occur to minimize impacts. Such local decision making is a critical aspect of demand management and IWRM for China, and risk based drought management planning is integrally linked to demand management techniques.

The TA team approach on all aspects of the work program will include final risk based drought management plans under a tiered approach of provincial DMPs providing oversight to the production of the local municipal and county level DMPs. The experience of WRDMAP project in the production of a prototype DMP for Chaoyang Municipality in Liaoning Province will provide an excellent case study on how to apply DMPs in local jurisdictions. Per the TOR, the provincial DMPs will be prepared for all three pilot provinces with guidance on the production of local DMPs in a complete systematic approach.

The IWHR guidance on drought relief plans is a comprehensive planning tool for managing droughts once they are underway. The TA team proposes to overlay a drought risk planning approach on the front of the existing drought risk planning protocols, not propose immediate replacement of these existing systems. As the drought risk management processes mature, it is likely that some of the triggered actions in these relief plans will also focus on risk reduction, but this is a long term proposition.

A **Provincial level drought management plan** (DMP) should provide adequate information and narrative and ideally include the following Plan elements:

5. *Documentation of the Planning Process* – processes used in DMP development, agencies involved, plan review and analysis.
6. *Monitoring and Forecasting for Early Warning* – using provincial DWR and meteorological department indices, monitor potential drought conditions and notify affected areas to conduct additional monitoring and forecasting of local water supplies and demands.
7. *Coordination of Agencies* – including Provincial Water Resources and their local offices, FCDRHs at various levels, and other ministries.
8. *Risk Assessment* – identification of drought hazards, comparative drought risk areas within the province, drought monitoring used, drought indicators, drought history, and probability of future droughts.
9. *Assessment of Vulnerability by Local Areas* – municipal and county level vulnerabilities compared, areas most threatened and most vulnerable, processes used to review and assess DMPs produced at local levels, changing development patterns.
10. *Water Saving Techniques for Normal Operations and Triggered Pre-Drought Conditions* – guidance on the use and application of demand management including water saving and water conservation measures that are always applicable, as well as additional measures that can be triggered in local DMPs with a potential drought prediction.
11. *Estimation of potential drought losses by Local Areas* – overview and analysis of potential drought losses, summary of local area DMP risk assessments relative to potential losses.
12. *Mitigation Strategy* – pre-drought risk based management program, goals of hazard reduction and mitigation, provincial assessment of current mitigation capabilities, post-drought hazard management program, provincial policies and funding for drought risk management mitigation.
13. *Proposed Mitigation Actions* – identification of options, evaluation and selection of actions, progress in implementing options, integration of local mitigation plans into regional and provincial program of mitigation, funding sources.
14. *Provincial Coordination of Local Mitigation Planning* – provincial processes to support the local plan development and implementation, methods used by province to review and approve local DMPs, process and timing used to link local DMPs to provincial strategy, criteria for planning and prioritizing drought assistance.
15. *Plan Maintenance Process* - monitoring, evaluating and updating the plan, monitoring progress of mitigation program,

A **Municipal or County level drought management plan** (DMP) must provide adequate information and narrative to indicate that the following Plan Elements, which are composed of various actions and programs related to the water suppliers within their jurisdictions:

1. *Stakeholders and Plan Objectives and Principles* – Focuses on the preliminary steps necessary to initiate the development of a drought management plan. This includes developing a planning team, securing stakeholder involvement, and developing plan objectives and operating principles.
2. *Water Saving Techniques for Normal Operations and Triggered Pre-Drought Conditions* – using provincial guidance on the use and application of demand management including water saving and water conservation measures that are always applicable, identify methods to implement these normal techniques within major water suppliers and water users in jurisdictions.
3. *Monitoring and Forecasting for Early Warning* – using local WAB and water supplier indices and meteorological department indices, monitor potential drought conditions and notify affected water suppliers and water users based on pre-identified triggers in local DMPs to implement additional water saving, water conservation measures and potentially re-adjust abstraction permits.

4. *Historical Drought and Impact Assessment* – Evaluation of the severity of historic droughts and corresponding effects on a provider's water supply system and service area demands. This step also includes the identification of specific drought-related impacts and an evaluation of historic drought mitigation measures and response strategies.
5. *Drought Vulnerability Assessment* – Review of water supply reliability planning efforts, from potential additional supplies and full demand techniques. This step also includes the identification of potential drought impacts and perceived severity of impacts.
6. *Drought Mitigation and Response Strategies* – Selection of a combination of mitigation and response strategies. Drought mitigation is ideally implemented prior to a drought to avoid and/or reduce potential future drought impacts. This step also includes guidance for the development of a public education and awareness strategy in conjunction with water suppliers.
7. *Drought Stages, Trigger Points, and Response Targets* – Identification of drought stages and corresponding drought trigger points and response targets. These may be specific criteria adhered to during a drought or simply Guidelines that a provider can incorporate into the drought monitoring and response efforts.
8. *Staged Drought Response Program* – Development of the specific drought response measures for each pre-drought and drought stage. These response measures should describe the actions necessary for water providers and customers to take to reduce water demand and enhance water supplies during each individual stage. This step may also include the development of a public drought education campaign plan.
9. *Implementation and Monitoring* – Implementation of the drought management plan, which includes an action plan for: mitigation; monitoring of drought indicators; drought declaration protocol; implementation and enforcement of the staged drought response program; revenue planning; and monitoring of the drought response effort.
10. *Plan Review and Updates* – Establish formal processes to review, approve, and update the drought management plan. This may include a public review process, review and approval by the local government, adoption of necessary policy, and a plan for future updates.
11. *Public Involvement Program* – Methods used for public review and comment in the development of the DMP.

Annex 1 – Actual Draft Drought Risk Management Guidelines

Separate volume

Capacity Development Program

TA8185: Pilot Implementation of the Drought Management Strategy

June 2014

Asian Development Bank

ADB

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Capacity Development Program

TA8185: Pilot Implementation of the Drought Management Strategy

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Contents

Executive Summary

This report summarizes the main constraints related to technical capacity in drought risk management, and proposes a capacity-building program on the basis of surveys undertaken in pilot provinces to identify needs:

- There is weak capacity, especially at low levels. There have been considerable efforts in the past decade to improve this situation but this is mostly related to general aspects of water management, with little detailed attention to droughts.
- There are many other institutional and other constraints, but even if these are relieved, the desired impact will not be achieved until capacity is raised.
- Most training to date is general, with limited coverage of drought issues. There is not even understanding to implement current guidelines fully. Training will need to address these as well as new concepts of risk management.
- Funding for capacity-building is a key issue. The amount of technical training that is provided is currently quite low and under-resourced. Additional training is needed and yet this will have to be funded from existing budgets.
- Implementation of guidelines and DMPs will not be possible without a significant effort in capacity building.

Provincial workshops have had a significant impact on high level understanding of some key aspects of drought risk management, and the changes needed to implement it.

The international study tour led to an understanding of international approaches to solving key problems: water-savings and water infrastructure can reduce the risk of drought occurring, but there is a need for drought monitoring, data sharing; drought management plans and better public understanding of risk; drought insurance and reallocation of supplies to high values uses are valuable, but can be difficult to implement

A capacity building program, for state, provincial, city and county-level FCDRHs has been planned and designed to address the key issues identified in the capacity needs assessment. These include:

- Drought vulnerability and risk assessment
- Drought prediction and early action
- Proposed tiered drought management planning responsibilities
- Co-operation between agencies for managing drought risk

It is anticipated that a rolling program of 10 days training for around 600 people in the three provinces will be required. In order to avoid disruption to daily work, it should be undertaken in two day blocks. This should later be extended to other provinces.

1 Current Capacity and Capacity Development

1.1 Current Capacity Related To Drought Risk Management

In September 2013, the TA Team evaluated the local capacity in drought risk management through a questionnaire survey in the pilot provinces and a drought risk management meeting. The following were the major conclusions of the survey and meeting:

1. Personnel engaged in drought management have insufficient understanding of drought risk management.
2. Provincial drought management personnel have a higher consciousness of risk than equivalent municipal and county personnel.
3. Those who are in relatively dry areas have a higher consciousness of drought risk management than those in relatively wet areas. The awareness in Gansu province, which is relatively dry and suffers from water shortage, is greater than in Liaoning province and Sichuan province which have relatively abundant water resources.
4. The drought management proficiency level in most areas is not high, and the management departments are in a transition phase from emergency response to risk management.

Although staff capacity is weak and needs to be strengthened, this must be undertaken in the context of other constraints to drought management:

- Specific laws and regulations related to drought management are lacking in most areas. Most areas depend on national laws and regulations, but lack corresponding local laws and regulations. This makes it difficult to give specific instructions on drought risk reduction and mitigation work.
- Technical standards on drought monitoring, early warning and drought assessment are lacking or not complete.
- Drought management staff numbers are not sufficient, especially at county level.
- The three pilot provinces generally lack drought monitoring and early warning means and methods.
- Cooperation between agencies, including water resources, agricultural and meteorological departments is weak. A mechanism for information sharing is needed to ensure that drought management staff have timely access to hydrological and meteorological and agricultural information, which is needed for drought assessment and decision making.

Further information on the findings of the surveys on institutional and water user capacity and understanding are provided in the appendices to this capacity-building program report, with full details in the final report on the TA.

In China, the main responsibility of drought management is led by Flood Control and Drought Relief Headquarters (FCDRH) offices at national, provincial, municipal and county levels. Strengthening drought management capacity thus essentially means strengthening the management and technical capacity of drought management and technical staff in the FCDRH on these four levels. In addition, training in IWRM is needed for the water resources administration at all levels, but this is a part of their normal work and not covered by this program.

However, there is also a need to raise understanding and capacity of staff in related technical organizations and local government to ensure that the importance and value of drought risk management is recognized, budgeted for and incorporated in wider development plans. This is also needed to facilitate collection of real-time data and information in technical organizations, data sharing between these organizations and the FCDRH, and coordinated planning and action, which are all crucial requirements for implementation of drought risk management approaches.

1.1.1 Capacity Development of Water Resources Management Staff

In the last 20 years the MWR has promulgated various regulations and plans in order to improve the technical capacity of water resources management staff including FCDRH. These include the education regulations for water resources staff (1995), notice on implementation of staff training registration system (2003), training management of water resources management staff (2003) etc., and training plans for water resources management staff during the tenth (2001-2005), eleventh (2006-2010), and twelfth five-year plan (2011-2015). These related policies and plans have been very helpful in strengthening the capacity of water resources management staff.

The training plan for water resources management staff during the tenth five-year plan (2001-2005) established a training registration system with a series of policies to implement training, and an evaluation scheme. It outlined the main objectives and tasks to be achieved by the end of 2005, including building the infrastructure for the training system such as the development of key training bases and implementation of multi-media training, improvement of the training management system and securing more funding sources for training.

In the training plan for water resources management staff for the eleventh five-years plan (2006-2010), a few training projects were developed including for cadres and civil servants under MWR, for raising the technical competence of cadres in the water sector at local level, and to renew the water resources knowledge of technical staff. Through training seminars held in association with the Ministry of Human Resources and Social Security, knowledge in key areas of planning and design, water resources management, construction management, water and soil conservation, rural water resources, flood control and drought management, hydropower and rural hydropower, hydrology and information system for irrigation works and water resources engineering was conveyed to 100,000 technical staff.

In the water resources management capacity building plan during the twelfth five-year plan (2011-2015), five issues in the current capacity of the water sector were recognized:

- Lack of advanced technical, experienced and innovative specialists.
- Need to raise the overall education level and technical competence of water sector staff.
- Uneven distribution of specialists with high average education level in MWR while lower education level in the water sector at local levels.
- Loss of outstanding technical staff in the water sector at local levels.
- Weak foundation for capacity building.

To solve the issues above, the twelfth five year plan proposed a project to encourage university graduates to work in the water sector at local level and improve directors' competence in the water sector at municipal and county level.

According to the tiered responsibility of each administrative level, the 10,000 bureau directors' training plan was implemented and targeted at municipal (and county) level. A training plan for the water managers of water resources management stations was also implemented. Specific training plans were implemented for key management staff in the water sector at local level and for young staff,

Currently, water resources management staff training is organized based on the notice on implementation of staff training registration system (2003) and training management of water resources management staff (2003) referred to earlier. Each sub-division needs to compile its own annual training plan and submit to the Human Resources and Labor Department for approval. In these regulations it is prescribed that the

required training time for administrators on different levels is no less than 3 months, for technical staff no less than 12 days over five years and the training should be undertaken away from the job but related to job requirements. Since 2003, water resources training certificates were issued to record the training hours.

The MWR also conducted training specifically targeted to meet occasional requirements. For example, in order to implement the 2011 Central No. 1 notice, "Speed-up development of water resources reform", MWR decided to start a training plan for 10,000 water resources bureau directors. It was planned that by the end of the twelfth five-year plan, 10,000 county level administrators, 10,000 local water resources monitoring administrators and five thousand key technical staff would have been trained. Through this plan, the percentage of personnel higher than grade 12 was increased from 33% to 45%, the percentage of administrators at county and municipal level water resources management departments with postgraduate education was increased from 49% to 60%. The percentage of local water resources monitoring station administrators with college education was increased from 54% to 65%.

According to the regulations, the funding source for a training program in a certain area is the budget of the corresponding sub-division. Specifically, the funding for drought relief training would be from MWR sub-divisions specialized in drought relief, such as national FCDRH, department of drought relief strategic research and analysis, etc. For example, to coordinate with the implementation of the Compilation Guideline for Drought Response Plan (SL590-2013), the department of drought relief strategic research and analysis is applying for funds for providing training on the specific area. This training could be expanded to include drought risk management.

1.1.2 Current Training Specifically Related to Drought Management

Technical training related to drought management has been provided by the drought risk strategic analysis and research department under IWHR and held in form of a series of seminars for staff in water sector at national to provincial level[1]. Seminar topics included drought risk assessment and mapping techniques; key contents of PRC Drought Relief Regulations; drought relief training for provincial administrators; and drought relief training for technical staff, etc. To help implement PRC Drought Relief Regulations, special training was provided after the regulation was promulgated. Drought relief manuals and workbooks were also prepared and distributed to the staff in water sector at provincial level for them to utilize as training materials when organizing training coursed for the staff in the water sector at the local level.

The drought-related training programs for staff in water sector at local level are organized by the local administration. In Liaoning, the provincial bureau of agriculture and water resources organized a training course on topics of flood control and drought relief, construction and management of rural water distribution system, integrated management of rural river courses, construction and management of drip irrigation projects, water and soil conservation, water saving irrigation techniques, and basic knowledge of Water Law etc. in 2013. Appointed by the provincial bureau of agriculture and water resources, seven water saving specialists from the provincial and municipal water sector lectured on these topics.

Municipalities have also organized some drought-related training programs. For example in Jiangsu province, Xuzhou Municipality organized a six-day training program with Tsinghua University to strengthen the overall capacity of staff in water sector at local level in 2013[2]. Water sector staff of Xuzhou Municipality

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[1] Source - Liaoning Government Website: http://www.ln.gov.cn/zfxx/tjdt/201307/t20130725_1151546.html Last access: May 1, 2014

[2] Source – Xuzhou Government Website: http://www.xz.gov.cn/zgxz/zwgk/20131217/008001_7b5aa04e-0ee6-4b95-9245-d867f7f0db8d.htm Last access: May 1, 2014

assembled in Beijing to take the training courses. Topics covered in this training included not only water resources and drought relief, but also public management and leadership development. Experts from Tsinghua University, Chinese Academy of Engineering, and the state FCDRH were invited to give lectures.

1.2 Constraints to Existing Capacity Development Programs

Current capacity development programs are facing the following main constraints:

1. The past training focused on increasing the overall capacity of water resources management staff and helped ensure a good understanding of basic water resources management. But the drought-related technical content of the training provided has been relatively limited. Because the specialized technical aspects are not emphasized, the capacity of drought risk management staff is not high enough and the understanding of drought risk management is limited.

2. The current drought-related training regarding focuses on drought response and emergency relief, rather than on drought risk management. Training is ***ad hoc*** and not part of a structured program of drought-related capacity building. This needs to be strengthened with additional material on Drought Risk Management included.

3. Approaches for drought management are changing, and capacity to implement even the earlier approaches is weak, and thus training is needed in both the current systems and proposed new developments. The current provincial drought management plans are drought relief plans prepared in accordance with the Drought Relief Regulations (DRR) and Drought Classification Rules of 2009. They have not yet been updated in accordance with the new "Compilation Guidelines for Drought Response Plan (SL 590-2013)" was issued by Ministry of Water Resources on 2013-01-22 and came into force in 2013-04-22. This guidance provides a blueprint for comprehensive planning and management of droughts once they are underway. FCDRH staff are not used to working even with these guidelines, but now it is proposed that a drought risk planning approach should be added to the front end of the existing drought relief planning protocols. Staff need to be trained not only on the new drought risk management aspects but also on the requirements of the 2013 Compilation Guidelines. For simplicity of implementation of drought management, it is not recommended that the 2013 guidelines be replaced but that they should be supplemented by risk-related provisions.

4. Additional capacity development and training will be necessary to enable water management staff at municipal and county levels to manage the drought management plans adequately. It will take significant time for municipal and county level FCDRHs to develop adequate DMPs so there must be a transition time, and indeed training will be needed in order to prepare and manage the local DMPs. Local officials will also require time to work with the various sector water management officials (urban water supply, industry, agriculture) on their sectorial drought management plans. There is a significant turnover in staff at all levels, and thus there needs to be a continued program of capacity-building.

1.3 Suggestions to Move from Drought Relief to Drought Risk Management

As the concept of drought risk management is relatively new and unfamiliar, capacity building will be needed so that it can be implemented effectively as recommended in the Guidelines for Drought Management. Capacity is needed in the four main topics in the strategic framework for drought risk management, including:

- Drought vulnerability and risk assessment

- Drought prediction and early action
- Proposed tiered drought management planning responsibilities
- Co-operation between agencies for managing drought risk

Capacity will also need to be built to enable preparation and implementation of the Drought Management Plans, and input from specialist research institutes will be required for this aspect. The prototype plans for the three pilot provinces provide detailed examples indicating the topics in which capacity needs to be built:

- Integrated drought database to allow for continuous monitoring of MWR and NCC data on meteorology using SPI, river flows and reservoir levels.
- Vulnerability assessments in the province coordinated with local jurisdictions.
- Development of standard protocols and minimum requirements for municipal, county and sectorial DMPs prepared in the Province.
- Coordination of local DMP responses especially where drought affects multiple municipal areas or major sectors.
- Establishment of an organizational structure and delivery system that assures information flow between and within levels FCDRHs.
- Drought relief planning and implementation managed on provincial level according to existing PRC regulations.
- Report on activities upward to National FCDRH and downward to local FCDRHs.

The Guidelines for Drought Management and the Drought Management Plans are recommended to be used as resource material for training and capacity development programs.

2 Capacity Development Program Conducted During TA

2.1 Provincial Workshops

2.1.1 Inception Workshop April 2013

An inception workshop was held in Beijing on 28 April 2013. About 20 officials and staff from MOF, MWR, FCDRH Offices of the State, Gansu, Liaoning, and Sichuan provinces, the consultants, and ADB participated in the workshop. An official from MWR made a speech on the background of the TA. The mission made a speech on the rationale and purpose of the TA. The consultants discussed with participants (i) theoretical underpinnings of the drought risk management approach, (ii) organization of the TA, (iii) the outputs of the previous TA, (iv) drought risk management approach, (v) the terms of reference and schedule for the consulting services for the TA, (vi) work program and tasks, and (vii) project deliverables. The presentation slides are shown as Appendix C. Officials from FCDRH Offices of Gansu, Liaoning, and Sichuan presented the situation and drought management practices in their provinces.

The director of Liaoning province FCDRH gave an overview of the provincial tools and activities related to drought risk management. His expectation from this project is that it will be practical so that it can be implemented. The province has participated in many drought risk management research projects including about risk mapping and forecasting models but many of these project have not been implemented. In Liaoning they have many monitoring stations and data availability should not be a problem. Hydrological bureau data are shared between the different levels (provincial, municipal, county) and come together in the provincial database. They have good relations with the climate departments.

The director of Gansu province FCDRH gave an introduction about his province and mentioned they are working on response plans and drought forecasting. He hopes this project will help to integrate the various activities related to drought risk management in his province. He also mentioned that Gansu province puts more emphasis on the drought part of FCDRH than floods since they are a dry province, and they even reverse the drought and flood in the name of the organization.

2.1.2 September 2013 Gansu Workshop

The first provincial workshop was held in Lanzhou, Gansu Province with participation by all three pilot provinces during September 2013 to discuss the following topics:

- Introduction of relevant concepts of drought
- Methods for evaluation of drought risk
- Concept of drought risk management and implementation internationally
- Framework for drought risk management
- Proposed methods for developing drought risk management plans (DMPs) for provinces under the TA, and how these provincial DMPs relate to local drought risk management planning.

Approximately 30 participants attended the workshop, including staff from FCDRH at national, provincial, municipal and county level as well as personnel from related departments, foreign affairs office and the Ministry of Water Resources project management institutions.

In the workshop, the team leader Lawrence Quinn, project team deputy team leader Lv Juan and water-saving expert Marieke Nieuwaal respectively gave presentations about drought risk management, China's

response to drought disasters and water saving measures. Case studies and examples of Chinese successes and international best practice were shown.

After the presentations, representatives of the three pilot provinces introduced the situations and constraints around drought risk management in their provinces and a discussion meeting was held.

The main conclusions of this meeting were as follows.
1. There are relatively few municipal and county personnel engaged in drought management.
2. The pilot provinces generally lack drought monitoring and early warning means and methods.
3. Drought risk management knowledge of drought management personnel at all levels is limited.
4. The relevant policies, regulations and technical standards of drought assessment require improvement.

Workshop presentations are shown as Appendix C to this document. Table 2 1 provides a brief summary of the discussions and main issues raised at the provincial workshop.

In addition, FCDRH of Gansu province organized a one-day field visit to show some drought risk reduction and mitigation practices, including rainwater collection systems in rural areas, large-scale soil and water conservation measures, water transfer projects, and water-saving agricultural techniques in the province.

Table 2.1: Summary of Gansu workshop discussion and main issues

Topic	Current Status	Recommendations
Drought management	Most people thought current drought management practice is emergency drought relief, rather than risk based drought management in an integrated way. They agreed the risk based management method could supplement current drought relief practice and improve drought management in China.	International examples will help to understand the risk based concept. More cases or examples could provide to inform people.
Monitoring and indicator system	Liaoning has good basis for data collection and sharing. But most places in Gansu and Sichuan have few monitoring stations, especially on soil moisture. Tiered approach can be adopted. Early warning or information sharing can start with primary meteorological data, mainly precipitation based indicators.	Data sharing could be a problem due to some institutional issues. Inter-agency cooperation needs to be strengthened. The power of FCDRH on coordination and cooperation needs to be improved. According to local situation, monitoring stations could be planned based on current station map within different organization. Overlap of stations should be avoided. Practical suggestions on local indicator selection could be given to guide local people to implement the indicators and triggers.
Institutional issues	It is difficult for FCDRH to implement drought management work 100% through daily work. Risk based drought management should be embodied into strategic documents and policies and implemented under the leadership of the government at different levels.	Suggestions can be provided to higher level and included into policies and regulations. Data sharing and inter agency cooperation needs to be strengthened. Integrated water resources management should be improved after several years implementation to include drought risk management and mitigation into the daily operation of related organizations.
Natural conditions (water shortage) vs drought	Especially in Gansu and mountainous areas in Sichuan and Liaoning, people talk about water shortage due to natural climatic conditions. Drought caused by abnormal climatic conditions, mainly by very low precipitation should be the	Coping with water shortage problem should be included in the integrated water resources management. FCDRH should focus more on emergent drought responses and coordinate on risk reduction

Topic	Current Status	Recommendations
management	focus of drought management by FCDRH and hence some actions in pre drought conditions need to be prepared.	measures during pre-drought condition. Emergent drought responses in pre and drought conditions should be included in daily operation of different organizations, with FCDRH's role on coordination and corporation.
Infrastructure focus	They all mentioned the engineering measures to cope with drought covering both supply and demand sides, including rainwater harvest, water storage, water transfer and water-saving irrigation and cultivation. Some of them think strengthening the infrastructure should still be one of the future focuses.	Focusing on infrastructure and the physical construction is common in China. The distinction between improvement water resource management in a situation of general shortage and drought management is not fully understood and needs to be addressed in training programs More training program need to be provided to expend the interests to other non-engineering measures. GDP-driven performance assessment should be switched to performance based evaluation, as a long term goal.
Drought relief service group	According to relevant policies and documents, drought relief service groups were set up for counties. Central government provided 2 million yuan per county to support the development of such organizations, mainly for purchase vehicles and pumps for transporting or pumping water during drought seasons.	In the light of water resources institutional reforms, drought relief service group could be part of the integrated service provider at lower level. The principle should be sharing the risks with the public and increasing the participation of the public in drought management to make it efficient and effective.
Public participation on drought management and relief	Shortage of labor in rural area is a problem for water transportation for irrigation during drought. Small size of land holdings reduces the affordability and incentive of individual farmers to save their agriculture losses by paying for insurance, if there is any available.	This is a common problem in most rural areas in China, and there is a need to design measures to provide enough incentive for farmers to participate the drought relief and risk reduction activities, rather than seek alternative employment to offset the losses incurred through a disaster
Lacking of funds	Most of the drought management budget has not been included in local financial annual plan, which means that the drought mitigation measures have not been fully implemented. Without financial support, drought relief actions embodied in the daily operations are hardly to be implemented.	Strengthening IWRM and including some of the drought risk mitigation activities into daily operation of other organizations. Get support from local financial department or bureau.

2.1.3 Provincial Workshops on DMPs, Sichuan and Liaoning, March 2014

Two workshops were held in Chengdu, Sichuan and Shenyang, Liaoning with local FCDRH staff at each province to collect feedbacks on provincial DMPs. During the workshops, following topics were discussed:

- Introduction to the current drought response plan being implemented in China
- Moving towards drought risk management
- Connections between municipal/county drought risk management plan and provincial plan
- Drought indices and triggers for drought risk mitigation measures (local/provincial)

Ten people from Sichuan and 15 people from Liaoning provincial and local FCDRH attended the provincial workshops, respectively. The team leader Lawrence Quinn, project team deputy team leader Lv Juan and water-saving expert Marieke Nieuwaal respectively gave presentations about how to move toward full time drought risk management, China's response to drought disasters and water saving measures for different phases in drought cycle.

After the presentations, a discussion meeting was held around how to implement risk-based drought management plans in the provinces.

The main feedback from Sichuan province was as follows:

- The DMP is very comprehensive and specific.
- It is difficult to have detailed and specific triggers in one DMP for the whole province in Sichuan.
- It is better to initiate the new DMPs from the state FCDRH so that they will get high-level institutional and funding support, and ensure that the local government budgets for this work.
- Due to low education level of general public in Sichuan, especially the rural area, it would be difficult to engage more people in drought management activities.
- Funds for drought relief were about to be cut, so the goal of managing drought risk during normal condition would be more difficult to achieve

The main feedback from Liaoning province was as follows:

- It is recognized at the provincial administrative level that the implementation of drought risk management calls for close inter-agency cooperation.
- Social stability could be another factor when considering trigger events,
- The Provincial FCDRH requires a template for county and municipal level drought management plans to help them to determine the required local capacity.
- Priorities for restrictions and reallocation of water use during a drought could be further specified and clarified with pre-approval to save decision-making time during the drought.
- Drought service groups play an important role in rural drought relief activities.
- The local FCDRH would like to have more guidance on how to implement drought risk management activities in their daily work.

Workshop presentations are shown as Appendix C to this document. Table 2 2 provides a brief summary of the discussions and main issues raised at the provincial workshop.

Table 2.2: Summary of Sichuan and Liaoning workshop discussion and main issues

Topic	Current Status	Recommendations
Inter-agency cooperation	The risk-based management approach calls for intensive inter-agency cooperation, and it is difficult for the provincial FCDRHs to take the leading role on spurring the coordination. Without a direct order from the administrator in their own sector, public service staff lack the motivation to maintain efficient inter-agency cooperation.	It is easier to implement this approach from the national FCDRH level, and incorporate the drought risk management duties into each agency's daily operation. Some risk management work has been implemented through analyzing data obtained from meteorological department every half month by Leshan FCDRH (Municipal level) in Sichuan to understand the trend in development of droughts.
Monitoring and early warning system	The numbers of monitoring stations are not sufficient to ensure a full coverage of the whole province and obtain a comprehensive understanding of drought risk in the province. Selecting a sampling location that is representative for drought monitoring is critical. The local FCDRHs would need more technical guidance on the selection of sampling location. Liaoning has established a data sharing mechanism with meteorological department. However, due to lack of maintenance of the information technical platform, the system is not working very efficiently.	Adopting mobile monitoring devices for monitoring of droughts could help to improve the poor monitoring infrastructure conditions.

Topic	Current Status	Recommendations
Drought risk assessment scheme	Using one index to evaluate the drought risk in the whole province is not practical in Sichuan. It is hard to evaluate the impacts of drought due to the inconsistent statistical methods used in different sectors to assess the drought losses.	Sichuan has valuable data from the drought event during the year of 2006 and 2007, recording the distribution of drought damages. It could be used to compare with the drought risk mapping results in the Sichuan DMP and help to improve the drought risk assessment scheme to generate a more accurate drought early warning.
Phased drought risk reduction measures	The affected sectors and enterprises were not consulted when the water resources bureau set up a water supply plan to mitigate the drought risk in Fuxin, Liaoning. The drought risk mitigation measures such as water cuts need to be more specific and pre-approved by local authority.	A memorandum of agreement (MOA) could be established to obtain approvals from multiple parties. A review of historical drought risk mitigation measures could provide information on the cost-effectiveness of various measures and details of common activities taken to cope with drought.

2.2 International Study Tour

An international study tour to Spain and Portugal was held in December 2013 to study the drought management techniques used in some EU countries which have faced significant drought problems in recent years. The full Study Tour report is included in Appendix 9 of the Final Report.

The following are some important lessons learnt from the Study Tour, with recommendations for applying these lessons in PRC for drought management.

2.2.1 Lessons

The main findings are grouped under six headings:
- Drought monitoring and drought classification.
- Water saving to reduce risk of drought
- investment in water infrastructure to reduce risk of drought, including storage and inter-basin transfers
- Development of drought management plans.
- Agricultural insurance
- Public awareness for water savings and drought understanding

(1) National system for monitoring of drought risk

Spain and Portugal shifted some time ago from drought relief to drought risk management, with real time monitoring since 1985. A joint EU internet-based drought monitoring and prediction system for European drought has been set up and has evolved to offer timely and authoritative information. This provides real-time of monitoring and drought forecast information for each area and river basin, including drought monitoring indicators (SPI, soil moisture) and drought classification. It provides a platform and standard format for shared data, with an annual seminar for the exchange of knowledge.

(2) Water saving management to reduce the risk of drought

Drought restricts agricultural development which is critical for Spain’s economy, so water-saving irrigation has been highly developed and promoted by the government. Modern techniques such as drip and spray irrigation are used on 90% of the land. Water distribution systems are automated, with accurate measuring

and control equipment, and all data is compiled and managed efficiently. Farmer cooperatives are actively involved in management, thus reducing the management costs.

(3) Water conservancy construction to reduce drought risk

Water storage dams have been built for thousands of years, and are very important for mitigating droughts. In addition, water transfers from the wet north to the dry south are very important for this purpose.

(4) Development of drought management plans

The new Water Law in Spain in 2001 required each basin to prepare drought management plans and these have been approved at ministerial level. These ensure adequate water supply to guarantee the human life and health; minimize the ecological impact of low flows; and determine priorities for water allocation at time of drought on public water supply.

The drought management plans draw on

- Diagnosis of the drought situation – basin characteristics, historical trends, drought indicators, thresholds and standards.
- Development of drought response measures. With the development and intensification of droughts, the response gradually rises from information management to water-saving measures, and finally to restrictive measures. Drought mitigation measures include new wells, canals, desalination plants, and non-engineering measures, such as changing priorities of water, and increased abstraction of groundwater. Conjunctive management of surface and groundwater has proved to be very effective
- Public consultation, stakeholder collaboration, and integration of local knowledge and practices into different levels of water management.

(5) Introduction of agricultural insurance systems

Drought risk insurance is high risk, low income in comparison with other types of insurance. However, Spain and Portugal have developed a good system through collaboration between insurance companies and the Government. This followed on from a law on agricultural insurance in 1978. The government subsidizes the premiums, at different levels ranging from 20-50% according to the crop (and differs between male and female farmers), and provides reinsurance to the insurance firms. This has proved to be very effective at sharing risks and has avoided the need for the government to pay out emergency relief. Farmers who do not take out this insurance will not get any relief from the government in the event of any drought.

(6) Enhanced public awareness and education

Public awareness of water-saving is essential, and this starts from a very young age and is comprehensive. Full details are provided and information is available to everyone. All forms of media are used.

2.2.2 Recommendations

2.2.2.1 Speed up the transformation of managing mode

Government intervention after a drought occurs is widely adopted in most countries currently. This kind of emergency management approach aids the drought-affected populations with subsidy or other forms of support through emergency aid project. From the perspective of disaster management, this kind of passive management is seriously flawed, because it does not involve the beneficiaries or encourage them to change their behavior to reduce their risks. Dependency on Government aid to a certain extent reduces the affected people's enthusiasm for disaster prevention and mitigation, and does not encourage people to invest more effort in enhancing their ability to cope with drought in order to achieve self-reliance. Implementing projects for drought disaster prevention and mitigation to reduce drought vulnerability, mitigate the impacts of drought, and achieve the transition from drought emergency management to drought disaster risk management is the trend of development for disaster management internationally. Therefore, further strengthening of drought risk management capacity is suggested in China.

2.2.2.2 Promote institutional reform

In Spain and Portugal, drought-related affairs are managed by the Ministry of the Environment, which reduces the problem of coordination. In China, state FCDRH and FCDRHs at lower levels are in charge of drought relief affairs, with many tasks done by Ministry of Water Resources, Ministry of Agriculture, Bureau of Meteorology, and Ministry of Civil Affairs. In condition of drought emergency and drought relief, organizations can efficiently and effectively command and coordinate relevant Department at all levels to respond jointly. But given the slow development characteristic of drought, this mechanism of cooperation between drought management departments under emergency does not meet economic and social demands of drought relief work. Therefore, in addition to emergency drought relief functions, functions of routine drought resilience in drought relief organizations at all levels need to be strengthened. This is required to break through the systematic obstacles from top to bottom; improve the organizational structure; get member units more involved in day-to-day drought management work; establish multi-sectorial integrated coordination mechanism; and play its organizational and coordinating role in day-to-day drought management.

2.2.2.3 Enhancing drought risk monitoring

At present, some work on drought risk monitoring has been carried out China, but it cannot support drought relief and disaster mitigation comprehensively and effectively. Therefore strengthening the capacity of drought-related monitoring systems of meteorological, hydrological, agricultural, industrial, and water abstraction and supply data is necessary to improve dynamic monitoring capacity of drought information. There should be a drought monitoring network with complete national coverage, reasonable layout and comprehensive indicators. In addition to the establishment of drought information monitoring system, the creation of information-sharing mechanisms between the various relevant departments is essential. At present, inter-departmental information sharing can be done smoothly in times of drought emergency communication, but is difficult to achieve in routine drought management. Information resources are managed by the various administrative departments, making the phenomena of "islands of information" serious. Current drought relief commanding institutions only share drought information after the escalation of the drought. There are certain obstacles to receiving timely and relevant information from other sectors, which has a significant adverse impact on achieving effective early warning for drought prediction and on objective and scientific assessment of drought disaster management. Therefore, the

state should formulate and introduce as soon as possible drought-related information-sharing arrangements or requirements and develop data-information-sharing networks, break the departmental, geographic and business segmentation of information resources, and establish inter-agency information-sharing mechanisms to achieve transformation from information-separated use to shared use.

2.2.2.4 Strengthening water-saving management.

Temporal and spatial distribution of water resources in China is extremely uneven and overall water resources per capita are 30% less than the world average per capita. In a situation of large-scale exploitation and global climate change, the water resources shortage is becoming increasingly severe. The traditional water management model has led to increasing water demand, which cannot be met on a sustainable basis. Water demand management should be a paradigm shift to reasonably regulate economic and social demands for water, based on the bearing capacity of water resources and to optimize the industrial structure to improve water use efficiency.

2.2.2.5 Improving emergency response capabilities

In Spain the core elements of the drought management plan are to identify and develop appropriate response measures in advance, so that when droughts occur, the response can be targeted, rapid and effective. In fact, China has carried out similar work, namely, drought relief planning system. Drought relief plans for droughts in recent years have played an important role in the work, but also exposed a lot of problems, mainly reflected in whether the plans are scientific, reasonable and operable, and so on. At present, China has completed the planning for drought resistance in many parts, but often with generic content without specific, in-depth, or clear plans for response measures. Targeting is not strong, with poor operability. There needs to be concern to different regions and different levels of drought, with the conditions for initiating plans clearly defined and easy to grasp so that there can be a prompt start to the emergency response. Different levels of emergency response measures, project scheduling, emergency engineering and non-engineering measures of water provision, and follow up activities, must all be clear and specific, highly targeted and operable, with well-defined responsibilities for each related departments.

2.2.2.6 The system of drought insurance

For a long time, temporary relief has been provided in response to natural disasters in China, through compensation for disaster losses to a certain extent, but it is a drop in the bucket compared with the total value of disaster losses. The foreign practice including Spain and Portugal shows that, given the random occurrence of natural disasters, establishing a comprehensive insurance system is an important and effective way of transferring disaster risk. Although the agriculture insurance in some provinces in China covers drought as a disaster-causing factor, but the conditions for its application are restricted. In fact, very few claim cases due to drought risk have been approved, and most damage caused by drought cannot be compensated by agricultural insurance. Achieving the goal of transferring drought risk is difficult given the severe drought situation in China. There is an urgent need to establish a system of drought insurance to attract social funds in drought prevention and relief based on the characteristics and regular pattern of drought in China and in accordance with the principles of insurance. Disaster risk could be borne by policyholders, insurance companies and the Government, and utilize the market and financial funds to spread and transfer drought risk.

The legislative framework developed in Spain since the passing of Law 87/1978 has made it possible to devise and implement an agricultural insurance system that has become one of the most effective

instruments available to farmers to help safeguard their revenue from the consequences of drought and other risks that they cannot control[3]. An effective agricultural insurance system that provides broad coverage against the main risks, such as drought has numerous benefits:

- Allowing farmers to reduce their exposure to production risks that are beyond their control. This makes the farm revenue more stable
- Prosperity is encouraged as farmers no longer have to devote financial resources to protecting themselves from risks that an insurance system can bear at a much lower cost, given its ability to offset losses between risks with independent causes.
- It provides an automatic compensation mechanism in the event of disasters avoiding the State needing to provide emergency compensation

There have been problems in the past with crop insurance, and it is important to learn from these lessons:

- insurance should not become a mechanism for generating revenue for farmers, or to offset negative general trends in any aspect of production: they cannot be a substitute for sound agricultural policies
- Insurance policies must therefore be suitably defined to ensure that the risks insured are not influenced by the actions of the person taking out the policy
- The terms of the insurance and the premiums must be established according to technical and actuarial criteria; this means that coverage cannot be provided for uninsurable risks. There should be no political interference in the determination of premiums, claim adjustment etc.
- Public involvement is needed to provide a legal framework for the institutional stability of insurance activity, informing and advising farmers, subsidizing the cost of insurance to farmers and establishing guarantees for insurers in the form of reinsurance systems.
- Insurance activity should be supervised to guarantee the fairness of the terms and conditions, and to ensure compliance with its own rules.

Such insurance has not yet been very successfully applied in China, but there have been some pilot programs[4]. Drought is often a specific exclusion from crop insurance. Index-based insurance is believed to be the most appropriate as calculating losses for a very large number of individual farmers would be too complex, expensive and time-consuming to manage. Speed of pay-outs in the event of disaster is important.

2.3 Current Training Plans

There are a number of ongoing and committed training programs and other activities related to water saving and drought risk management. Three related programs will be implemented with some confidence, including:

1. The SL 590-2013 ‘Guideline for preparing Drought relief plan’ came into effect in April 2013. The dissemination and training program for this ‘Guideline’ was approved by MWR in early 2014. It is planned to complete preparation of the training materials by this August and organize the training by bringing the management professionals together from drought management organizations at all levels, including river basin, provincial, municipal and county level. The trainees would be at around 80. The national consultant

[3] Further information on drought insurance is available from Burgaz F.J. The application of insurance as a tool for mitigating the effects of drought in agriculture. Zaragoza : CIHEAM, 2008 (http://om.ciheam.org/article.php?IDPDF=800452), and from related publications from CIHEAM

[4] Zhang, Q., Y. Kobayashi, M. Howell Alipalo, and Y. Zheng. Drying up: What to do about droughts in the People’s Republic of China, with a case study from Guiyang Municipality, Guizhou Province. Asian Development Bank, 2012.

team of this TA is providing technical support to this training. In order to facilitate the promotion of risk-based drought management concept and practices, the main recommendations of this TA, as explained in the guidelines, provincial DMP, capacity building program and public awareness program, have been incorporated into the training materials.

2. The SL663-2014 'Standard of Classification for Drought Disaster' was enacted and put into effect in April 2014. It has also been included into the dissemination and training program plan organized by the MWR. The outputs from this TA could be included into the training materials during the preparation. The actual timing for this training is still not confirmed.

3. The State Flood Control and Drought Relief Commanding System Phase II Project was launched in October 2013. The main components relate with drought management include establishment of drought related data collection system, establishment of integrated database for flood control and drought relief, and the establishment of the decision making supporting system for drought management. The integrated drought database built under this TA for Liaoning Province will provide a good basis for the one to be established under the Phase II project.

3 Recommendations for Further Capacity Development

The workshops described above provided capacity-building to higher level personnel in FCDRHs and related organizations. The study tour to Portugal and Spain was also an part of the capacity development program. However the capacity and competence of drought management professional at all levels need to be strengthened in a regular basis to enable them to cope better with droughts, especially given their increasing frequency and impacts,. Recommendations for further capacity development have therefore been. A capacity building program has been drafted as outlined in this section, and includes information related to training organizers, implementation institutes, teachers, training content, training methods and budgets. The chapter outlines list the key contents of training course in tabular form with key issues and concepts highlighted.

3.1 Capacity Development Program

3.1.1 Objectives

The objectives of the capacity development program are to promote understanding and knowledge of the following topics, and ensure that FCDRH staff are capable of using this knowledge in their daily work:

- Drought policies and regulations; technical standards
- Drought vulnerability and risk assessment
- Drought prediction and early action
- Proposed tiered drought management planning responsibilities
- Co-operation between agencies for managing drought risk

3.1.2 Participants

The main participants will be the provincial and county level drought management staff from Liaoning, Gansu and Sichuan. The greatest need is for training for these low-level staff in FCDRH, who currently have the weakest understanding of the concepts. Ultimately the program should be extended to other provinces, drawing on the experience, methods and materials from the pilot provinces.

There are 316 FCDRH at different administrative levels in three pilot provinces (detailed in Table 3.1). Assuming each FCDRH send 2 staff for training, the number of total staff to be trained would be 630. In order to ensure good training outcomes, the staff would be grouped and given training in batches.

Table 3.1: Number of FCDRH at each level in the Pilot Provinces

Level	Liaoning	Gansu	Sichuan	Total
Provincial	1	1	1	3
Municipal	14	14	21	49
County	44	86	134	264
Total	**59**	**101**	**156**	**316**

Source: Project studies

3.1.3 Lead institutions

Training for provincial FCDRH staff should be organized and provided by national FCDRH, county level FCDRH by provincial FCDRH. Specialized research institutes should also be involved in developing and implementing the training

3.1.4 Lecturers

The lecturers should be organized by national FCDRH, and should be research scientists from drought research institutions, drought management staff from national FCDRH and drought researchers from universities.

3.1.5 Course contents

The course contents include three main aspects:
1. Drought management policies and regulations, including institutional arrangements and related technical standards
2. Drought monitoring, forecasting and triggering, including data sharing and management
3. Drought risk management

The main contents under each heading are listed in Table 3.2. The overall contents for the state, provincial and county level training are similar, but the level of detail and technical content will vary. Capacity building for government staff from related organizations will mainly include the overview sections to regulations and to drought risk management.

Table 3.2: Drought Risk Management Capacity Building Training

Category Of Contents	Main Contents		
	State Level	Provincial Level	Municipal And County Level
Laws, regulations and technical standards	PRC laws related to drought	PRC laws related to drought	PRC laws related to drought
	PRC drought relief regulations	PRC drought relief regulations	PRC drought relief regulations
	Technical standards related to drought	Technical standards related to drought	Technical standards related to drought
	Institutional arrangements	Compilation guidelines for drought plans	Compilation guidelines for drought plans
		Institutional arrangements	related drought management policies, regulations and technical standards in the province
			Institutional arrangements
drought monitoring, forecasting,	drought monitoring stations arrangement	drought monitoring stations arrangement	drought monitoring stations arrangement
	drought monitoring techniques	drought monitoring techniques	drought monitoring techniques
	drought database building	drought database building	drought database building
	Data-sharing and drought information management	Data-sharing and drought information management	Data-sharing and drought information management
	Latest updates in the development of drought monitoring technology		characterization of droughts within the province

Category Of Contents	Main Contents		
	State Level	Provincial Level	Municipal And County Level
			water resources distribution in time and space within the province
drought risk management	basic knowledge of drought	basic knowledge of drought	basic knowledge of drought
	drought risk theory	drought risk theory	drought risk theory
	drought risk management techniques	drought risk management techniques	drought risk management techniques
	drought risk management framework	drought risk management framework	drought risk management framework
	drought risk mapping categories	drought risk mapping categories	drought risk mapping categories
			drought monitoring, forecasting and triggering situation in the province

3.1.6 Training methods

There are several training methods which could be adopted. Online training could be used for some aspects, but most will be covered by formal training courses. Separate training materials could be prepared by water professionals, but in some cases it may be sufficient to add drought-related material into existing courses. The presentations used during this TA should be useful material, and other material can be developed from the guidelines and DMPs. In additional, short classroom courses could be employed. It's also a good opportunity for people to share experience by bringing people together.

It is anticipated that the full course would be broken down into around 5 blocks of 2 day training in order to ensure that it can be accommodate within the constraints of other commitments and pressures on staff time. The local staff would assemble in either the capital of the province or major cities to take the training courses. The training methods would be largely lecture-based using centrally prepared material as a starting point. These would be adapted to the local context as there is considerable variation across the provinces. Participatory methods would be used to the extent possible to ensure effective learning outcomes

3.1.7 Funding

The capacity building program will largely be undertaken during the course of normal working activities, so it is anticipated that the funding would come from the existing drought management budgets at each level, although additional specific budget might be needed for initial preparatory activities.

3.2 Expand Training and Capacity Building Program to Other Provinces

Currently, drought risk management capabilities in all provinces of the PRC are limited and need to be further improved. After completion of the project, the capacity-building program (along with the provincial Drought Management Plans and the Drought Risk Guidelines), can be used to improve the drought risk management capacity in other provinces.

Appendices

Appendix A. Institutional Survey

A.1 Drought Disaster Risk Management Survey

A questionnaire with 30 questions was undertaken with drought management personnel in the pilot provinces, at all levels including provincial agriculture and meteorology departments and research institutions and the main office of the county administration.74 responses were received in September 2013: 16 from province, 23 from municipality and 35 from the county levels. The results are presented in the table below, both as total numbers and percentages. It should be noted that some respondents did not answer all questions. In some cases only one answer is possible, and in others multiple answers are possible. The percentages take this into account.

A.2 Conclusions from the Survey

The main conclusions are that:

1. Those who engaged in drought management feel that they have insufficient understanding of drought disaster risk management: 30% still do not know anything about drought disaster risk management and 70% have inadequate knowledge.
2. Those who are in relatively poor-water area have a higher consciousness of drought management than those in relatively wet areas: 90% of drought management-related personnel in Gansu province know about drought disaster risk management, whereas 63% and 62% respectively in Liaoning province and Sichuan province are aware.
3. Provincial personnel have a higher consciousness of DRM than equivalent city and county personnel.
4. In most cases the drought management level is not high, and the drought disaster risk management is in a transition period.
5. Most areas have few relevant laws and regulations to follow for drought relief management work. Relevant technical standards are also not perfect.
6. There are perceived to be numerous constraints to DRM: funds, inter-departmental cooperation and manpower numbers are the greatest constraints; skills, technical support and public awareness are less significant
7. Despite these constraints about 50% feel that DRM is practical without excessive time or effort
8. Limitations of data, and particularly sharing of data between institutions and inadequate systems for managing and using the data in effective drought risk management are widely reported
9. Actions during a drought are reported to be reasonably good, particularly at county-level; community-level responses are weaker. Restrictions on water use are most commonly reported, but reallocation between sectors is less common
10. Although agricultural insurance is widely reported it has rarely given protection against drought damage

Topic	No.	%
1. Have you ever heard about drought risk management? [Yes, No]		
A. Yes	52	74%
B. No	18	26%
2.Identifying the existing management model for drought hazards management in your area		
A. Emergency response	28	39%
B. Transition period from reactive emergency response to proactive risk management	29	40%
C. Risk management	15	21%
3. In your opinion, the level of drought management work in your local area is		
A. Good	4	6%
B. Moderately good	34	49%
C. Poor	26	38%
D. Very poor	5	7%
4. What departments actually were involved in drought management?		
A. Water resources department	73	99%
B. Meteorology department	64	86%
C. Agriculture department	68	92%
D. Administrative department	50	68%
E. Financial management department	35	47%
F. Other Department	19	26%
5. What policy, regulation, and law are you aware of in relation to drought management?		
A. PRC Water Act	58	78%
B. PRC Drought Management Regulations	68	92%
C. Requirements of Improving Drought Management from National Council	43	58%
D. Local Drought Management Regulations or Implementation Guidelines	30	41%
E. National flood control and drought management plan	52	70%
F. Local Drought Management Plan	44	59%
G. Other	2	3%
6. Are you aware of any standards, guidelines or handbooks in relation to drought management? What are those?		
A. Meteorological Drought Classification	55	74%
B. Drought Events Classification	61	82%
C. Handbooks of Developing Drought Management Plans	57	77%
D. Standards for Drought Damage Classification	56	76%
E. Other	10	14%
7. What current drought management plans are in place for your area?		
A. Provincial Drought Management Plan	39	53%
B. Municipal Level Drought Management Plan	47	64%
C. County Level Drought Management Plan	58	78%
D. Drought Management Plan for Urban Area	27	36%
E. Other Drought Management Plan	7	9%
8. Have the pre-planned actions in the DMPs in your area been triggered? How practical? And how do those actions relieve drought risk or damage		
A. triggered, very practical and prevented damage	11	15%
B. triggered, moderately practical and prevented some damage	37	50%
C. triggered, not so practical and prevented a little damage	12	16%
D. triggered, not practical and limited effects on preventing damage	3	4%
E. never triggered before	16	22%
9. What is the weakness you experience when you work in drought management?		
A. Manpower	61	82%
B. Interdepartmental Cooperation	59	80%
C. Funds	71	96%
D. Water Manager's Competence level	50	68%
E. Public Awareness	52	70%
F. Technical Support	55	74%
G. Other	1	1%
10. What do you think moving toward drought risk management would require and achieve?		
A. Nothing, could achieve risk-based management very soon	2	3%
B. basic capacity is available, could achieve risk-based management with some efforts	30	49%
C. only limited capacity is available, still needs a lot of time and effort to achieve risk-based management	22	36%
D. lack of capacity building, need to start from the beginning, very little chance to achieve risk-based management	7	11%

11. What parameters or indicators are used to monitor the drought impact to agriculture? How many drought monitoring stations for agricultural use? Operated by what departments?		
A. Precipitation: No. of Stations, Affiliation	62	84%
B. Evaporation: No. of Stations, Affiliation	48	65%
C. River Water Level: No. of Stations, Affiliation	55	74%
D. Reservoir Water Level: No. of Stations, Affiliation	53	72%
E. Soil Moisture: No. of Stations, Affiliation	46	62%
F. Agriculture Conditions: No. of Stations, Affiliation	27	36%
G. Other: ______: No. of Stations, Affiliation	2	3%
12. What is the data sharing frequency?		
A. real-time data sharing on all available data	10	14%
B. real-time data sharing of part of data	30	42%
C. no real-time data sharing, only share data on drought management planning meeting during drought events	29	40%
D. no data sharing at all	3	4%
13. Is there a database designated for drought management use? What is the condition of that database?		
A. Yes, data generated from thorough monitoring	3	4%
B. Yes, data is complete	8	11%
C. Yes, but data is not complete	37	51%
D. No, dependent on other database	14	19%
E. No database at all	10	14%
14. What indicators are used trigger the agriculture drought conditions?		
A. Continuous Rainless Day	63	85%
B. Precipitation Anomalies	31	42%
C. Soil Moisture	59	80%
D. Crop Water Stress Index	44	59%
E. Percentage of crops that under drought impact	44	59%
F. Other	14	19%
15. When the drought event is coming, is there a pre-drought condition triggering and prediction system in your area?		
A. Yes, and they are	42	58%
B. No	30	42%
16. How does the drought management system operate in your area?		
A. has drought information management system	31	42%
B. has drought monitoring system	27	36%
C. has triggering system for drought events	16	22%
D. has dispatching command system for drought events	32	43%
E. Other systems, please specify	2	3%
F. No relevant systems	14	19%
17. When the emergency response was triggered by drought events, how was the institutional capacity and inter departmental coordination?		
A. the institutions are competent on their job, departments coordinated well	14	19%
B. the institutions are capable of doing their job, departments coordinated moderately well	56	76%
C. the institutions are not capable of fulfil their responsibility, departments coordinated poorly	5	7%
18. During drought period, the drought relief actions for drinking water supply shortage in your area are?		
A. Deliver water by administrator	61	82%
B. Deliver water by administrator-organized and funded organizations.	54	73%
C. Haul water by local people	63	85%
D. Other, please specify	18	24%
19. What is the current condition of organizations responsible for drought relief?		
A. County and community level drought relief organizations are both well established	10	16%
B. County level drought relief organizations are well established, while community level drought relief organizations are not	34	53%
C. community level drought relief organizations are well established, while county level drought relief organizations are not	12	19%
D. both county and community level organizations are not well established	8	13%
20. What is the condition for the drought relief materials reserve in your area		
A. has a warehouse to reserve drought relief materials, sufficient types and amount of drought relief materials	11	15%
B. has a warehouse to reserve drought relief materials, insufficient types and amount of drought relief materials	54	75%
C. no drought relief materials reserve warehouse	7	10%

21. What is the current agriculture insurance coverage in your area?		
A. has agriculture insurance, successfully protected farmers from drought damage	14	19%
B. has agriculture insurance, did not protect farmers from drought damage	41	56%
C. no agriculture insurance	18	25%
22. What indicators are used for monitoring urban drought level?		
A. water shortage in urban area (%)	45	61%
B. reservoir water reserve	44	59%
C. river water level	57	77%
D. precipitation	56	76%
E. other, please specify	3	4%
23. Is there a monitoring or triggering system to predict drought event		
A. Yes	34	49%
B. No	36	51%
24. Is there drought management plans in your area?		
A. there is a drought management plan for each city	40	56%
B. some critical cities have drought management plan	24	34%
C. no drought management plan whatsoever	7	10%
25. Has the drought management plan been triggered in your area? Does it prevent the drought damage?		
A. they are triggered in some cities (please specify), prevented drought damages	21	31%
B. they are triggered in some cities (please specify), prevented major drought damages	14	21%
C. have not been triggered	32	48%
26. Is there contingency water sources for your area?		
A. contingency water sources for each cities	13	18%
B. contingency water sources for some cities	39	54%
C. contingency water sources for a few cities	8	11%
D. no contingency water sources	12	17%
27. What are the responses when drought event is happening		
A. emergency water transfer	57	77%
B. start to supply water from contingency water sources	53	72%
C. water restriction	60	81%
D. water reallocation (reduce water supply in other sector, eg. agriculture) to ensure sufficient urban water use	50	68%
E. other responses, please specify	14	19%
28. Has there been ecological drought in your area?		
A. Yes	46	65%
B. No	25	35%
29. Is there an ecological drought management plan?		
A. No	55	76%
B. Yes	17	24%
30. What are the drought relief actions for ecological drought?		
A. emergency water supplementation	57	86%
B. other, please specify	9	14%

Appendix B. Water User Survey

B.1 Drought Disaster Risk Management Survey

A questionnaire with 25 questions was undertaken with drought management personnel in the pilot provinces, at all levels including FCDRH, water resources, hydrological, meteorological and agriculture departments or research institutions at provincial, municipal and county level.74 responses were received in September 2013: 16 from province, 23 from municipality and 35 from the county levels. The results are presented in the table below, both as total numbers and percentages. It should be noted that some respondents did not answer all questions. In some cases only one answer is possible, and in others multiple answers are possible. The percentages take this into account.

The water user surveys have been completed in August 2013 and the results have been analyzed in September 2013. The surveys aimed to determine the current state of knowledge and awareness of water saving methods in the three provinces. The water user survey results would be valuable input to the capacity building and public awareness programs.

B.2 Conclusions from the Survey

The main conclusions are that:

- Overall water demand is expected to continue to rise with poor awareness of water savings and the need to promote economic measures to stimulate water-saving activities
- Agriculture is seen to have the greatest potential for saving, although mainly through introduction of new technology rather than better management. Both awareness and cost are seen as critical constraints which limit uptake of the new technology and thus a continued rise in water demand is anticipated [despite essentially no increase in agricultural area]
- Industrial users are aware of water reuse and recycling but there is limited coverage because of a lack of incentive and high cost (and also lack of enforcement of regulations). A large increase in industrial use is anticipated, presumably a consequence of rapid industrialization
- Domestic users are aware of the need to save water, but need to be given an incentive to do so through administrative regulation.

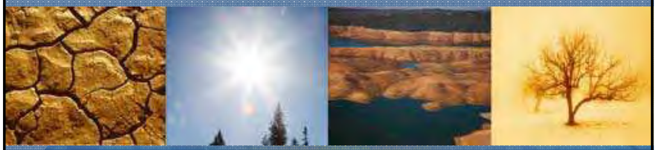
Topic	Nr	%
1. How will the water demand change in next 5 years in your area?		
A. rapidly increase	32	45%
B. slowly increase	34	48%
C. will not change	5	7%
D. slowly reduce	0	0%
2. Is the progressive water price implemented in your area for urban water supply?		
A. a few sectors	40	56%
B. all sectors	9	13%
C. not implemented	20	28%
D. planning on implementing	3	4%
3. How public is aware of water savings?		
A. very well	11	16%
B. moderately	49	70%
C. poor	10	14%
D. no public awareness on water saving		
4. What are the public educational programs in your area?		
A. TV programs	57	77%
B. Community education	48	65%
C. Internet educational program	38	51%
D. Program implemented occasionally during certain period of time	58	78%
5. In your opinion, the water saving education and public awareness program should be facing?		
A. Students	44	59%
B. Civilians	53	72%
C. Farmers	37	50%
D. Employees	35	47%
6. In your opinion, the most efficient water saving measures are?		
A. increase water price	9	12%
B. implement progressive water price	48	65%
C. improve public awareness program	17	23%
D. water saving equipment	51	69%
E. optimize industrial structure	29	39%
7. What are the constraints towards water saving in your area?		
A. lack of techniques	30	41%
B. lack of management measures	34	46%
C. lack of public awareness	52	70%
D. lack of regulations and standards	28	38%
E. water price is not reasonable	9	12%
8. The sectors that have the greatest potential on water saving are?		
A. Industrial water use	44	59%
B. Agriculture water use	54	73%
C municipal water use	49	66%
D. other water use	23	31%

Agriculture water saving		
9. What are the technical measures for water saving in your area?		
A. Sprinkler irrigation	61	82%
B. pipe irrigation	62	84%
C. drip irrigation	58	78%
D. micro irrigation	44	59%
10. What is the current condition of agriculture water saving in your area?		
A. almost no implementation	5	7%
B. less than 25% of area	30	42%
C. 25% to 50%	31	44%
D. 50% to 75%	3	4%
E. more than 75%	2	3%
11. In your opinion, what is the major reason why the water saving irrigation is implemented?		
A. no water shortage	10	14%
B. too much initial investment	53	72%
C. lack of techniques	28	38%
D. lack of public awareness	13	18%
12. Have you ever done water saving training to farmers?		
A. occasionally	40	56%
B. regularly	22	31%
C. very often	4	6%
D. no	5	7%
13. How the agriculture water use in your area will change in next 5 years?		
A. rapidly increase	12	17%
B. slowly increase	36	51%
C. will not change	11	15%
D. will slowly reduce	12	17%
Industrial Water saving		
14. When did the industrial water saving technical improvements start?		
A. not	7	10%
B. in recent 5 years	23	33%
C. ten years ago	34	49%
D.20 years ago	5	7%
15. What are the industrial water saving measures?		
A. water reuse	55	74%
B. reclaim grey water	32	43%
C. sea water use	1	1%
D. progressive water price	20	27%
16. What percentage of industry in your area has implemented technique improvements to save water?		
A. more than 60%	6	9%
B. 40% to 60%	9	14%
C.20% to 40	20	31%
D. less than 20%	10	16%
E. not clear	19	30%
17. How will the industrial water use change in your area in the next 5 years?		
A. rapidly increase	36	49%
B. slowly increase	29	39%
C. will not change	10	14%
D. will reduce	2	3%
18. In your opinion, why some industries did not implement technical improvement to save water?		
A. lack of water saving awareness	22	30%
B. lack of regulations or standards	13	18%
C. too much initial investment	52	70%
D. water price is too low	15	20%

Urban domestic water saving		
19. When was the water saving equipment installed in your area?		
A. just started	9	13%
B. 2 years ago	6	9%
C. 5 years ago	9	13%
D. 10 years ago	19	27%
E. not clear	27	39%
20. Why the water saving equipment was adapted by urban people in your area?		
A. administrative force	4	7%
B. administrative lead	27	44%
C. voluntarily adapted by local people	19	31%
D. water price is high	11	18%
21. What is the percentage of your area that the urban water saving equipment was installed		
A. less than 20%	35	47%
B. 20% to 40%	18	24%
C. 40% to 60%	27	36%
D. more than 60%	9	12%
22. What are the constraints in your area toward installing water saving equipment?		
A. lack of water saving equipment	12	16%
B. the water saving equipment are expensive	32	43%
C. lack of public awareness	34	46%
D. water price is too low	7	9%
23. Why the water saving equipment in some of the cities in your area was more adapted?		
A. administrative force	9	12%
B. administrative lead	40	54%
C. voluntarily adapted by local people	29	39%
D. water price is high	8	11%
24. What percentage of tap water lost due to leakage in your area?		
A. less than 5%	4	6%
B. 5% to 10%	11	16%
C. 10% to 15%	17	24%
D. more than 15%	22	31%
E. not clear	16	23%
25. How often do you have public awareness program in your area?		
A. very often	10	16%
B. regularly	41	66%
C. occasionally	10	16%
D. never	1	2%

Appendix C. Workshop Materials used during this TA

2013



我国干旱基本情况及抗旱减灾管理发展趋势

水利部防洪抗旱减灾工程技术研究中心
中国水利水电科学研究院
吕　娟
2013.9.5

主 要 内 容

一、我国旱情旱灾演变特点与趋势

历史旱灾　一、我国旱情旱灾演变特点与趋势

1928-1932年西北发生特大旱灾：陕西88县死亡人数达到250万人；甘肃58县死亡230万人。

清光绪年间（1874～1879年）北方发生特大旱灾：山西、河南、河北、山东4省因旱灾死亡1300万人

明末清初（1637-1646年）发生特大旱灾：影响范围遍及全国20个省份，为近500年来持续时间最长、范围最大、受灾人口最多的全国性旱灾。

历史旱灾　一、我国旱情旱灾演变特点与趋势

1928-1932年西北大旱陕西灾民拔草充饥

1972年华北大旱河南岗塔水库干涸

1934年华东大旱嘉兴郡庙祈雨会

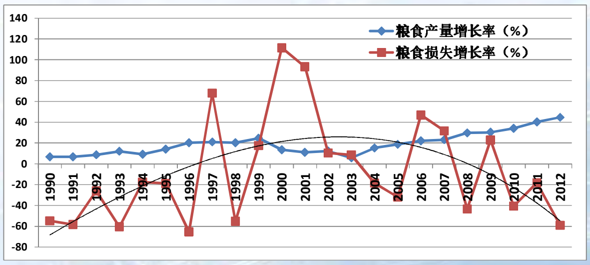
特点与趋势　一、我国旱情旱灾演变特点与趋势

- 本世纪农作物平均因旱受灾程度最重，但总体呈下降趋势
- 春旱对农业影响大，南方地区旱情频发
- 城市干旱缺水事件频发，本世纪以来开始好转
- 本世纪因旱人畜饮水困难数量减少，总体呈下降趋势

增长率

一、我国旱情旱灾演变特点与趋势

1.本世纪农作物平均因旱受灾程度最重，但总体呈下降趋势

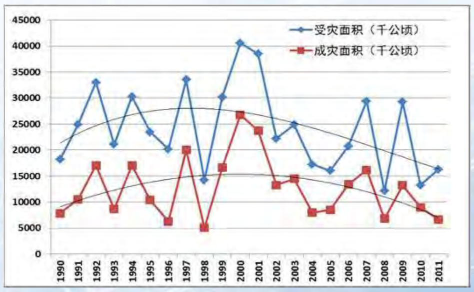


1990年以来粮食产量增长率和因旱粮食损失增长率情况

受灾趋势

一、我国旱情旱灾演变特点与趋势

1.本世纪农作物平均因旱受灾程度最重，但总体呈下降趋势



1990年以来农作物因旱受灾面积和成灾面积情况

旱灾程度

一、我国旱情旱灾演变特点与趋势

二十一世纪以来因旱粮食损失情况

春旱频发

一、我国旱情旱灾演变特点与趋势

2.南北方春旱频发

1990～2011年的23年间，共有15年发生过较大春旱，分别是1991年、1993年、1994年、1995年、1996年、1997年、1998年、1999年、2000年、2001年、2002年、2006年、2007年、2010年和2011年，其中：

北方春旱7年：1995年、1996年、1997年、1999年、2001年、2009年、2011年。

西南春旱3年：1991年、1998年和2010年

南北方均有春旱5年：1993、1994年、2000年、2002年、2006年

西南冬春旱

一、我国旱情旱灾演变特点与趋势

- **2010年西南冬春旱**

南方夏伏旱

一、我国旱情旱灾演变特点与趋势

3. 南方夏伏旱频发

南方干旱年份16年：1990年、1991年、1992年、1994年、1995年、1997年、1998年、2000年、2001年、2002年、2003年、2004年、2006年、2007年、2010年、2011年，其中除**1998年、2006年、2010年**西南地区是春旱外，其他年份都是夏伏旱。

最严重的年份是1992年，江苏、安徽、浙江、江西、福建、湖北、湖南、广西、广东、四川、云南、贵州、西藏13省受旱；

其次是**2003年**，福建、江西、浙江、湖南、广东、广西、重庆、云南、贵州、湖北、安徽、陕西12省受旱。

近年来，最受关注旱灾的是2006年重庆夏伏旱、2010年西南春夏旱和2011年长江中下游春夏旱。

城市缺水

一、我国旱情旱灾演变特点与趋势

4 .城市干旱缺水事件频发，本世纪以来开始好转

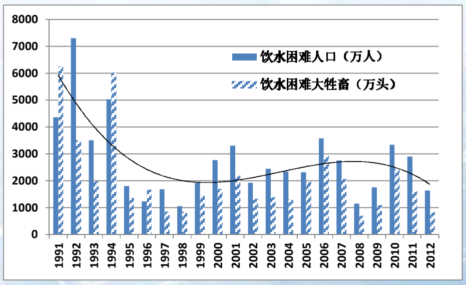
时间段	发生干旱城市数量和累计次数
1954～1970	8座城市、16次
1971～1980	16座城市、32次
1981～1990	45座城市、135次
1991～2000	400多座城市、严重110座
2000～2007	331座城市、严重175座

严重气象干旱影响城市数最多的分别是2000年（620座）、1986年、2011年、1967年。

人饮困难

一、我国旱情旱灾演变特点与趋势

5. 本世纪因旱人畜饮水困难数量减少，总体呈下降趋势



1991年以来全国因旱人畜饮水困难情况

生态退化

一、我国旱情旱灾演变特点与趋势

6. 因旱生态退化现象严重，但近年来得到有效控制

在上世纪50年代开始至90年代末，我国北方一些地区曾因干旱出现河道断流，地下水位下降、地下漏斗扩大，湖泊、绿洲、湿地面积萎缩，土壤沙漠化，植被退化，珍稀生物濒临灭绝等现象，水生态一度出现严重危机。

河北白洋淀，1966～1988年，共发生6次干淀事件；

山东南四湖，2002年发生了建国以来最严重的干湖；

吉林向海湿地，2011年以前由于受嫩江流域来水持续偏枯影响，湿地严重萎缩，面积锐减，生态环境恶化。

此外，还有黑河下游、塔里木河下游、扎龙湿地等都遭受过生态危机。

生态补水

一、我国旱情旱灾演变特点与趋势

6. 因旱生态退化现象严重，但近年来得到有效控制

水利部于20世纪末开始针对河湖湿地生态危机实施应急调水补水

2004年实施了1次引岳济淀调水

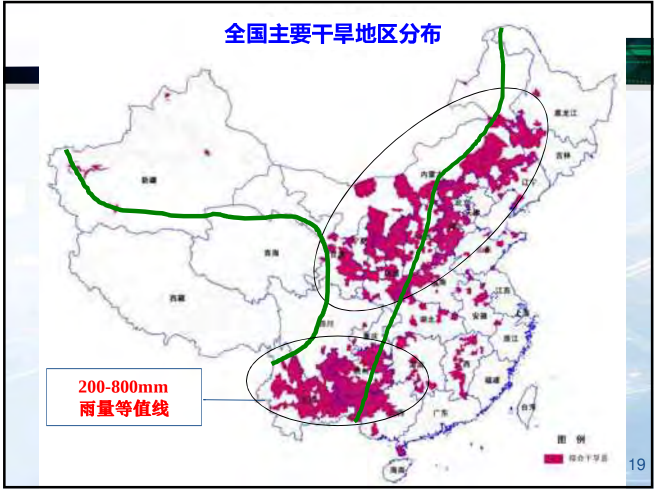
2006年起实施了5次引黄济淀调水

2002年起开始实施了引江济太工程、引长济湖工程

2004年起实施了2次引察济向工程

2001年起实施了10余次塔里木河流域生态调水工程

2000年专门成立了水利部黄河水利委员会黑河流域管理局



区域旱灾

一、我国旱情旱灾演变特点与趋势

年份	东北	黄淮海	长江中下游	华南	西南	西北
2000	O	O	O		O	O
2001	O	O	O		O	O
2002	O	O			O	O
2003	O	O		O	O	O
2004	O			O		O
2005		O	O		O	O
2006		O			O	
2007	O	O	O		O	O
2008	O	O				
2009	O	O			O	O
2010					O	
2011		O	O		O	

区域干旱灾害受灾年份

旱灾成因

一、我国旱情旱灾演变特点与趋势

7. 二十一世纪以来旱灾成因

□ 气候异常频繁

近年来，副热带高压活动经常出现异常，造成高温少雨天气。如2006年，副热带高压位置偏北偏西，冷空气活动偏弱，高原热状况偏强，自2005～2006年冬春季青藏高原积雪偏少造成高原热力作用显著从而有利于夏季风偏强，直接导致夏季川渝地区高温干旱。

旱灾成因

一、我国旱情旱灾演变特点与趋势

7. 二十一世纪以来旱灾成因

□ 人为因素影响渐强

（1）用水需求增大

21世纪以来，全国用水量由2000年的5498亿方，增加到2010年的5998亿方，增长率为50亿方/年；耗水量由2000年的3012亿方，增加到2009年的3110亿方，增长率为10.9亿方/年。

旱灾成因

一、我国旱情旱灾演变特点与趋势

7. 二十一世纪以来旱灾成因

□ 人为因素影响渐强

（2）水资源利用率低

2000～2009年10年间，平均耗水率（耗水量占用水量的比例）54.5%，水资源利用率较低，其中，耗水率最大的地区分布在降水量较少的海河流域及西北诸河区域，接近70%。

旱灾成因

一、我国旱情旱灾演变特点与趋势

7. 二十一世纪以来旱灾成因

□ 人为因素影响渐强

（3）水污染严重，水质恶化

2009年全国废污水排放总量768亿吨，大于30亿吨的省有10个，以沿海地区为重。河流污染最严重主要分布在华北、西北东部地区。

薄弱环节

一、我国旱情旱灾演变特点与趋势

8. 大旱暴露出来的主要问题

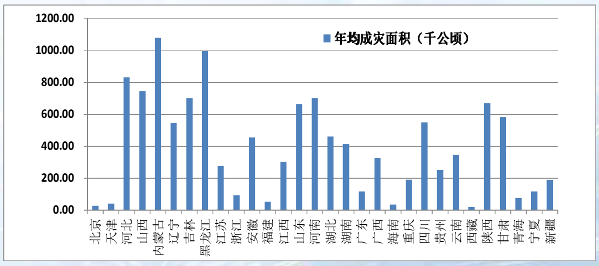
1. 水资源调控能力不足
2. 农田水利基础设施薄弱
3. 抗旱应急备用水源匮乏
4. 旱情监测预报预警手段缺乏
5. 抗旱减灾保障体系不健全
6. 社会防灾减灾意识不强

二、我国干旱灾害类型及时空分布特征

农业受灾分布

二、我国干旱灾害类型及时空分布特征

1. 因旱农业受灾主要分布在粮食主产区

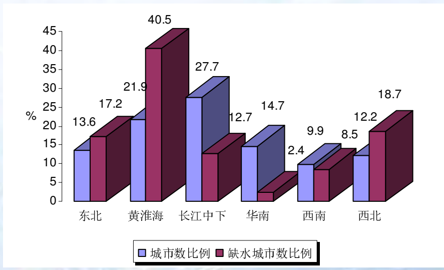


13个粮食主产获得：内蒙古自治区、黑龙江省、河北省、吉林省、河南省、山东省、四川省、辽宁省、湖北省、安徽省、湖南省、江西省、江苏省

农业受灾分布

二、我国干旱灾害类型及时空分布特征

2. 因旱缺水城市主要分布在北方地区

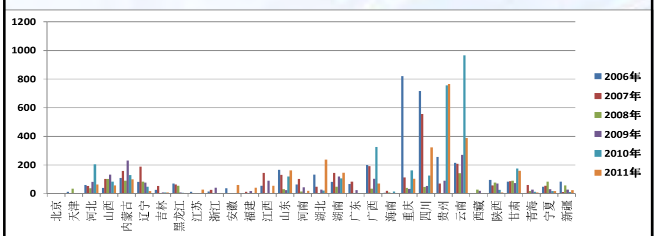


2000～2007年因旱缺水城市分布比例

农业受灾分布

二、我国干旱灾害类型及时空分布特征

3. 因旱饮水困难人口主要分布在西南地区



2006～2011年各省（区、市）因旱饮水困难人口情况

农业受灾分布

二、我国干旱灾害类型及时空分布特征

4. 因旱生态退化问题主要分布在北方地区

从以上可以看出，河湖生态退化现象主要发生在20世纪60年代至本世纪初的北方，如白洋淀、向海湿地、扎龙湿地、南四湖、塔里木河、黑河等，2000年以后开始，由于国家重视生态修复与保护，河湖生态退化现象得到一定的控制和恢复。

三、我国干旱灾害管理现状与思路转变

管理机构

三、我国干旱管理现状及思路转变

1. 我国干旱灾害管理机构沿革

1949年新中国刚成立时，我国城市化率仅有10.64%，1980年有19.39%，1990年有26.41%，城市化率一直偏低，干旱主要是对农业农村造成较大影响。因此，1949年至1988年我国的抗旱管理机构多设在农田水利部门。随着近二十年来城市化进程的加快，城市干旱和生态干旱日益突显，抗旱职能向全面抗旱转变。

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管理机构

三、我国干旱管理现状及思路转变

1. 我国干旱灾害管理机构沿革

时间	管理机构名称	主管部门
20世纪50～60年代	农田水利局	先后由农业部、水利部、水电部主管。
1971年6月	中央防汛抗旱指挥部	由总参谋部、国家计委、商业部、交通部、农林部、财政部、水利电力部组成，办公室设在水利电力部。
1977年	抗旱领导小组	农林部，办事机构设在农林部。
1979年	抗旱领导小组	由国家计委副主任任组长，水利部部长任副组长，办事机构改设在水利部（后水利电力部），其他部门负责人参加。之后各省、市、县陆续都成立了抗旱机构。
1988年	国家防汛总指挥部	防汛抗旱办公室设在水利部。
1992年	国家防汛抗旱总指挥部	办事机构设在水利部，国务院其他部门为成员单位。

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管理现状

三、我国干旱管理现状及思路转变

2. 我国干旱灾害管理发展现状

工程措施方面：

目前已基本形成以蓄水工程、引水工程、提水工程、调水工程等为主的抗旱减灾工程体系。

截至2011年底，全国蓄水工程供水量1782.8亿m3，引水工程供水量1751.5亿m3，机电排灌泵站总装机容量达44030兆瓦，泵站工程供水量762.4亿m3，建成机电井541.4万眼，另外还建成引滦入津、引黄济津济淀、引黄济青、引黄入晋、引察入向等一批调水工程，有效地缓解了农业旱情、城乡供水短缺和生态退化问题。

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管理现状

三、我国干旱管理现状及思路转变

2. 我国干旱灾害管理发展现状

非工程措施方面：

已经初步形成了由政策法规、抗旱规划、抗旱预案、抗旱信息管理、抗旱服务组织等组成的非工程体系。截至2011年，我国先后颁布实施了《中华人民共和国抗旱条例》以及安徽、浙江、云南、重庆、天津、江西、广东等省（区、市）抗旱条例，建立了旱情统计和报告制度、旱情会商制度、旱情发布制度、抗旱总结制度、水量统一调度制度、抗旱预案制度等抗旱管理制度体系，初步形成了抗旱预案体系和抗旱规划体系，同时还加强了旱情监测预警系统、抗旱服务组织和抗旱物资储备等方面建设。

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思路转变

三、我国干旱管理现状及思路转变

3. 我国干旱灾害管理思路转变

国家防总在2003年提出了防汛抗旱“两个转变”的战略指导思想，即由控制洪水向洪水管理转变，由单一抗旱向全面抗旱转变。所谓从单一抗旱向全面抗旱转变，是指根据经济社会发展需求，扩大抗旱工作的领域和内容，从主要为农业和农村经济服务转向为包括农业、城市、生态在内的整个经济社会发展服务，从注重农业效益转变为注重社会、经济和生态效益的统一，从被动抗旱转变为主动防旱，最大限度地减轻干旱灾害对整个经济社会以及生态环境造成的损失和影响。“两个转变”实施十年来，仅就抗旱效益来说是十分显著的

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取得成效

三、我国干旱管理现状及思路转变

3. 我国干旱灾害管理思路转变

十年来，在两个“两个转变”的思想指导下，我国抗旱减灾工作取得了显著的成效。

包括 **工程措施** 和 **非工程措施** 两方面。

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工程措施

三、我国干旱管理现状及思路转变

水库、塘坝和水窖等 — 蓄水工程

无坝引水和有坝引水 — 引水工程

泵站和机电井 — 提水工程

引滦入津、引黄济津、引黄济青、引黄入晋等 — 调水工程

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工程措施

三、我国干旱管理现状及思路转变

1. 蓄水工程

蓄水工程包括水库、塘坝和水窖等。

截至2011年底，全国蓄水工程供水量1782.8亿m^3，主要用于农业灌溉、工业生产、城镇及乡村生活和生态环境等；

共建成水库8.8万余座，总库容7201亿m^3，其中大型水库567座、中型水库3346座、小型水库8.47万座。

工程措施

三、我国干旱管理现状及思路转变

2. 引水工程

引水工程包括无坝引水和有坝引水。

几千年来，中国各地兴修了许多引水灌溉工程，譬如周代安徽的芍陂，春秋时期关中的郑国渠，秦代四川的都江堰，黄河前套宁夏的秦渠、汉渠、唐徕渠，湖南韶山灌区，陕西宝鸡峡引渭灌区、泾惠渠灌区、洛惠渠灌区等，有些至今还在发挥重要作用。

截至2011年底，全国引水工程供水量1751.5亿m^3，除了用于灌溉，也广泛地用于城乡居民生活和生产。

工程措施

三、我国干旱管理现状及思路转变

工程措施

三、我国干旱管理现状及思路转变

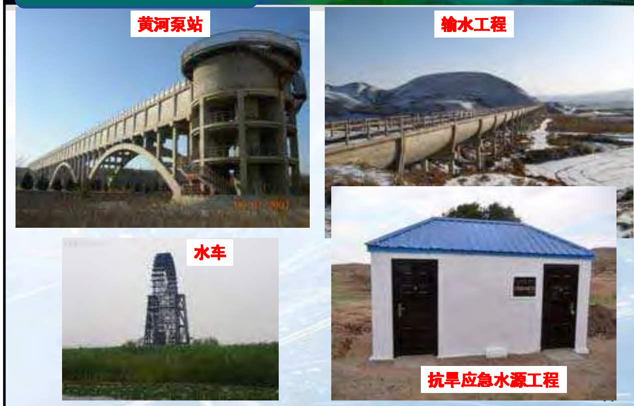
3. 提水工程

提水工程主要包括泵站和机电井。

截至2011年底，全国机电排灌泵站总装机容量达44030兆瓦，泵站工程供水量682亿m^3，机电井工程供水量883.8亿m^3。这些提水工程在改善农业生产条件，建设高产稳产农田，解决城镇供水等方面发挥了显著作用。

工程措施

三、我国干旱管理现状及思路转变



工程措施

三、我国干旱管理现状及思路转变

4. 调水工程

在20世纪70年代以前，调水工程多以农业灌溉为主要目标。从80年代起，为缓解城市水资源短缺问题，陆续建成了一批新的调水工程，如引滦入津、引黄济津、引黄济青、引黄入晋等。

目前，中国正在实施和规划中的大型调水工程，主要有南水北调、滇中调水、引额济乌、引江济淮等，这些工程的建设为水量调入区解决农业抗旱减灾灌溉、缓解城乡供水短缺、改善地区生态环境以及保证水量调入区的社会经济发展等方面发挥了重要作用。

工程措施

三、我国干旱管理现状及思路转变

非工程措施

三、我国干旱管理现状及思路转变

1. 政策法规制定

《中华人民共和国抗旱条例》（2009）
《安徽省抗旱条例》（2003）
《云南省抗旱条例》（2007）
《浙江省防汛防台抗旱条例》（2007）
《重庆市防汛抗旱条例》（2008）
《江西省抗旱条例》（2010）
《山西省抗旱条例》（2011）
《天津市防洪抗旱条例》（2011）
《贵州省抗旱办法》（2011）

非工程措施

三、我国干旱管理现状及思路转变

2. 抗旱规划编制

根据2007年国务院办公厅下发的《关于加强抗旱工作的通知》（国办发[2007]68号）要求，水利部2008年启动了抗旱规划编制工作，着重就未来十年抗旱应急备用水源工程、旱情监测预警系统、抗旱指挥调度系统、抗旱减灾管理服务体系等方面内容进行规划，2011年11月《全国抗旱规划》已通过了国务院常务会议审议并批复，正在编制抗旱规划实施方案。

非工程措施

三、我国干旱管理现状及思路转变

3. 抗旱预案编制

抗旱预案制度建设是变被动抗旱为主动抗旱的有效措施，是推动抗旱工作实现正规化、规范化、制度化的一项重要内容。自2003年起开展抗旱预案编制工作，制定了《抗旱预案编制导则》等指导性文件。全国县级及以上行政区和流域已基本编制完成了抗旱预案。这些抗旱预案的发布实施对我国有效应对干旱灾害发挥了积极的作用。

非工程措施

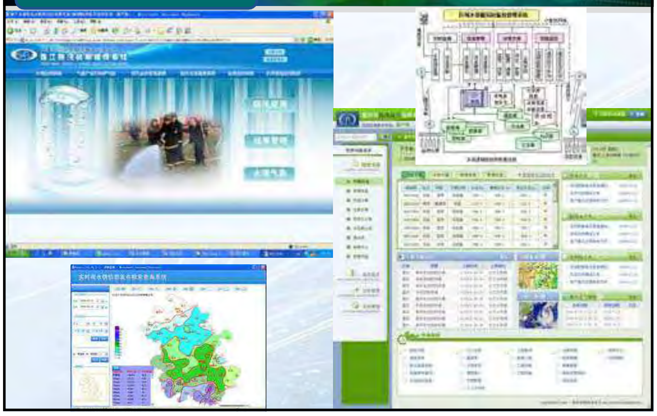
三、我国干旱管理现状及思路转变

4. 抗旱信息化建设

近些年，国家防办推进的系统建设工作包括：《水旱灾害统计报表制度》、抗旱统计信息管理系统、抗旱会商系统、水利信息骨干网络、异地会商系统、数据汇集平台、旱情信息采集试点建设、抗旱管理应用系统建设、部分墒情监测系统、旱情监测系统以及旱情信息管理系统等。

非工程措施

三、我国干旱管理现状及思路转变



非工程措施

三、我国干旱管理现状及思路转变

5. 抗旱服务组织和物资储备建设

抗旱服务组织是农村社会化服务体系的组成部分，是抗旱减灾的重要力量。目前，全国已建立县级抗旱服务队1848个和乡镇级抗旱服务队10108个，从事抗旱服务的正式工作人员达11.3万人。

2011年中央财政加大了对抗旱服务组织的支持力度，先后分3批下达24亿元资金，补助17个省1200支县级抗旱服务队购置抗旱设备。

国家防总还相应印发了《县级抗旱服务队建设管理办法》。

非工程措施

三、我国干旱管理现状及思路转变

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非工程措施

三、我国干旱管理现状及思路转变

6. 抗旱应急水量调度

国家防总先后11次实施引黄济津应急调水，先后7次实施珠江水量统一调度，先后实施了多次引岳济淀生态调水、引黄济淀生态调水、扎龙湿地生态补水、引察济向生态应急补水和南四湖生态应急补水等。此外，在2009、2011年，为了应对长江中下游地区可能出现的更为不利的枯水局面，保障沿江及洞庭湖、鄱阳湖区域生活、生产和生态等用水需求，国家防总和水利部进一步加强三峡水库调度，首次对长江上游大型水利水电工程实施枯水期水量统一调度。

存在问题

三、我国干旱管理现状及思路转变

目前存在的问题

- 抗旱应急备用水源储备不足
- 旱情监测系统建设严重滞后
- 抗旱监测预警和指挥调度手段不完善
- 抗旱服务组织和物资储备还有未达标
- 旱灾保险机制、社会救助补偿体系、抗旱投入机制不健全
- 社区和乡镇等基层组织机构不健全，预案不落实，管理不到位
- 高效节水等抗旱措施应用不足

国际差距

三、我国干旱管理现状及思路转变

4. 我国干旱灾害管理与世界的差距

我国的干旱灾害风险管理应该从2003年算起，与发达美国和澳大利亚相比晚10～20年，但工作开展得非常迅速，目前与国外的差距最大的是在信息采集与共享方面，资料序列短，数据不共享。因此，在未来相当长一段时间内，干旱灾害管理的科学化水平的提高都将受其制约。

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四、未来我国干旱灾害管理的发展方向

风险管理

四、未来我国干旱管理发展方向

1. 推行干旱灾害风险管理

干旱灾害危机管理模式是当干旱灾害发生后才开始作出反应，临时制定应急对策和措施，以期减轻干旱灾害损失和影响。但由于干旱灾害危机管理模式主要是针对眼前和局部的问题，采取的措施往往是临时性和应急性的，效果十分有限。

干旱灾害风险管理模式是通过监测、分析、预测干旱的发生、发展规律，评估干旱灾害可能造成的损失和影响，优化组合各类抗旱措施，有序、有效应对干旱灾害，并对干旱灾害进行后评价的全过程。因此，干旱灾害风险管理是一种主动、有备、周密和有效的防旱抗旱减灾管理模式，贯穿于干旱发生发展的全过程，其本质是积极地预防和降低干旱灾害风险。

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风险管理

四、未来我国干旱管理发展方向

1. 推行干旱灾害风险管理

联合国近年来广泛组织各国开展干旱灾害风险管理研究，2009年提出了减轻干旱灾害风险框架。框架内容主要包括5个方面：

一是认为应以当地需要、社会参与和政治承诺、体制机制以及资源为基础制定干旱政策及管理；

二是认为干旱灾害风险识别、监测和预警是有效掌握干旱灾害的发生发展、潜在影响以及脆弱性根源的基本手段；

三是认为加强防灾减灾意识和教育也是减轻干旱灾害风险的有力措施；

四是认为减轻干旱灾害风险潜在因素有助于降低干旱灾害的脆弱性；

五是认为如果政府、个人和社区都具备必要的干旱灾害管理知识和抗旱减灾能力，做好充分的准备，并能随时采取行动，可以大幅减轻干旱灾害影响和损失。

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风险管理

四、未来我国干旱管理发展方向

2. 完善工程和非工程措施

60多年来我国修建的大批水利工程已经消化掉了常态化旱情，农业供水保证率达到50%～70%，城市供水保证率达到70%～100%，但对于较大干旱来说，在旱情紧急时，常规的水利工程已经不能满足快速缓解旱情的需要，所以必需有新的工程型式即抗旱应急备用水源来作为补充。但目前我国抗旱应急备用水源工程及配套制度还没有得到广泛应用与推广，导致各地抗旱期间无抓手，目前地方抗旱部门急切地期盼抗旱规划能够早日实施。

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风险管理

四、未来我国干旱管理发展方向

2. 完善工程和非工程措施

在非工程措施方面，虽然也颁布了抗旱条例，制定并实施了抗旱预案制度、旱情会商制度、抗旱物资储备制度、旱情信息发布制度、水量统一调度制度、应急响应制度，以及应急保障制度等，但其可操作性、科学性以及完备性等方面还有待进一步提高。另外，实现干旱灾害的风险管理还需要加强灾前的预测、预报、预警研究，灾中应对的有效性研究，灾后求助的快速恢复性研究等。

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风险管理

四、未来我国干旱管理发展方向

3. 提高干旱灾害管理科学化水平

干旱灾害不同于其他灾害之处，是它涉及的面广，对其进行机理分析、规律分析需要许多基础数据支撑，如气象数据、水情墒情数据、农业工业数据、社会经济数据、水资源数据、土地利用数据、土壤数据以及空间数据等，这些数据分散在各个部门，且许多数据无长序列，这种情况若想开展大范围的旱灾规律分析研究基本是不可能的。所以，开展与干旱、旱灾研究有关的数据统计、调查及数据共享是今后提高干旱灾害管理科学化水平的关键，也是必经之路。不过，解决这一问题，首先要解决部门之间的体制机制问题。

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风险管理

四、未来我国干旱管理发展方向

4. 实现干旱灾害管理的社会化

当前我国的干旱灾害管理基本上是政府行为，除政府设立干旱灾害管理机构外，基本没有民间和非政府组织参与。抗旱的基础设施、应急时的人力、物力、财力，灾后的救济、救援、救助全部由政府承担。但是，由于中国的事务繁多，需要资金的地方也很多，不可能动用很大的资金来满足干旱灾害管理的需要，干旱灾害管理存在薄弱环节是必然的。国外实践经验表明，灾害的风险分担是降低干旱风险，也是减轻灾害损失的有效手段，政府主导，企业、个人共同承担，保险公司和再保险公司托底，可以使干旱灾害的影响降至最低。

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风险管理

四、未来我国干旱管理发展方向

5. 加强干旱灾害风险应对的公众教育

当前我国的干旱灾害管理基本上是政府行为，除政府设立干旱灾害管理机构外，基本没有民间和非政府组织参与。抗旱的基础设施、应急时的人力、物力、财力，灾后的救济、救援、救助全部由政府承担。但是，由于中国的事务繁多，需要资金的地方也很多，不可能动用很大的资金来满足干旱灾害管理的需要，干旱灾害管理存在薄弱环节是必然的。国外实践经验表明，灾害的风险分担是降低干旱风险，也是减轻灾害损失的有效手段，政府主导，企业、个人共同承担，保险公司和再保险公司托底，可以使干旱灾害的影响降至最低。

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风险管理

四、未来我国干旱管理发展方向

6. 做好防范大灾的精神准备和物质准备

在我国历史上，特大旱灾常常导致饥谨频生，灾民流徙，抢米、暴乱等一系列事件，对社会的固有秩序造成冲击，引发社会动荡与混乱。积谷仓储，以备救济，在历史上曾发挥过非常重要的作用。早在《礼记•王制》中规定：“国无九年之蓄，曰不足；无六年之蓄，曰急；无三年之蓄，曰国非其国也”。也就是说，没三年之度荒的物资储备，遇大灾将会出现亡国的大动乱。在国外，日本和英国都开展了雨洪利用工作，将雨水大量储备于地下，既可保护地下水资源，又可作为备战水源，是一个一举多得的战略措施。

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五、结束语

五、结束语

随着全球气候变化加剧，以及用水需求量的不断增加，未来干旱灾害还有发生频率增加和影响加重的趋势。任何一个部门和一种手段都不可能解决干旱灾害的全部问题，必须全社会各行业、各部门，各司其职，密切合作，共同研究、探讨形成干旱灾害的各种因素，深入开展科学研究，运用科学的减灾手段，努力消除自然因素的不利影响，纠正人类社会的不良行为，在干旱灾害风险管理思想的指引下，真正从被动抗旱走向主动抗旱，从危机管理走向风险管理。

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Pilot Province Workshops, March 2014



TA-8185 PRC

Pilot Implementation of the Drought Management Strategy – Tiered DMPs

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Drought Risk Management Approach

Benefits of Drought Plans

- Proactive, emphasizes mitigation and response
- Improves coordination between and within levels of government → organizational structure
- Enhances early warning through integrated monitoring efforts
- Involves stakeholders

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Drought Risk Management Approach

Benefits of Drought Plans

- Identifies areas, groups, sectors at risk
- Reduces economic, environmental, and social impacts (i.e., risk)
- Reduces conflicts between water users
- Improves information dissemination → better delivery systems
- Builds public awareness

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Drought Risk Management Approach

- **Strategic Approach to Drought Risk Management Plans**
  - Drought risk theory should be cognizant of PRC drought management institutions and constraints, including that water-related risk mitigation and water conservation measures more properly managed at level of local county/municipal DMPs (with local water suppliers.)
  - Provincial DMPs provide historical drought-related vulnerabilities in province, guidance on use of risk based proactive approaches to drought prior to the drought actually beginning, tools to assist in the production/implementation of the local county/municipal DMPs (in conjunction with local water suppliers), and a regional perspective and oversight when droughts extend to multiple local jurisdictions. Triggers in provincial DMPs relate to needed actions at local levels.
  - Local county/municipal DMPs contain detailed triggered risk reduction and water conservation measures at the level of the local water suppliers (domestic, agricultural, etc.)

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Drought Risk Management Approach

- Conceptual Framework proposed during Phase II TA includes tiered Drought Management Planning responsibilities between provinces and local municipal and county level DMPs:
  1. Provincial FCDRH uses new improved drought management integrated database to track recommended indicators (SPI, river flow and reservoir anomalies in Normal or Pre-Drought), SL24-2008 indicators during actual drought levels (Slight IV to Extreme I).
  2. Daily provincial indicators disseminated to local jurisdictions and potential problematic index levels flagged for local FCDRHs.
  3. Local FCDRHs and water managers work daily under Normal roles and responsibilities, monitoring their local suite of water resources indices. As drought indices are received from the provincial FCDRH relative to potential index levels of concern, local agencies move into pre-drought management levels (based on potential risk level) and refine and/or add local index information (hydrologic, soil moisture, etc.) to the provincial precipitation indices.

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Drought Risk Management Approach, 2

4. Local FCDRHs report back to provincial FCDRH on status of pre-drought or actual drought management activities to allow provincial coordination in affected regions of the province.
5. Local FCDRHs and water managers implement appropriate risk reduction and mitigation measures to minimize potential impacts of impending drought, or actual drought.
6. As potential drought accelerates into actual drought with damages, the pre-drought management moves into drought response and recovery activities as outlined in current PRC drought management regulations/guidance and current provincial drought response plans.

- Conceptual framework requires that drought management activities are conducted on a daily basis, regardless of the situation of drought and they do not wait for drought damages and response actions before they are triggered.

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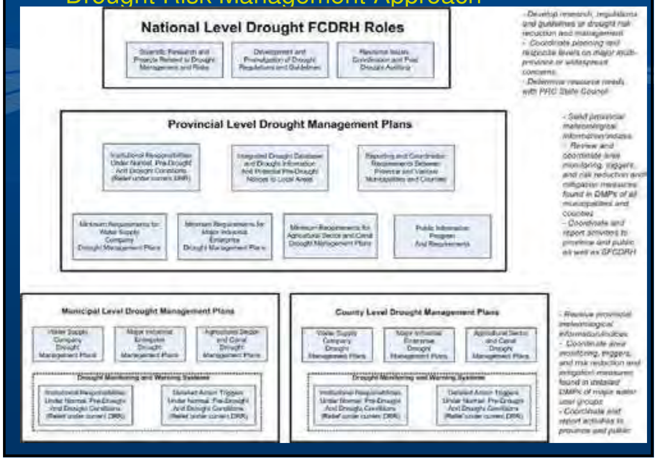
Drought Risk Management Approach



Drought Risk Management Approach

National Level Drought FCDRH Roles

Scientific Research and Projects Related to Drought Management and Risks	Development and Promulgation of Drought Regulations and Guidelines	Resource Issues, Coordination and Post Drought Auditing

- **Develop research, regulations and guidelines or drought risk reduction and management**
- **Coordinate planning and response levels on major multi-province or widespread concerns**
- **Determine resource needs with PRC State Council**

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Drought Risk Management Approach

Provincial Level Drought Management Plans

Institutional Responsibilities Under Normal, Pre-Drought And Drought Conditions (Relief under current DRR)	Integrated Drought Database and Drought Information And Potential Pre-Drought Notices to Local Areas	Reporting and Coordination Requirements Between Province and Various Municipalities and Counties	
Minimum Requirements for Water Supply Company Drought Management Plans	Minimum Requirements for Major Industrial Enterprise Drought Management Plans	Minimum Requirements for Agricultural Sector and Canal Drought Management Plans	Public Information Program And Requirements

- Send provincial meteorological information/indices
- Review and coordinate area monitoring, triggers, and risk reduction and mitigation measures found in DMPs of all municipalities and counties
- Coordinate and report activities to province and public, as well as SFCDRH

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Drought Risk Management Approach

Municipal or County Level Drought Management Plans

Water Supply Company Drought Management Plans	Major Industrial Enterprise Drought Management Plans	Agricultural Sector and Canal Drought Management Plans

Drought Monitoring and Warning Systems

Institutional Responsibilities Under Normal, Pre-Drought And Drought Conditions (Relief under current DRR)	Detailed Action Triggers Under Normal, Pre-Drought And Drought Conditions (Relief under current DRR)

- Receive provincial meteorological information/indices
- Coordinate area monitoring, triggers, and risk reduction and mitigation measures found in detailed DMPs of major water user groups
- Coordinate and report activities to province and public

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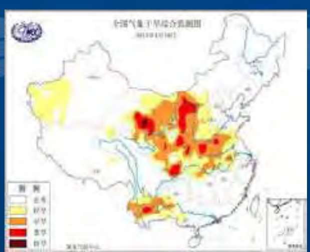
Drought Risk Management Approach



SPI Values Standardized Precipitation Index (SPI)	
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to +0.99	Near normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2.0 and less	Extremely dry

Drought's Magnitude	Drought Intensities	Percentage Of Precipitation Anomalies /%		
		Time Scale In A Month	Time Scale In Three Months(Quarter)	Time Scale In A Year
1	Near Normal	-40＜Pa	-25＜Pa	-15＜Pa
2	Slightly Drought	-60＜Pa≤-40	-50＜Pa≤-25	-30＜Pa≤-15
3	Middle Drought	-80＜Pa≤-60	-70＜Pa≤-50	-40＜Pa≤-30
4	Severe Drought	-95＜Pa≤-80	-80＜Pa≤-70	-45＜Pa≤-40
5	Extreme Drought	Pa≤-95	Pa≤-80	Pa≤-45

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Drought Risk Management Approach

Proposed Prototype Drought Database for Liaoning Province

Potential Database Information	Availability in existing Liaoning database	Data granularity
Precipitation	Yes	Daily
Temperature	Yes	Daily
Evapotranspiration	Yes	Daily
Soil moisture	Yes [some areas]	Daily
Surface water flow rates	To be added	Daily
Groundwater levels	To be added	10days – monthly
Reservoir and lake levels (multi-purpose national)	To be added	Daily
Municipal, agricultural and industrial reservoir levels	To be added	Daily

SPI, River and Reservoir Anomalies - Daily Drought Indices to Municipal and County Level FCDRHs

Municipal and County Level Indices Added to Provincial Indicators, DMP Operations Drought Risk Reduction and Mitigation

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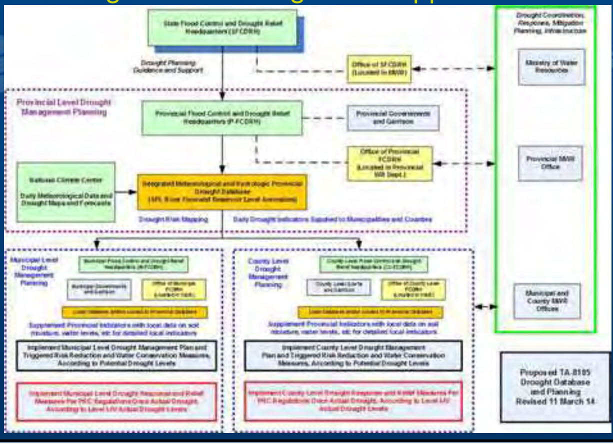
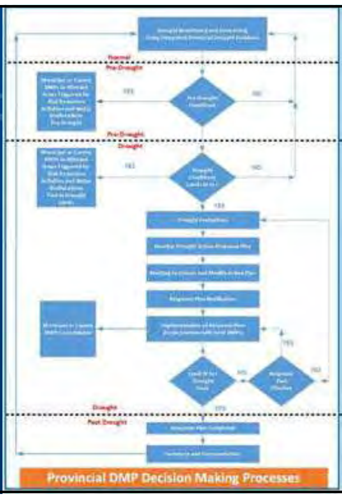
Drought Risk Management Approach



Management Phase		Index and Triggers		Potential Drought Impacts
		Indices	**Triggers**	
Before Drought	Normal	Standard precipitation index (**SPI**) River flow anomaly D_F Reservoir level anomaly D_L	**$SPI \geq 0$** **$D_F \geq 0$** **$D_L \geq 0$** **Two conditions met**	No drought
	Pre-Drought	Standard precipitation index (**SPI**) River flow anomaly D_F Reservoir level anomaly D_L	**$-0.5 \leq SPI < 0$** $-15\% \leq D_F < 0$ $-10\% \leq D_L < 0$ **Two conditions met**	No drought impacts
Actual Drought Conditions PRC Levels IV to I	IV- Slight Drought	Regional agriculture drought index I_a	$0.1 \leq I_a < 0.5$	Water shortage in agriculture
	III Medium Drought	Regional agriculture drought index I_a population ratio under drinking water stress P_a	$0.5 \leq I_a < 0.9$ Or $2.0 \leq P_a$ One condition is met	Increasing shortage on agriculture water use, some livestock and resident may be stressed for drinking water shortage in distant area
	II Serious Drought	Regional agriculture drought index I_a population ratio under drinking water stress P_a Percentage of urban water shortage P_g	$0.9 \leq I_a < 1.5$ Or $5.0 \leq P_a < 7.0$ Or $20 \leq P_g < 30$ One condition is met	Serious shortage on agriculture water use, increased difficulty on drinking water supply in distant area, urban water use may be affected
	I Severe Drought	Regional agriculture drought index I_a population ratio under drinking water stress P_a Percentage of urban water shortage P_g	$1.5 \leq I_a \leq 4$ Or $7.0 \leq P_a$ or $30 \leq P_g$ one condition is met	Agriculture, rural drinking water and urban water use are all significantly affected
	Recovery			The direct impact is relieved



Drought Risk Management Approach

Municipal or County Level DMPs In Affected Areas Triggered for Risk Reduction Activities and Water Reallocations

Pre-Identified Actions (Pre-Drought to Drought Levels):

- Prioritizing water uses and water sources
- Organizing institutions for early actions to minimize impacts
- Supply side options ready to be employed
- Water conservation measures developed and ready to apply at various pre-drought and drought conditions.
- Water reallocations from lower value to higher value uses within a detailed and planned framework including compensation to areas losing water.
- Systems to employ and monitor the sectoral level drought plans of municipal, industrial and agriculture sectors.
- Drought relief supplies and planning ready to implement.

Drought Risk Management Approach

Normal

- **Collect and analyze drought-related information in a timely and systematic manner.**
- **Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.**
- **Provide an organizational structure and delivery system that assures information flow between and within levels of government.**
- **Define the duties and responsibilities of all agencies with respect to drought.**
- **Maintain a current inventory of government programs used in assessing and responding to drought emergencies.**
- **Identify drought-prone areas of the province and vulnerable economic sectors, individuals, or environments.**
- **Identify mitigation actions to address vulnerabilities and reduce drought impacts.**

Drought Risk Management Approach

Normal, Continued

- **Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.**
- **Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and internet).**
- **Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages, and requirements or provide incentives to encourage water conservation.**
- **Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state or region.**
- **Integrated drought database to allow for continuous monitoring of MWR and NCC data on meteorology using SPI, river flows and reservoir levels.**
- **Vulnerability assessments in the province coordinated with local jurisdictions.**
- **Development of standard protocols and minimum requirements for municipal, county and sectoral DMPs prepared in the Province.**

Drought Risk Management Approach

Pre-Drought	- Based on Integrated drought database for continuous monitoring of MWR and NCC data on meteorology using SPI, river flows and reservoir levels, notify potentially affected municipal FCDRH of potential drought conditions. - Oversee implementation of standard protocols and minimum requirements for municipal, county and sectoral DMPs prepared in the Province. - Coordination of local DMP Pre-drought responses especially where drought affects multiple municipal areas or major sectors. - Report on activities upward to National FCDRH and downward to local FCDRHs. - Coordinate public information on risk reduction activities.

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Drought Risk Management Approach

Drought	- Based on Integrated drought database for continuous monitoring of MWR and NCC data on meteorology using SL24-2008 identified drought indicators, notify potentially affected municipal FCDRH of actual drought conditions. - Oversee implementation of standard protocols and minimum requirements for municipal, county and sectoral DMPs prepared in the Province and begin drought relief activities as specified in PRC regulations. - Coordination of local DMP drought responses especially where drought affects multiple municipal areas or major sectors. - Report on activities upward to National FCDRH and downward to local FCDRHs. - Coordinate public information on risk reduction activities as well as drought relief activities.

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Drought Risk Management Approach

Post - Drought	- Based on Integrated drought database for continuous monitoring of MWR and NCC data on meteorology using SL24-2008 identified drought indicators, notify potentially affected municipal FCDRH of end of actual drought conditions. - Oversee implementation of standard protocols and minimum requirements for municipal, county and sectoral DMPs prepared in the Province and begin drought relief activities as specified in PRC regulations. - Coordination of local DMP drought responses especially where drought affects multiple municipal areas or major sectors. - Report on activities upward to National FCDRH and downward to local FCDRHs. - Coordinate public information on risk reduction activities as well as drought relief activities. - Determine end of drought relief following end of drought and return to Normal conditions.

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Drought Risk Management Approach

- **For a provincial, municipality, or regional plan, objectives that should be include the following:**
  - Collect and analyze drought-related information in a timely and systematic manner.
  - Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.
  - Provide an organizational structure and delivery system that ensures information flow between and within levels of government.
  - Define the duties and responsibilities of all agencies with respect to drought.
  - Maintain a current inventory of government programs used in assessing and responding to drought emergencies.
  - Identify drought-prone areas and vulnerable economic sectors, individuals, or environments.

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Drought Risk Management Approach

- **Continued:**
  - Identify mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.
  - Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, cities, environment, tourism and recreation, health, and other areas.
  - Keep the public informed of current conditions and response actions.
  - Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
  - Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the area.

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Drought Risk Management Approach

- **Specific goals must be developed for DMPs in China, and then tailored to the issues and needs of the specific provinces. Typical goals might include issues such as**
  - Improve Water Availability Monitoring and Drought Impact Assessment
  - Increase Public Awareness and Education
  - Augment Water Supply Through Mechanisms to Transfer Water from Areas of Surplus to Areas of Shortage During a Drought
  - Coordinate and Provide Technical Assistance for Province, Local, and Watershed Planning Efforts
  - Reduce Water Demand/Encourage Conservation
  - Reduce Drought Impacts to China's Economy, People, Assets, and Environment
  - Develop Intergovernmental and Interagency Stakeholder Coordination
  - Evaluate Potential Impacts from Climate Change

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Drought Risk Management Approach

- **Typical Constraints to Drought Risk Management:**
  - Drought gets little respect because of lack of structural impacts and the fact that loss of life is usually nonexistent or minimal.
  - Drought monitoring/early warning is complex, requiring data from all elements of the hydrological system and blending of this information.
  - Drought relief discourages risk-based management approach because it reduces self-reliance, increases reliance on government.
  - Societal change effects on vulnerability poorly understood with insufficient research on critical element of risk-based management.
  - Drought mitigation actions are less obvious to most decision makers because these measures are usually non-structural in nature.
  - Political will for a national drought policy and drought risk management can be weak because drought relief is often a measure of success for local officials.
  - Poor understanding of drought impacts and the proven cost-effectiveness of mitigation over relief.

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Drought Risk Management Approach

- **Specific Constraints to PRC Drought Risk Management:**
  - Drought funding and budgets are tied to drought relief activities and there is insufficient budget and motivation to perform drought management activities in Normal and Pre-Drought time periods.
  - Collaboration and cooperation amongst PRC water management agencies remains problematic, and will be more of a problem when there is not a definite drought relief crisis.
  - Additional capacity development and training will be necessary to allow water management staff at levels below the provincial government to adequately manage the drought management plans at these municipal and county levels.
  - It will take significant time for municipal and county level FCDRHs to develop adequate DMPs so there must be a transition time.
  - Local officials will also require time to work with the various sector water management officials (urban water supply, industry, agriculture) on their sectoral drought management plans.

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Pilot Province Workshops, March 2014



TA-8185 PRC Pilot Implementation of the Drought Management Strategy

Triggered Drought Risk Reduction and Mitigation Measures – Normal Operations, Pre-Drought, Drought, Post-Drought Operations

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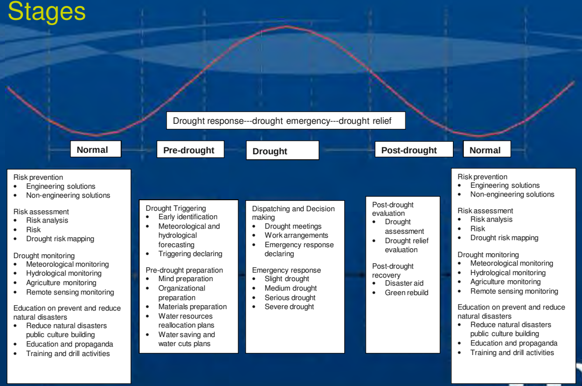
	Management Phase	Index and Triggers		Potential Drought Impacts
		Indices	Triggers	
Before Drought	Normal	Standard precipitation index (**SPI**) River flow anomaly D_F Reservoir level anomaly D_L	$SPI \geq 0$ $D_F \geq 0$ $D_L \geq 0$ **Two conditions met**	No drought
	Pre-Drought	Standard precipitation index (**SPI**) River flow anomaly D_F Reservoir level anomaly D_L	$-0.5 \leq SPI < 0$ $-15\% \leq D_F < 0$ $-10\% \leq D_L < 0$ **Two conditions met**	No drought impacts
Actual Drought Conditions PRC Levels IV to I	IV- Slight Drought	Regional agriculture drought index I_a	$0.1 \leq I_a < 0.5$	Water shortage in agriculture
	III Medium Drought	Regional agriculture drought index I_a population ratio under drinking water stress P_a	$0.5 \leq I_a < 0.9$ Or $2.0 \leq P_a$ One condition is met	Increasing shortage on agriculture water use, some livestock and resident may be stressed for drinking water shortage in distant area
	II Serious Drought	Regional agriculture drought index I_a population ratio under drinking water stress P_a Percentage of urban water shortage P_g	$0.9 \leq I_a < 1.5$ Or $5.0 \leq P_a < 7.0$ Or $20 \leq P_g < 30$ One condition is met	Serious shortage on agriculture water use, increased difficulty on drinking water supply in distant area, urban water use may be affected
	I Severe Drought	Regional agriculture drought index I_a population ratio under drinking water stress P_a Percentage of urban water shortage P_g	$1.5 \leq I_a \leq 4$ Or $7.0 \leq P_a$ or $30 \leq P_g$ one condition is met	Agriculture, rural drinking water and urban water use are all significantly affected
	Recovery			The direct impact is relieved

Drought Risk Management Activities at Different Stages



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Examples of Drought Risk Reduction and Mitigation Measures – Supply and Demand Management

Short-term	Sector	Long-term	Sector
Supply management			
• Mixing fresh and low quality waters	• U,A,I,R	• Increase water collection and storage opportunities (reservoirs)	• U,A,I,R
• Exploiting high-cost waters	• U,A,I	• Desalination of brackish and saline water	• U
• Over-drafting aquifers	• U,A,I	• Treatment and reuse of wastewater	• A,I
• Diverting water from given uses	• U,A,I	• Water transfers	• U,A,I,R
• Decreasing transport and distribution losses	• U,A,I	• Artificial precipitation	• U,A,I,R
• Adjust legal and institutional framework	• U,A,I,R	• Locate potential new resources (standby supplies)	• U,A,I
• Etc.		• Aqueducts and canals	• U,A,I
		• Groundwater recharge	• U,A,I
		• Monitoring and forecasting	• U,A,I,R
		• Adjust legal and institutional framework	• U,A,I,R
Demand management			
• Restricting agricultural uses (rationing, subjecting certain crops to stress, …)	• A	• Adopting supplementary and deficit-irrigation	• A
		• Water saving irrigation techniques (drip, sprinkler, …)	• A
• Restricting municipal uses (lawn irrigation, …)	• U	• Incentives to invest in water saving technology	• U,A,I
• Review operations of reservoirs	• U,A,I		
• Water metering and pricing	• U,A,I	• Water recycling	• U,I
• Water rationing	• U,A,I	• Dual distribution networks for drinking water supply	• U
• Education and awareness creation	• U,A,I		
• Provide permits to exploit additional resources	• U	• Inventory private wells and negotiate their public use	• U,I
• Provide drilling equipment	• U	• Assess vulnerability and advise water users	• U,A,I
• Adjust legal and institutional framework	• U,I,A,R	• Elaborate alert procedures	• U,A,I,R
• Negotiate transfer between sectors	•	• Carry-over storage	• U,A,I
	• U,A	• Conjunctive use	• A,I
• Etc.		• Adjust legal and institutional framework	• U,A,I,R
Impact Minimisation			
• Temporary reallocation of water resources (on the basis of assigned use priority)	• U,A,I	• Development of early warning system	• U,A,I
		• Reallocation of water resources on	• U,A,I

By sector:
A = Agriculture,
I = Industry,
R = Recreation,
U = Urban

Source: Bazza, M (2002)

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Examples of Drought Risk Reduction and Mitigation Measures – Long Term Versus Short Term DMP

Short Term Mitigation Measures (suitable for consideration in drought management plan)	Long Term Mitigation Measures (suitable for river basin plan, integrated water resources plan etc)
Improve the accuracy of seasonal runoff and water supply forecasts	Reduction in leakage in canals and main pipelines
Develop early warning systems	Reduction in leakage in distribution pipe network
Establish new data collection networks and data sharing arrangements	Agricultural extension to advise farmers on more efficient irrigation, more drought resistant crops, rotations, deficit irrigation etc.
Emergency limitation on abstraction permit holders (prioritised list of users) in accordance with SCD 460	Introduce more efficient water use in industrial processes by introduction of new technologies
Rotational cuts in water supply	Introduce new technology for clean up of process effluent to improve quality of return flow
Public education and awareness of water saving actions	Take marginal land out of production
Advice to farmers on cropping before planting based on drought forecast	Implement waste water re-use where water quality permits
Avoid high water use crops	Review development plans to avoid new industry with high water use unless committed to new technologies for recycling etc
Revise reservoir operating rules	Establish protection zones above reservoirs to maintain runoff potential and minimise sediment ingress
Waste water reuse where water quality permits	Artificial recharge
Maintain and use cloud seeding capability	Conjunctive use of surface and groundwater
Emergency borehole drilling	Water transfer from outside (inter-basin transfer)
Step up leakage control activities in urban areas	Construct new storage (dam) or transfer infrastructure
Change any subsidies that promote greater water use (eg subsidised electricity for pumping)	Develop water grid to allow internal transfers between sources
Inventory of industrial users with own source of supply to see if this supply could be used for domestic water supply in an emergency	Establish charging mechanisms that discourage wasteful use of water but protect low income users' water for living

Source: WRDMAP (2010)

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Normal Conditions Versus Triggered Drought Risk Conditions

- Many drought risk reduction and mitigation measures are applicable under normal conditions.
- For pre-drought and drought conditions additional / enhanced measures can be triggered, such as limits to water abstraction permits.
- The regulatory arrangement for implementing these short term, additional / enhanced measures should be prepared under normal operations and triggered at various drought warning levels in the proposed DMPs.

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Normal Conditions : Activities to Prepare for Drought Conditions

Examples:

- Prioritizing water uses and water sources
- Organizing institutions for early actions to minimize impacts
- Evaluating and rating reliability of existing suppliers
- Setting up water saving plans of individual suppliers to be ready to implement during pre-drought or drought conditions
- Water conservation measures developed and ready to apply at various pre-drought and drought conditions.
- Water reallocations from lower value to higher value uses within a detailed and planned framework including compensation to areas losing water.
- Systems to employ and monitor the sectoral level drought plans of municipal, industrial and agriculture sectors.
- Drought relief supplies and planning ready to implement

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Normal Conditions : Activities to Prepare for Drought Conditions

- Water use priorities have to be agreed, i.e., which users are to be asked to make sacrifices to protect the use by others, pre-agreed compensation plans, etc.

Priority	Description
Top	Domestic water use for basic needs (urban and rural), hospitals, schools, livestock
	Minimum flows for the environment and basic needs for downstream water users
	Pillar industries e.g. power stations
	Irrigation for vegetable crops
	Industry
	Supplementary irrigation of field crops
	Mining and other industries needing large quantities of water and discharging polluted waste water
Bottom	Non-essential or 'luxury' use

Source: WRDMAP (2010), Example of water supply priorities from Chaoyang DMP

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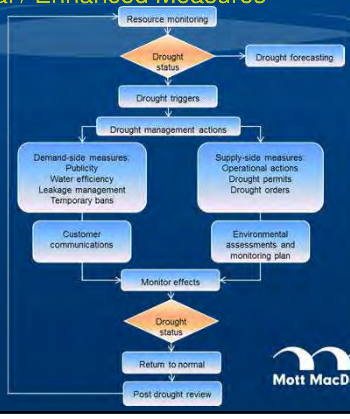
Pre-drought and Drought Conditions : Potential Additional / Enhanced Measures

UK example

Drought management process



Source: Anglian Water (2012), Drought Management Plan

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Pre-drought and Drought Conditions : Potential Additional / Enhanced Measures

UK example

- Temporary reductions in water use
  - Assessment (e.g. 'Prospects for Spray Irrigation')
  - Voluntary reductions
  - Restrictions of abstraction licences (should be in place before action needs to be taken)
- Temporary water reallocation
  - Reallocation to prioritized users or areas
  - Water transfers water transfers to redistribute water from areas of surplus to area of local deficit

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Pre-drought and Drought Conditions Potential Additional / Enhanced Measures

UK example

- Drought orders
  - To restrict waster use in certain areas.
  - Examples include water use for car / vehicle washes; garden sprinklers; sprinklers for landscaping (terminated or limited to a set number of hours per day); water to clean any premises, apart for safety or hygiene reasons; 'wetting' of roads to curb dust nuisance; public fountains; swimming pools and ornamental ponds; automatically-flushing toilet cisterns at times when buildings are unoccupied, etc.
- Drought permits
  - To enable additional supplies to be provided to certain users during droughts.
  - Related to meeting human needs (e.g. water for hospitals).

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Pre-drought and Drought Conditions Potential Additional / Enhanced Measures

- Under the PRC Water Law (2002) water supply companies, industries, and irrigation use require a permit to abstract. Abstraction permits may be restricted during a drought.
- The DMP should set out the principles by which such emergency limitations will be decided with where relevant pre-agreed plans for compensation to reduce the sacrifice.

State Council Decree No. 460 'Regulation for Water Abstraction Permit and Collection and Management of Water Resources Fee': Article 41: In any of the following cases the competent authority may put limitation to the amount of water abstraction by a water abstraction unit or individual:

1. Water resources are inadequate to sustain the normal water supply in the area due to natural conditions;
2. Water abstraction or discharge has created significant impacts on the functions, ecology and environment of water bodies in a water function zone;
3. Groundwater over-abstraction is serious or geological hazards such as land subsidence have been induced by groundwater over-abstraction;
4. Any other special cases needing limitation to water abstraction amount.
5. If a major drought occurs, the competent authority may implement emergency limitation to the amount of water abstraction by units and individuals.

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United States, California Example

- Potential Actions by Agencies in Preparing for a Drought

  Drought Indicators – Current Water Conditions throughout the State are at normal levels. No drastic water conservation measures are necessary, although water conservation should always be practiced. The state's reservoirs are full or nearly full and runoff across the state is at normal levels.

  – Monitoring: key indicators of drought and drought impacts

  – Communication/Coordination and Planning: Drought plans, public awareness and education, coordination and communication protocol, vulnerability assessment, program for temporary water transfers

  – Local assistance: permits and approvals for water transfers, contracts for drought contingency water supplies, water systems assistance

  – Conservation: promote detection efforts, increased use of recycled water, improving on-farm efficiencies

  – Other: budget needs and allocation procedures, lessons learned

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US, California Example, continued

- Potential Actions by Agencies in Responding to a Drought

  Level 1 - Abnormally Dry (Raising Awareness of Drought)

  Level 2 - First Stage Drought (Voluntary Conservation, heightened awareness, increased preparation)

  Drought Indicator – The State's precipitation, snowpack, or runoff is lower than normal, or reservoir levels are below average. Conservation measures should be increased voluntarily, to help manage the state's current water supply

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US, California Example, continued

- Potential Actions by Agencies in Responding to a Drought

  Level 3 - Severe Drought (Mandatory conservation, emergency actions)

  Level 4 - Extreme Drought (Maximum mandatory conservation)

  Drought Indicator – Reservoirs are low; precipitation, snowpack and runoff are all well-below normal, and forecast to remain so. Mandatory conservation may need to be enacted in communities that do not have adequate water supplies.

  Level 5 - Exceptional Drought (Water supplies cut off, maximum response)

  Drought Indicator – Extremely dry conditions persist across the state. Water safety, supply, and quality are all at risk, due to shortages. All sectors of water usage are facing hardship as a result of inadequate supply and dry conditions.

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US, California Example, continued

- Potential Actions by Agencies in Recovery from a Drought

  Drought Indicators – Current Water Conditions throughout the State are at normal levels. No drastic water conservation measures are necessary, although water conservation should always be practiced. The state's reservoirs are full or nearly full and runoff across the state is at normal levels.

  – Communication/Coordination and Planning: Identify and communicate when drought restrictions set by the State should ease or cease.

  – Monitoring: reservoir replenishment, groundwater levels, salt-water intrusion

  – Facilitation of watershed and local planning for drought: Manage pasture, rangelands and forest recovery

  – Local assistance: technical assistance, maintenance assistance, etc.

  – Conservation: Maintain drought conservation measures

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四川省旱灾风险分析及管理阶段划分

亚行技援项目组

2014年3月17日

汇 报 提 纲

一 四川省旱灾风险分析

二 四川省旱灾风险管理阶段划分

一、四川省旱灾风险分析

1、现行旱灾风险分析方法

2、四川省旱灾风险分析方法及结果

一、四川省旱灾风险评估

1、现行旱灾风险分析方法

目前，旱灾风险评估方法主要有3类：

①基于灾害系统理论的模糊综合评估

②基于历史损失频率分布的旱灾风险评估

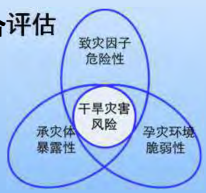
③基于干旱事件分析的旱灾风险评估

一、四川省旱灾风险评估

1、现行旱灾风险分析方法

①基于灾害系统理论的模糊综合评估

$$R = f\,(H, E, V)$$

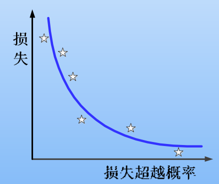


从致灾因子的危险性、承灾体的暴露性和孕灾环境脆弱性三方面着手建立评价指标体系，采用专家打分、层次分析等模糊数学方法计算得到灾害风险，进而实现旱灾风险评估。

一、四川省旱灾风险评估

1、现行旱灾风险分析方法

②基于历史损失频率分布的旱灾风险评估



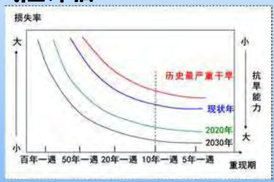
根据某一特定区域的历史旱灾损失序列，采用旱灾损失序列的频率分析方法，估计旱灾损失的概率分布，以不同损失的概率水平反映干旱灾害风险。

一、四川省旱灾风险评估

1、现行旱灾风险分析方法

③基于干旱事件分析的旱灾风险评估

R= f（P，C）



R：旱灾风险；

P：干旱发生的概率，用干旱频率反映；

C：不利影响，用一定抗旱能力下可能引起的损失来反映。

一、四川省旱灾风险评估

2、四川省旱灾风险分析方法及结果

本项目中，采用"基于灾害系统理论的模糊综合评估"进行四川省旱灾风险分析。基本步骤如下：

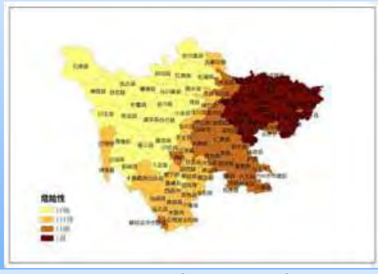
- 建立旱灾风险模糊综合评价指标体系
- 进行指标归一化处理
- 层次分析法确定指标权重
- 确定旱灾风险估算模型 $R = H * E * V * 100$

一、四川省旱灾风险评估

目标层	指标层	指标方向	权重
危险性（H）	降水量	－	0.429
	年降水量变差系数	＋	0.429
	人均水资源量	－	0.143
暴露性（E）	人均GDP	＋	0.125
	单位国土面积人口	＋	0.375
	单位国土面积牲畜数量	＋	0.125
	单位面积粮食产量	＋	0.375
脆弱性（V）	第一产业比例	＋	0.197
	有效灌溉面积比例	－	0.197
	水田比例	＋	0.079
	农村人口比例	＋	0.197
	水资源开发利用程度	＋	0.079
	人均收入	－	0.31
	单位面积可供水量	－	0.079
	抗旱队伍数量	－	0.079
	旱情监测系统数量	－	0.031
	应急备用水源个数	－	0.031

一、四川省旱灾风险评估

2、四川省旱灾风险分析方法及结果



四川省旱灾危险性分布图

一、四川省旱灾风险评估

2、四川省旱灾风险分析方法及结果

四川省旱灾暴露性分布图

一、四川省旱灾风险评估

2、四川省旱灾风险分析方法及结果

四川省旱灾脆弱性分布图

一、四川省旱灾风险评估

2、四川省旱灾风险分析方法及结果

四川省旱灾风险图

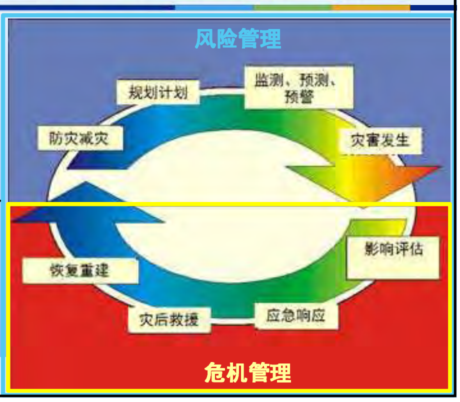
二、四川省旱灾风险管理阶段划分

1、管理阶段划分

2、各阶段触发条件

二、四川省旱灾风险管理阶段划分

1、管理阶段划分



二、四川省旱灾风险管理阶段划分

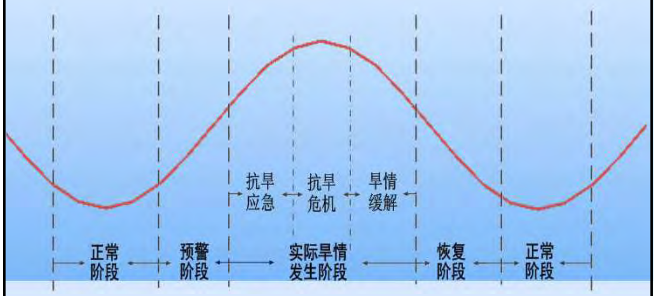
1、管理阶段划分

目前，我国已经形成了抗旱预案制度，包括四川省在内大部分省、地、县编制完成了抗旱预案。但是，现行的抗旱预案由于编制时间较早，加上对干旱问题的认识也是一个逐渐深入的过程，普遍存在以下问题：

- 将干旱预警和应急响应等同起来
- 干旱管理阶段触发指标存在不合理之处

二、四川省旱灾风险管理阶段划分

1、管理阶段划分



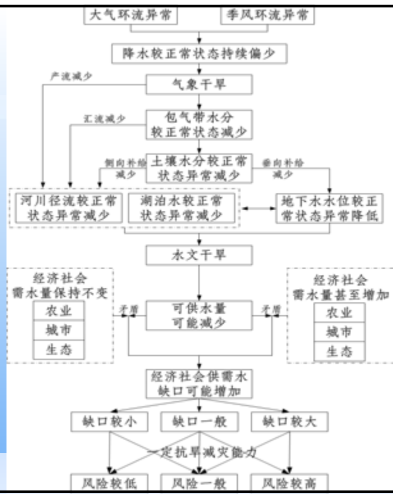
管理阶段			判别指标及触发点：指标	判别指标及触发点：触发点	可能的干旱影响
旱前	正常阶段		标准化降水指数SPI	SPI≥0	没有任何旱象
旱前	预警阶段		标准化降水指数SPI 河道径流距平 水库蓄水量距平	−0.5≤SPI<0 −15%≤ <0 −10%≤ <0 以SPI指数为主，其他两个指标为辅	尚未造成影响
旱中	实际旱情发生阶段	轻度干旱	区域农业旱情指数I_a 因旱人饮困难人口P_a 城市干旱缺水率P_g	$0.1 \le I_a < 0.5$ 100万人≤P_a<200万人 $5\% \le P_g < 10\%$ 有1个条件满足即可	农业用水出现短缺
旱中	实际旱情发生阶段	中度干旱	区域农业旱情指数I_a 因旱人饮困难人口P_a 城市干旱缺水率P_g	$0.5 \le I_a < 0.9$ 200万人≤P_a<400万人 $10\% \le P_g < 15\%$ 有1个条件满足即可	农业用水短缺加剧，部分偏远山区可能发生因旱人畜饮水困难
旱中	实际旱情发生阶段	严重干旱	区域农业旱情指数I_a 因旱人饮困难人口P_a 城市干旱缺水率P_g	$0.9 \le I_a < 1.5$ 400万人≤P_a<500万人 $15\% \le P_g < 25\%$ 有1个条件满足即可	农业用水短缺严重，偏远山区因旱人畜饮水困难加重，城市用水可能受影响
旱中	实际旱情发生阶段	特大干旱	区域农业旱情指数I_a 因旱人饮困难人口P_a 城市干旱缺水率P_g	$1.5 \le I_a \le 4$ 500万人≤P_a $25\% \le P_g$ 有1个条件满足即可	农业用水、农村人畜饮水、城市用水都受到较大影响
旱后	恢复阶段				直接影响解除

二、四川省旱灾风险管理阶段划分

（1）正常阶段：标准化降水指数SPI

- 旱灾风险形成机制
- 应用最为广泛
- 数据容易获取
- 具有时空可比性

降水距平百分率：将序列平均值作为标准化基准，受选择序列长度影响。



二、四川省旱灾风险管理阶段划分

（2）预警阶段：标准化降水指数SPI
河道径流距平
水库蓄水量距平


全国水库蓄水情况统计表

二、四川省旱灾风险管理阶段划分

（3）旱情实际发生阶段：区域农业旱情指数
因旱人饮困难人口
城市干旱缺水率

主要依据《旱情等级标准》（SL424-2008）和《四川省抗旱预案》（2007）确定评估指标及其阈值。需要指出的是，农业旱情监测评估需要分两步进行，第一步是点上农业旱情即耕地或农作物受旱程度评估；第二步是区域农业旱情评估。

敬请批评指正！

基于干旱风险的数据库

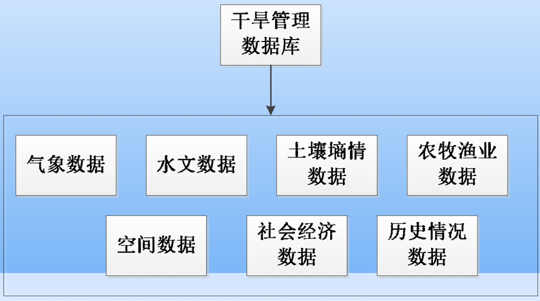
亚行技援项目组

2014年3月17日

主要内容

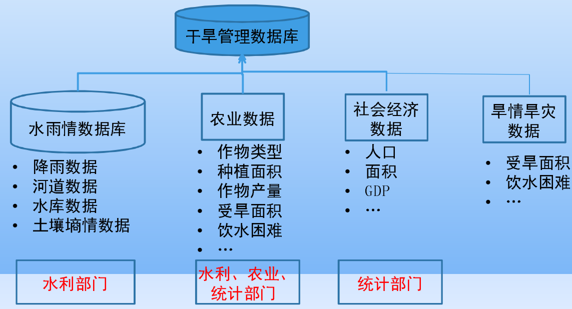
一、干旱管理数据库构建

1、组成部分



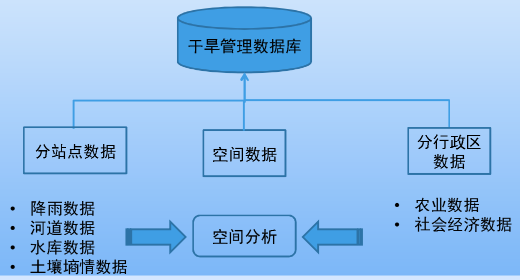
一、干旱管理数据库构建

2、数据内容和来源



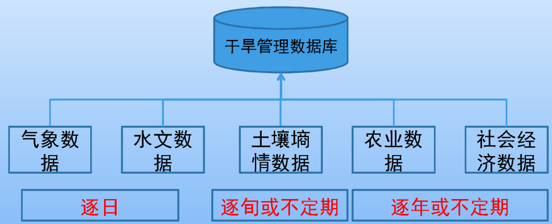
一、干旱管理数据库构建

3、数据的空间处理



一、干旱管理数据库构建

4、数据获取的时效性



二、干旱管理数据库详情

1、降水数据

站点数量	1100处，其中水利部门695，气象部门405处
监测项目	日降水量
监测频次	逐日
采集方式	自动遥测
数据应用	降水量距平、标准化降水指数（SPI）、连续无雨日数

二、干旱管理数据库详情

1、降水数据库表结构

ST_PPTN_R

序号	名称	代码	数据类型	非空	单 位	主键
1	测站编码	STCD	C(8)	Y		Y
2	时间	YMD	T	Y		Y
3	日降水量	DYP	N(5,1)		mm	

二、干旱管理数据库详情

2、水库数据

站点数量	223处
监测项目	水库水位等
监测频次	日、周、月
采集方式	自动遥测
数据应用	水库蓄水距平、需水量情况

二、干旱管理数据库详情

2、水库数据库表结构

ST_RSVR_R

名称	代码	数据类型	非空	主键	外键
测站代码	STCD	C(8)	Y	Y	
时间	TM	T	Y	Y	
库水位(米)	RZ	N(7,3)			
入库流量(立方米每秒)	INQ	N(9,3)			
蓄水量(百万立方米)	W	N(9,3)			
出库流量(立方米每秒)	OTQ	N(9,3)			
库水特征码	RWCHRCD	C(1)			
库水水势	RWPTN	C(1)			
入流时段长	INQDR	N(5,2)			
测流方法	MSQMT	C(1)			

二、干旱管理数据库详情

3、河道数据

站点数量	167处
监测项目	河道水位和流量等
监测频次	日
采集方式	自动遥测
数据应用	河道径流距平

二、干旱管理数据库详情

3、河道数据库表结构

ST_RIVER_R

名称	代码	数据类型	非空	主键	外键
测站编码	STCD	C(8)	Y	Y	
时间	TM	T	Y	Y	
水位(米)	Z	N(7,3)			
流量(立方米每秒)	Q	N(9,3)			
断面过水面积(平方米)	XSA	N(9,3)			
断面平均流速(米每秒)	XSAVV	N(5,3)			
断面最大流速(米每秒)	XSMXV	N(5,3)			
河水特征码	FLWCHRCD	C(1)			
水势	WPTN	C(1)			
测量方法	MSQMT	C(1)			
测积方法	MSAMT	C(1)			
测速方法	MSVMT	C(1)			

二、干旱管理数据库详情

4、土壤墒情数据

站点数量	103处，其中水利部门17处，农业部门86处
监测项目	不同深度土壤含水量等
监测频次	旬或不定期
采集方式	遥测和人工
数据应用	土壤相对湿度

二、干旱管理数据库详情

4、土壤墒情数据库表结构

ST_SOIL_R

序号	名称	代码	数据类型	非空	主键
1	测站编码	STCD	C(8)	Y	Y
2	时间	TM	T	Y	Y
3	垂线平均含水率	VTAVSLM	N(4,1)		
4	表层含水率	SRLSLM	N(4,1)		
5	10cm深度含水率	SLM10	N(4,1)		
6	20cm深度含水率	SLM20	N(4,1)		
7	30cm深度含水率	SLM30	N(4,1)		
8	40cm深度含水率	SLM40	N(4,1)		
9	50cm深度含水率	SLM50	N(4,1)		
10	作物种类	CRPTY	C(1)		
11	土壤类别	SLTP	C(1)		
12	干土层厚度	DRSLD	N(4)		
13	灌溉相隔天数	IRRINTV	N(3)		
14	降雨相隔天数	PINTV	N(3)		

二、干旱管理数据库详情

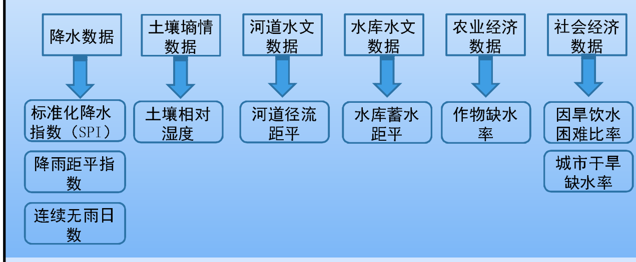
5、其他数据

- 站点基本属性
- 行政区编码
- 农业基本信息
- 社会经济基本信息
- 作物生长信息
- 农业旱情动态信息
- 城市干旱情况
- 水源基本情况和动态情况
- ……

《实时水雨情数据库结构》、《抗旱统计报表制度》、《国家防汛抗旱指挥系统》相关跪地个等

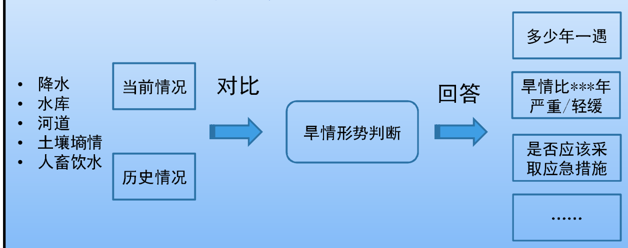
三、干旱管理数据库应用

1、计算实时干旱监测预警指标



三、干旱管理数据库应用

2、查阅和对比历史情况



三、干旱管理数据库应用

3、加强数据库建设和应用的建议

- 进一步加强各行业之间的数据共享
- 结合《国家防汛抗旱指挥系统二期工程》建立和完善抗旱管理综合数据库
- 结合上述项目逐步建立完善抗旱相关业务应用系统，真正实现抗旱决策支持

谢谢大家

Final Project Workshop, June 2014



TA-8185 PRC: Pilot Implementation of the Drought Management Strategy

Capacity Building & Awareness-Raising

Mott MacDonald

Institutional capacity and public awareness assessments

- Institutional survey with 74 respondents in 3 provinces, covering issues, methods, resources for drought management
- Water user survey, covering uses of water and options and constraints for saving water in each sector
- Provincial workshop to discuss issues in greater depth

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Survey of institutional capacity and knowledge: conclusions

- Need to strengthen technical capacity, especially at county levels.
  - Many recent efforts, but mostly related to general aspects of water management
  - Even current drought relief guidelines not fully understood
  - Need to distinguish between capacity to implement normal water savings and drought management
  - Many other institutional constraints, but technical capacity constraints are critical.

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Importance of Training

- Implementation of guidelines and DMPs will not be possible without a significant effort in capacity building.
- High-level understanding of and capacity to implement innovative topics also needs to be raised:
  - drought risk insurance
  - cost effectiveness of risk reduction and mitigation over relief
  - reallocation of water supplies when a drought is forecast but before it starts
- Study tours and workshops have had a significant impact on this high level knowledge

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Need focused training on drought

- Expand scope of existing water management training to cover drought, and especially risk management
  - Drought vulnerability and risk assessment
  - Drought prediction and early action
  - Water allocation and reallocation during drought periods
  - Proposed tiered drought management planning responsibilities
  - Co-operation between agencies for managing drought risk

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Main Training topics

- Laws, regulations and technical standards, and related institutional arrangements
- drought monitoring - techniques, stations, data management and sharing; drought forecasting,
- drought risk management - theory, detailed risk reduction and mitigation measures, triggers and actions

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Arrangements for training

- 10 days training (in 1-3 day blocks) for around 600 people in the three provinces will be required
  - 5-10 in FCDRHs at national / provincial level
  - 100 in Municipality FCDRHs
  - 500 in County FCDRHs
- Trainers would be specialists from National and Provincial FCDRH and research institutes
- Funding for capacity-building is a key issue, but should be covered from existing budgets

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Public Involvement Program

- According to survey results and information obtained from the workshops, the public awareness and the water saving activities of the whole society should be raised.
- For different target groups take different approaches to enhance their awareness of water conservation
  - General public: water conservation through radio/TV propaganda and education. Improved regulatory system and drought mitigation
  - Children and students: to carry out water-saving knowledge and education through school
  - Farmers: through agricultural water conservation and raise their awareness of water conservation in technical manuals
  - Urban residents: Water saving education through newspapers.

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Awareness-raising and public education related to water savings

- Water-saving should build resilience to drought, but additional actions needed for drought risk reduction and mitigation. Awareness of both water-saving and drought risk management is needed.
- Many constraints to water-saving. Must address the constraints at the same time as raising awareness:
- Be wary of 'awareness fatigue' if these constraints are not addressed.

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Constraints to making awareness effective

- People will be unable to put their awareness of water saving into comprehensive, practical use if there is
  - lack of regulations or weak enforcement, including abstraction permits
  - limited data on actual abstractions and little auditing of the abstraction permit system
  - inflexible management of surface irrigation, with a need for large-scale reforms
  - high initial and recurrent cost of water savings methods, with little incentive to use them
  - lack of sufficient technical knowledge to implement water saving

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What can water-aware individuals do now?

- Individuals: water-saving at household level
- Farmers: water-saving agricultural practices on existing crops; negotiate with WMS for more appropriate irrigation scheduling on surface irrigation; change to higher-productivity crops on groundwater irrigation, etc
- Industry leaders: adopt water-efficient processes, reuse and recycling

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How can they be persuaded?

- Focus awareness-raising on locally-appropriate measures
- Identify the costs and benefits to individuals
  - productivity of labour, land & water for farmers
  - cost saving, water security and reputational benefits to industry
- Provide more detailed information on incentives and motivation to adopt water-saving techniques
- Implement local level and sector DMPs

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Normal water-saving to cope with shortage

- ‘Normal’ water-saving actions will increase resilience in the face of a drought – for example
  - improved irrigation management and water saving agriculture
  - additional water infrastructure
  - water-efficient industrial processes etc

But

- additional specific drought-related water-savings are needed

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Water saving in relation to drought

- Public awareness and understanding needed of
  - drought risk management; the triggers for initiating drought actions;
  - actions when trigger levels reached, such the need
    - to reallocate water from low to high priority uses
    - to reduce irrigation supplies during the crop season
    - to ration urban water use
    - to make arrangements for providing emergency water supplies; etc.)
  - Management of abstraction permits before and during droughts
- These will be driven by local DMPs

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Conclusions

- Capacity-building, particularly at county level is a prerequisite for drought risk management
- Public awareness of water savings and drought risk needs to be raised
- Other institutional constraints need to be addressed at the same time to make the training and awareness-raising more effective

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Public Awareness Raising Program on Water-saving

TA8185: Pilot Implementation of the Drought Management Strategy

June 2014

Asian Development Bank

ADB

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Public Awareness Raising Program on Water-saving

TA8185: Pilot Implementation of the Drought Management Strategy

June 2014

Asian Development Bank

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A	3 July 2014	Wu Yucheng Mia Yu Marieke Nieuwaal Simon Howarth Larry Quinn	Yi Zhang	Fang Songchuan	Draft version submit to ADB	

Contents

Executive Summary

Water-saving is not the same as drought management. Water-saving should build resilience to drought, but additional and different actions needed for drought risk management. Awareness of both water-saving and drought risk management is needed. The ToR call for a water-saving awareness program, but the study indicates an even greater need for drought-risk management awareness.

Awareness of water-saving is not sufficient as there are many constraints to putting this awareness into practice. These constraints to water-saving are well recognized: lack of regulations or weak enforcement, notably of abstraction permits; limited data on actual abstractions and little auditing of the abstraction permit system; inflexible management of surface irrigation, with a need for large-scale reforms before individual actions can be effective; high initial and recurrent cost of water-savings methods, with little incentive to use them; and lack of sufficient technical knowledge to implement them.

Nevertheless, some individual actions can be undertaken in isolation: motivated individual households, farmers and industry leaders can be encouraged to do so by much more carefully focused awareness-raising, with more detailed information than is currently provided. However, this will not stimulate widespread action, and further general awareness-raising without addressing the other constraints will lead to frustration and boredom – 'awareness fatigue' - rather than action.

There is good experience both locally and internationally with a wide range of awareness-raising techniques in relation to water saving and other water-related issues. Examples given in this report highlight the need for a culturally-sensitive approach; the use of a combination of traditional and modern methods; the value of humor, games and building the messages into everyday enjoyable activities; the value of schools programs; the potential for many innovative ways of getting across simple messages; and the need to reinforce awareness with provision of specific technical information.

The distinction between water-saving in general and water-saving to cope with a forecast or on-going drought is critically important. 'Normal' water-saving actions – improved irrigation management, additional water infrastructure, water-efficient industrial processes etc. - will increase resilience in the face of a drought, but additional drought-related water-savings are needed. Awareness of the reasons for this is important, and should be the focus of any public awareness program.

There needs to be public awareness of topics such as: drought risk management; the triggers for initiating drought actions; actions when trigger levels reached (such the need to reallocate water from low to high priority uses; to reduce irrigation supplies during the crop season; to ration urban water use; to make arrangements for providing emergency water supplies; etc.); the need for abstraction permits and how they are managed; and so on.

Water education in schools will have a long term impact through ensuring a wider understanding of water issues in society as a whole. It should also have a short-term impact by influencing parents through their children..

As the concepts of drought risk are either new or subtly different from current practice for drought management, awareness raising and capacity-building amongst government personnel and technical staff at all levels is also important to ensure a common understanding and awareness of the issues and how they can be resolved. This is required not just in the FCDRH, but also in other related departments and levels of local Government. This is addressed in the capacity-building program.

1 Public Education and Awareness on Water-saving

1.1 Background

Water-saving has the potential to close a large part of the gap between water supply and demand in the PRC, and thus reduce the impact of droughts. Implementation of water-saving strategies calls for conscious efforts from the whole society and should be based on a good technical understanding. According to the water survey results and information obtained from the workshops in this Technical Assistance project (TA), the public awareness of the whole society need to be raised further. Although some meaningful work has been carried out in raising public awareness of water-saving, the activities are generally not systematic and the impact not lasting. The past activities were mainly carried out in the form of yearly campaigns. Raising the public awareness of water-saving in the whole society is a long-term task, which requires structured programs with more frequent activities.

First, however, it is important to recognize that water-saving is not the same as drought management. The distinction between water-saving in general and water-saving to cope with a forecast or on-going drought is critically important. ‘Normal’ water-saving actions – improved irrigation management, additional water infrastructure, water-efficient industrial processes etc. - will increase resilience in the face of a drought, but additional and different drought-related water-savings are needed. Awareness of the reasons for this is important, and should be the focus of any public awareness program. There is an urgent need for a water-saving awareness program, but the study indicates an equally strong need for drought-risk management awareness.

Furthermore, awareness of water-saving is not sufficient as there are many constraints to putting this awareness into practice. Many of these constraints to water-saving are well recognized: lack of regulations or weak enforcement, notably of abstraction permits; limited data on actual abstractions and little auditing of the abstraction permit system; inflexible management of surface irrigation, with a need for large-scale reforms before individual actions can be effective; high initial and recurrent cost of water-savings methods, with little incentive to use them; and lack of sufficient technical knowledge to implement them. Nevertheless, some individual actions can be undertaken in isolation: motivated individual households, farmers and industry leaders can be encouraged to do so by much more carefully focused awareness-raising, with more detailed information than is currently provided. However, this will not stimulate widespread action, and further general awareness-raising without addressing the other constraints will lead to frustration and boredom – ‘awareness fatigue’ - rather than action.

As the concepts of water-saving as part of drought risk management are either new or subtly different from current practice, awareness-raising is also needed amongst government personnel and technical staff at all levels - not just in the Flood Control and Drought Relief Headquarters (FCDRH), but also in other related departments and levels of local Government. Although such personnel should be aware of and involved in the public awareness program, there needs to be a separate awareness program for political and technical leaders at various levels.

1.2 Current Awareness of Water Users on Water-saving

The current state of knowledge of water-saving methods was assessed based on the water user surveys carried out for this TA. The general conclusions found from these surveys are:

- The public awareness of water-saving measures is generally low. This holds for farmers, urban residents, enterprises, and even water management departments. There is a large potential for water-

saving. For most cities, leakage rates are high. The agricultural irrigation efficiency and water utilization coefficient are far below international levels in countries with higher water conservation awareness levels. The water consumption per unit of industrial value added is also high.
- Water-saving-relevant policies are limited. Regulations related to water-savings are general, lack feasibility and are not helpful in improving public awareness of water-saving. Only a few areas and sectors have adapted progressive water price policies.
- The main two constraints to improve public awareness of water-saving are perceived to be:
  – The lack of systematic water-saving publicity and education programs. Currently, most regional water conservation education is limited to a number of thematic activities, and there are no long-term structured programs; and
  – The lack of water-related policies, regulations and regulatory incentives that could encourage the people, including farmers, urban residents, companies, and administrative institutions, to save water.

More specific findings include:
- Overall water demand is expected to continue to rise with poor awareness of water-savings and the need to promote economic measures to stimulate water-saving activities
- Agriculture is seen to have the greatest potential for saving, although mainly through introduction of new technology rather than better management. Both awareness and cost are seen as critical constraints which limit uptake of the new technology and thus a continued rise in water demand is anticipated [despite essentially no increase in agricultural area]
- Industrial users are aware of water reuse and recycling but there is limited coverage because of a lack of incentive and high cost (and also lack of enforcement of regulations). A large increase in industrial use is anticipated, presumably a consequence of rapid industrialization
- Domestic users are aware of the need to save water, but need to be given an incentive to do so through administrative regulation.

It is apparent that there are numerous awareness programs, but limited awareness is still seen as a key constraint. This suggests that more focused and targeted programs are needed, with greater focus on addressing the issues which constrain awareness from becoming effective action.

1.3 Current Public Education and Awareness Programs in Pilot Provinces

1.3.1 World Water Day, China Water Week and China Urban Water Conservation Awareness Week

After the promulgation of the Water Law of the People’s Republic of China in 1988, the Ministry of Water Resources of China designated July 1 to 7 each year as “China Water Week”. World Water Day was introduced by the United Nations in 1993, which highlights a specific aspect of freshwater each year on March 22. As "World Water Day" and "China Water Week" basically share the same theme and content, the Ministry of Water Resources changed the date of “China Water Week” to March 22 to 28 each year in 1994, China Water week now propagates and highlights the theme of "World Water Day” in greater depth. Public awareness activities on water conservation are organized as part of the China Water Week by the Ministry of Water Resources and local administrations (Water-Saving Office and China Water Education Centre). Television, newspapers and other sources are used to display educational content. In some big cities promotional materials are prepared and distributed amongst pedestrians. In 2014, the theme of the

World Water Day was 'Water and energy', and the Chinese Water Week theme was 'to strengthen the management of rivers and lakes, water, construction of ecological civilization[1].

In 1992, the Chinese Ministry of Housing and Urban-Rural Development (formerly the Ministry of Construction) established the National Urban Water Conservation Awareness Week (1992) in the week of May 15, and focuses water-saving awareness activities on urban residents.

1.3.2 Activities organized by the Ministry of Water Resources

Established under Water Resources Bureau of Ministry of Water Resources in 1999, the National Water-saving Office is in charge of organizing, guiding and supervising water-saving activities nationwide. Its responsibilities include:

- Organizing, guiding, and supervising nationwide water-saving activities.
- Day to day operations of National Water-Saving Office.
- Organizing the compilation of water-saving plan and supervising its implementation.
- Organizing and guiding the water-saving society.
- Guiding the compilation of regional and sectorial water-saving plans, allocations and quota, guiding the management of total water consumption and quota, guiding water balance monitoring for different sectors.
- Guiding the promotion of water-saving techniques and products.

1.3.3 China Water Education Centre

In order to improve the public awareness of water-saving for the whole society and promote water-saving, the China Water Education Centre (WEC, originally the Press Agency of China Water Resources) implements various public education and awareness programs. The main tasks of the China Water Education Centre are:

- Preparing and implementing nationwide water education plan (compilation initiated in 2013).
- Organizing and developing theoretical research activities, training and communications on water education, interviewing and reporting on key water resources related activities.
- Organizing and developing water education activities and key non-profit exhibition activities related to water resources.
- Producing and promoting non-profit water education products.
- Reviewing publications on China Water, China Water Journal and China Water Net.
- Managing China Water Press Agency.

The WEC is raising the public awareness on current situation of water resources, concerns about water shortage, crisis of water deficiency, responsibility of water conservation, and perception of water integrity to call the public for "understanding of water, protection of water, and harmony with water". The focus is thus on general water awareness, rather than specific drought-related water-saving awareness.

Collaborating closely with national Water-Saving Office, the WEC has developed public awareness programs on water-saving for five target groups.

- Industrial enterprises: recognizing that, generally speaking, the owners of industrial enterprises are more conscious about water-saving while the employees lack motivation for water-saving, it is very

[1] Source: Ministry of Water Resources website, http://szy.mwr.gov.cn/zwgk/jgzn/201206/t20120604_323153.htm last access: Apr 25, 2014

important to improve the awareness of water conservation of employees and workers of industrial enterprises.

- Communities: As it has been found that water-saving education program in communities is not generally very effective, the WEC has tried innovative methods to attract residents to participate in water-saving activities, by drawing more public attention through distributing propaganda materials via local administrators. This has stimulated local communities to develop short training courses to convey water-saving knowledge and messages for the residents. Delivering basic water-saving ideas to children in community kindergartens has been done in the hope that they could bring the ideas back home and influence their family members to implement water-saving measures. In addition, water-saving competitions and water-saving Q&A sessions were also held in communities to encourage and help resident actively join in water-saving activities.
- Schools: School and university students are an important target group, and they are able to have a wider and longer-term impact. Since it's relatively easy to organize campaigns in schools, the water-saving awareness raising could be very effective with the focus on lower grade student in primary schools. In addition, through establishment of water education base in schools, water-saving knowledge was introduced to classes during China Water Week. Meanwhile, water-saving volunteering has been developed in Universities to promote water-saving activities.
- Government: Since the structure of government is well organized, water-saving education programs in Government are very effective.
- Army: similarly there is a strong structural organization in the army, making the water-saving education program very effective.

The contents included in the public awareness programs are modified to fit the target audience. Current water-saving education programs utilize materials resulting from the outcomes of research projects, water-saving policies, and basic knowledge of water resources.

1.3.4 Form and methods for raising water-saving awareness by MWR

Water-saving public awareness activities are held every year for World Water Day and China Water Week campaigns. On March 22, 2014, activities named "*water-saving, on the way*" were held in Beijing South Railway Station to promote the ideas of water-saving, water cherishing, and water protection and to establish a water-saving institutional system, life style and social atmosphere.

The event holders set up a water-saving education booth and exhibition in Beijing South Railway Station. The water-saving education commercials were advertised on LED screens. Water-saving brochures were distributed to the passengers to introduce the current situation of water resources in China, the strict water resources management system, and to convey water-saving knowledge. On the train to Tianjin, water-saving materials and souvenirs including notebooks were distributed to passengers and feedback was collected.

Journals including China Water and China Water Journal are published on regular basis. In addition, a water education special journal is produced to educate public on specific water-saving topics. Other methods used to raise public awareness include: TV broadcasting, exhibitions, books, social networks as well as cell phone application platforms, such as 'weichat' application on smartphones that can send notifications of daily updates of news in China water sector.

TV series and short movies were also developed by the WEC to promote the China Water Law. Based on the true case experiences during water resources work, the TV series 'Man Water Law' was run, to

emphasize the common confusions the public may have and invited legal experts to give comments. The contents involved water resources management, river course management, water resources engineering project management, and water affairs.

In addition, in order to enhance public water conservation education and raise public awareness of water conservation, in 2006 the Ministry of Water Resources, the Ministry of Education and the National Water Conservation Office jointly established three national water conservation education bases. The purpose of these is to provide knowledge of water conservation to students. The first group of education bases was set up in Beijing Exhibition Hall of Water Conservation, Tianjing Luanshui Garden and Zhangye Water-saving Society Exhibition Center.

The education activities mainly focus on students in schools. For example, the two ministries organized a series of activities including a batch of wall pictures or photos for publicizing water-saving knowledge, making a propaganda film and a TV program. The students are encouraged to use water wisely for building a resource-saving and environment-friendly society.

The program needs both regulatory and financial support. Although the benefits are long lasting from both social and environmental perspectives, this is not a profitable activity in the short term. Therefore, the government must issue policies and develop financial support means to guarantee the implementation of water-saving propaganda and education in order to improve public awareness of water-saving.

For specific water-saving public awareness programs, a range of funding sources are available, including i) central financial budget, ii) budget from river basin management bureaus iii) project budget from research projects, and iv) fundraising from industrial enterprises. However, funding is recognized to be a key constraint.

1.3.5 Activities Organized Jointly with other Ministries

Since 2012, a nationwide water-saving publicity project named Cleanliness and Water-saving Initiatives has been organized for the World Water Day. The project starts with a three-day water conservation campaign in Beijing organized by the Center for Environmental Education and Communications under the Ministry of Environmental Protection. In addition to exhibitions promoting water conservation tips, the campaign also features games and brainstorming sessions to stimulate creative ideas for efficient water use. In 2013, the project encouraged every household to save 30 liters of water a day — 10,000 liters a year. Around 30,000 people from 10,000 households in Beijing were expected to participate over three days. Two more campaigns to promote water conservation were launched in Shanghai and Guangzhou in April as part of the project.

For the National Urban Water Conservation Awareness Week, the Ministry of Housing and Urban Development Office joined by national water-saving office to issue a thematic slogan to the provinces. For example, a common slogan that was used in 2013 in many cities such as Beijing and Shanghai was '*All of us are watering the flower of the ecosystem, water conservation in urban areas depends on us all'*. It was given to each urban water consuming unit to utilize in their own water-saving public awareness campaign. During the week, almost every city in the country carried out water-saving publicity and education activities. For example, in Chengdu, the national water-saving week was initiated under the topic of advocating green lifestyle - promoting urban water-saving and emission reduction. The municipal Water-Saving Office along with each water resources management station set up propaganda booths at the water culture square and large towns. Through water-saving films, banners, brochures and other propaganda methods, this activity

educated the public about the water-saving techniques and experiences, and created an atmosphere of water-saving in the city. In recent years, cities have held water-saving knowledge contests with prizes and organized voluntary publicity activities in a variety of media.

1.4 Current Issues and Constraints

Current water-saving education in China is generally believed to face three major challenges:

1. Lack of public interest, especially by farmers. Given the current situation of society, the general public is not interested in and does not see the benefits of water-saving activities. Overcoming these constraints calls for the general public's recognition of the importance of water-saving and understanding of individual responsibility for water-saving. The WEC has found that the public awareness program for farmers in rural areas is not very effective. There are two main constraints. First, farmers lack basic knowledge of water resources, and access to knowledge of advanced water-saving technologies, so the details of water-saving ideas are not accessible to farmers, and there are many other constraints to their implementation. Secondly, due to the non-centralized structure in the rural area, farmers are living very distant from each other, which make it difficult for them to be brought together and given lectures on water-saving topics. Therefore, the water-saving program is not very effective and the farmers are not very participative in water-saving activities.
2. Lack of innovative water-saving education methods to improve the efficiency of publicity programs. Traditional methods such as using slogans in residential areas have proved to be not very efficient. WEC has strived to develop innovative methods for raising the public awareness including holding a competition to recruit innovative ideas of public water education on water-saving to convey the information more effectively to the general public. The center also developed a TV series and some short advertisements or films focusing on water-saving methods.
3. Lack of a structured, continuous public awareness and education program. Up till now, raising public awareness on water-saving has mainly been done through intermittent water-saving campaigns, including World Water Day, China Water Week and China Urban Water Conservation Awareness Week. Because these public awareness activities are organized just once a year, the effect seems to be rather limited. There is no continuous water-saving education program afterwards. As a result, not only most of the public do not receive water-saving education, but also those that do receive the education do not care about water-saving issues, and act in their own way.

In addition, the findings of the survey undertaken for this project would suggest that a greater focus is needed on more tangible and implementable methods of saving water in the key sector – which is generally seen to be agriculture. However, although urban water supply requires much less water in total, most cities are water-stressed and there is greater potential for individuals to make an impact. In the context of this project, greater drought awareness is also needed. There needs to be greater awareness of the issues of water-savings specifically in relation to drought, as well as in the general sense of savings in a situation to a consistent shortage of water.

2 International Examples of Public Awareness-Raising

2.1 Background

This section provides some international ideas and examples that may be of use to overcome the constraints described above for raising water-saving awareness and making this effective.

The UNDP (2012) review[2] of practitioner perspectives on Drought Risk Management contains some useful general information around water-related awareness-raising. This notes at the outset that it is important to stress that the sort of measures that are required depend on high level political will "*Good practice starts with awareness-raising of high-level authorities … followed by intensive public awareness campaigns (mainly through the media), development of multi-hazard risk reduction strategies, policies, programmes and activities, involving community-based organizations and in which, awareness, education and training are high priority activities*" (*op. cit.* p.24). It also stresses the need for a comprehensive approach, rather than a narrow focus:

- an integrated approach around sustainable land / water resource management practice
- Community-led participatory approaches and organizations are important
- a focus on livelihood diversification
- a range of methods for raising community awareness

In Australia, a major drought stimulated actions at all levels and the way that they coped with this resulted in much greater awareness: "*the city of Perth managed its way through a major drought in 2001-02 very effectively. This was achieved through a multi-faceted approach of strong political leadership, collaboration between government agencies which traditionally have misaligned or competing objectives, programmes to include the community in finding the solutions (including discussion forums and funding for water-saving products and activities), technical investigations and increased funding for water resource management and drought response. The drought that came to Perth and the other capital cities in Australia provided an opportunity to support the community in changing its views and practices relating to water. The political process took notice, then leadership. The challenge now is to ensure that the drought is remembered and that changes are implemented before the next drought in the cycle."* (*Op. cit.* p.26)

It cites examples of methods which have been tested elsewhere. The range of awareness-raising techniques which have been effective in many places across Asia and Africa include:

- Use of various modern technologies eg. cell phones, videos
- Integration of water-saving approaches within agricultural extension services.
- Use of Participatory Geographic Information System (GIS), to allow communities to observe and measure the impact of local practices and hence to come up with locally owned solutions.
- Community-to-community visits and training-by-doing: In-field exchange and peer assistance tools are used widely to improve diversification of livelihoods, crops and livestock, such as introduction of early-maturity, short-duration and drought-tolerant crop varieties and changing cultivation practice.
- Knowledge products: E.g., technical update leaflets (to mitigate poorly informed decision-making).

2.2 Methods

Raising awareness effectively depends on careful choice of culturally-appropriate methods, across many forms of media. This section highlights some international experiences with suitable methods in diverse

[2] Drought Risk Management: Practitioner's Perspectives from Africa and Asia, UNDP, New York, Jan 2012

countries. Schaap and Steenbergen (2001)[3] give a range of examples of awareness-raising techniques used in programs related to water-saving, as described below.

2.2.1 Ideas for TV or Radio Broadcasts

Video clip**:** Water Awareness Campaign, UNDP/PWA (Palestine territories) produced a video clip showing a conversation, in the form of a song, about water between a peasant and a cloud.

Radio spots with traditional songs: UNICEF's Saniya Project (Burkina Faso) uses radio-spots which rely on traditional jari-songs as well as a composition of sanitation messages to the "namta," a mathematics table set to song.

Humor in water-related commercials: A Dutch commercial prepared by *NUON*, a major water and energy provider in the Netherlands has the following story line: A man visits several homes with a questionnaire to ask people bluntly whether they ever drink water out of their toilet bowl. People respond, puzzled at this question. In the end the message turns out to be related to water conservation: why flush so much water down the drain which is actually of drinking water quality? However, remember that jokes are subject to local taste. Differences between countries are clear, but there may be differences between regions, age groups, castes or occupational groups.

Commercials using cartoons: *UNDP/ONEP Water Conservation Campaign (Morocco)* created two commercials, designed as cartoons. The commercials focus on pollution and its consequences for human consumption.

Collaborating with new radio station**:** WaterAid Kabarole (Uganda) attempted to involve the newly opened "Voice of Toro" radio station to see whether it is open to the idea of broadcasting hygiene and sanitation messages as part of its programing. The same organization worked with the Ntuuha Drama performers who have had a strong impact on hygiene knowledge and practices in the communities it has visited. WaterAid started work with the performers with a training session for the actors in participatory approaches to hygiene, sanitation and wells operation and maintenance and then a pilot project of several hygiene and sanitation drama performances to ensure that both the messages and the media were appropriate and effective.

Radio soap opera: "*New Home, New Life*" is a radio soap opera designed and produced for broadcasting in Afghanistan. It was first aired in April 1994 and has since been aired weekly by the BBC. The drama series has both entertainment and informative purposes. It covers a wide range of subjects from women's issues, income-generation activities, methods for conflict resolution, awareness of mines, community participation in development to livestock raising and agriculture. Personal and environmental hygiene is also an important issue in the soap opera.

The soap opera was initially chosen as a format because it allows for the repetition of educational messages. The opera is rooted in real-life situations and sounds real and authentic to both rural and urban communities. Characterization of problems, human conflict and dilemmas, and how to overcome them through dialogue, are all part of the soap opera genre. New themes are progressively incorporated into the soap's scenario as listeners respond to the story or as the project's authors (in particular the evaluation team) identify new concerns or relevant topics. New problems and cases for discussion naturally arise as

[3] Schaap, and van Steenbergen. 2001. Ideas for Water Awareness Campaigns. Stockholm, Sweden: The Global Water Partnership

the drama unfolds. The drama is totally Afghan in context and content. It has drawn from the rich history of community action and customs to achieve its high degree of relevance. It has, therefore, played a significant role in reviving old traditions and customs. Oral legends and customs are being written into the drama.

Celebrating ten years of New Home, New Life in 2004, then-UN Secretary General Kofi Annan said that it was "*a perfect illustration of how the media can use drama and entertainment to advance the cause of peace and development*." The soap opera is supported by a more detailed programme “Learning for Life” which is an educational series of programmes, comprising four strands: Village Voice, City Voice, People Talk and Health & Life. The feature format is ideal for communicating technical information in the kind of detail that would not be appropriate within a soap opera. This reinforces the messages and helps listeners put lessons learned into practice. The main goal of Village Voice is to provide Practical information to rural Audiences on issues such as reconstruction and rebuilding homes, agriculture, livestock, clean water and social issues like dowry.

Regular TV-slot: Water Wise (South Africa) has a regular slot every Saturday morning on KTV, children’s television. It is called KTV Roundabout. They also have a wide range of fun materials on a website, including hands-on activities, games, drama, songs, puppet shows, experiments, nature walks, roadshows, exhibitions, birthday parties, and education material.
http://www.waterwise.co.za/site/education/index.html

Co-operating radio stations: Several commercial and noncommercial radio stations in the US have formed the *Great Lakes Radio Consortium.* They aim to improve the quality of reporting on the environment of the Great Lakes. They also provide a regional outlet for local producers to air their material and enhance reporting skills. Through examining the environment in the context of related political, social and economic issues they want to address the media’s tendency to report environmental topics in a brief and superficial manner. The consortium has developed a weekly news service which can be inserted into the news programming of local stations.

2.2.2 Posters and billboards

Good posters can have a very positive impact, but good design is important. Some guidelines from Pakistan (Schaap and Steenbergen, 2001) recommended that it is important to:.

- Use a simple style.
- Clean firm lines, not sketchy broken ones.
- Avoid shading.
- Avoid unnecessary details.
- Make the size fairly large and visible from a distance.
- Speed is important; do not be a perfectionist in drawing human figures.
- Figures should be complete whenever it is possible.
- The layout should be functional.
- Concentrate on elements, remove background element that is not necessary to the message.
- Use familiar, realistic imagery, not abstract symbols.
- Use true to life colors.
- Use multiple perspective rather than vanishing point perspective.
- Maintain continuity in figures, clothes and other features.
- Do not offend religious or cultural beliefs of people.
- Ensure it fulfills the purpose? You are not producing works of art, but artwork for a particular purpose.

Further recommendations from the UK include:

- Use strong visualization: Visualizing the result of behavior change can help encourage the adoption of this behavior change.
- Find a good slogan: “Turn it off. Don’t use water like there's no tomorrow.”

Some good international examples of water-savings posters are given below.

AMWUA Conservation Publicity Program*,* Phoenix (USA) promotes Xeriscape (low water use gardening) with billboards and posters. The same based events and carries pencils, erasers and other gifts for children with messages encouraging water conservation and groundwater protection.

Durable posters: *SAWA (Cambodia)* has provided metal posters to schools, to be placed on latrine doors, with messages on the correct use of the latrines. As schools have a limited budget and there often isn’t even money for chalk, it is necessary to provide schools with an adequate supply of *durable* educational material.

UNDP/PWA’s Water Awareness Campaign (Palestine territories). A color poster with the Arabic slogan “Your water tank is your safe deposit box, your water is dearer than gold” was distributed. Fifteen street billboards were erected in different places.

2.2.3 Newsletters and Books

Water newspaper: *The Green Movement (Lithuania)* publishes a newspaper “Green Lithuania” that popularizes the different aspects of water management: protection of water bodies, waste water treatment, restoration of regulated rivers, establishment of vegetative protection zones near water bodies, water quality in wells, restriction of military training grounds and small hydropower projects.

Save Water Mailer: *Public Utilities Board (Singapore)* sends a "save water" mailer to each household. It incorporates a graph for households to track down their water consumption. The *City of Austin, Water Conservation (USA)* also provides customers with a graph to see how efficiently they use water. It can be compared to the amount on the water bill.

Collection of stories, songs and poems: *Umgeni water (South Africa)* has produced a booklet with a collection of southern African songs, stories and poems. The book also contains some creative ideas for children to use handicrafts related to water. Some tips on using water in a healthy way and bits of general information related to the South African water situation have been included as well.

Comic books: *The Dutch Union of Water Boards* had prepared several comic books.They dealt with, among others, the way that polders are operated and how to limit water contamination.

2.2.4 Other methods

Environment overview report card: *Austin Environmental Directory (Several Organizations Involved) (USA)* has issued a report card with a summary of environmental developments. The evaluation is expressed in percentages of worse or better per issue.

Free public transport *Public Utilities Board (PUB) (Singapore)* provides free public transport tickets with a promotion message on one side. The ticket is wrapped in a small envelope (top picture) which shows the ducks when you open it.PUB also distributed car bumper stickers with the text "use water wisely." image has been reproduced on T-shirts and coffee mugs.

Gifts to children: *Orange County Water District (USA)* has a mascot, "Ginny Groundwater," a lady dressed up as a drop of groundwater. She participates in community based events and carries pencils, erasers and other gifts for children with messages encouraging water conservation and groundwater protection.

Ceramic tiles: *NEWAH, WaterAid (Nepal)* uses stickers and ceramic tiles with hygiene messages, to be placed inside latrine doors, within schools and health posts and in other public places.

Lid covers: In some cities in USA the lids of the stormwater sewage were fitted with the following text "all you dispose in here ends up in the river."

Games: *The Water Education Foundation (California)* published the "No-Know Game." The players in this game race down the "Dirty Old River" and pick up action cards on the way. The action cards relate to do's and don'ts with respect to nonpoint source pollution.

Hand-washing games and lessons *(Uzbekistan)***:** The highlight of the hand-washing campaign was 'Masqaraboz Tozavoy', or Mr. Clean, a clown who came to Secondary School Number Two in Oltiarik District, Ferghana Province . He entertained the children with his pranks but also engaged them in a collective hand-washing activity. Together, they sang and scrubbed their hands to the refrain *'Maaza, maaza, Kandai soza'*, which is Uzbek for '*What fun, what fun, to wash hands clean'*.

Masqaraboz Tozayoy told his fans that they could watch him on television singing the same song, and that they would also find him on posters in their schools. He asked them to take his hygiene messages home to

their families, friends and neighbors. "*I would like you to be hand-washing heroes in your school and at home*," he told them.

Home leak detection kit: *The City of Austin, Water Conservation (USA)* distributes leak detection kits; basically a brochure with a leak detection checklist, some leak detector tablets, and some technical information for repairing leaks. The leak detector tablets are thrown in the flush tank of the toilet, they color the water so you can see whether any water leaks out into the bowl when the toilet is not flushed.

2.2.5 Examples of Water-Saving Awareness

2.2.5.1 GWP 'Ideas for Water Awareness' Campaigns

The Global Water Partnership (GWP) has published a book 'Ideas for Water Awareness Campaigns[4]'. This book attempts to bring together many ideas on public awareness campaigns in the water sector, some of which were highlighted earlier in this chapter, from a variety of organizations working in a diverse range of countries, including some materials on water conservation awareness. Evidence from several campaigns shows that awareness-building can effectively reduce water demand. For example, in Zaragoza, Spain, a large water conservation awareness-campaign made it unnecessary to raise the level of a reservoir, as had been planned earlier.

Besides the traditional means of public involvement through activities such as group discussions there are many other ways to involve the public. This could be through the educational sector, internet, youth involvement, large public events, advocacy, and so on. These techniques are discussed in various chapters of the book, with selected examples highlighted in this chapter. Some examples of activities involving communities and volunteers in a direct and active way related to water-saving are shown in Box 2.1 below.

The book also highlights some of the constraints, such as the dependence on other activities to make awareness effective and avoid concern over 'free-riders'. For example, in Gujarat (India) farmers are not always confident of the benefits, and fear that other farmers will take advantage of the water saved. This can only be tackled by wider programs: community awareness must extend across the entire affected area and combined with effective administrative regulation. Such regulation depends on a system of abstraction permits, based on a good understanding of the resource and consensus on allocation policies both in normal and drought situations. Simply raising awareness amongst farmers is unlikely to be effective on its own.

Awareness-raising is much more easily effective in situations where individual benefits can be achieved, as the examples for hygiene promotion and sanitation indicate in the box below. However, there are also good examples globally of topics and methods which are effective on a larger scale, as in the Saurasthra case below.

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[4] W. Schaap, and F. van Steenbergen. 2001, referred to earlier

Box 2.1 GWP Ideas for Water Awareness Campaigns - Examples of activities involving communities
Asking the "who benefits?" question
Gujarat (India). Several NGOs are involved in water related issues with an emphasis on the construction of lined ponds and/or groundwater recharge schemes. Several of the NGOs involved have included awareness raising activities related to water conservation and groundwater recharge in their programs, especially through personal contacts. One of the constraints is that farmers do not always feel sure about the benefits. They fear that others, who are not taking conservation measures, will capture the benefits and withdraw the unutilized water.
Involving community members in education
In PHAST Programs communities are stimulated to undertake house-to house hygiene education themselves. As a result, for example, in Kenya, communities began to operate independently of the extension agents but they also asked extension agents to come back again to talk about hygiene. They approached public health officers to learn more technical details about latrines, water source protection and housing, and began to view them as "resource people."
Supporting early-adopters
Espacios de Salud (Mexico) suggested in their "lessons learnt" that it may be useful to wait until a few "brave" families have adopted the new toilets advocated by an NGO. These families can be supported with frequent troubleshooting check-ups and they can be volunteers to keep other demonstration sites in perfect condition. It was shown that it is better to have several demonstration sites rather than one.
Ensuring a wider impact
"All the major religions of the world consider water as the precious good that is the essence of creation and the source of cleansing. Religion has brought some of the oldest and time-tested rules on water management— such as the "harim" the Islamic rule on groundwater abstraction. A recent powerful example of the potency of religion on water behavior is the groundwater recharge movement in Saurashtra in Gujarat, India which reversed a seemingly irreversible trend of groundwater depletion. This movement was inspired religiously, with the Swami...encouraging action by his message that a thirsty earth cannot quench. Religion has the capacity to appeal to large numbers of believers—many of whom are otherwise not easily reached..." (Framework for Action, Second World Water Forum, 2000

The book also highlights the value of including water issues in the school curriculum and suggests ways that this might be done. Water related issues can easily be integrated into most regular subjects taught in schools (e.g. history, legislation, geography, chemistry, language and mathematics). Water related topics are great opportunities to integrate practical real-life situations into education programs rather than focusing on abstract topics. These involve children in thinking about the relevant water issues in their city or region. By using a topic like water, students can practice skills such as researching issues, debating, studying the economics of decision-making, and developing marketing material.

2.2.5.2 UNESCAP – awareness of water conservation

The UNESCAP publication (2002)[5] on Public Awareness on Water Conservation and Water Efficiency presents a guide to promote public awareness. This Guide explains the importance of Water Conservation Awareness (WCA) in integrated water resources management before focusing on a framework for promoting WCA to users of piped water supplies. It does not address in detail water conservation in agriculture, which is the largest water-user category, although it states that most of the proposals can be adapted and applied to that sector. The Guide advocates a multi-step framework for preparing an overall strategy and designing WCA promotional activities, implementing the activities and monitoring and evaluating their effectiveness. Countries will need to adapt the proposals to suit their social, economic and cultural circumstances.

[5] Water Conservation: A Guide to Promoting Public Awareness, Water Resources Series No 81, UNESCAP, 2001

The Guide advocates that governments should first develop a broad national strategy for water conservation. This might acknowledge, for example, that sustaining water resources requires a nationwide effort in conservation to achieve a balance between supply and demand. It might also commit to integrated water resource management and to conservation promotion - improving supply-side management to reduce losses and introducing demand-side management to limit wastage.

Eleven steps in a top-down approach are recommended to prepare a detailed strategy for promoting WCA. These steps may be used to prepare the proposed public awareness:

1. Set up a managing committee(or board) to manage the public awareness program and ensure public participation
2. Identify stakeholders
3. Analyze policy issues
4. Review local factors
5. Identify target groups(farmers, institutions, enterprises, general public, school children)
6. Identify partners and sponsors
7. Agree on aims and key messages
8. Identify activities
9. Set communication targets and timetables
10. Set budget and secure funding
11. Set up project teams

This is a sound approach, which is described in greater depth in Appendix 1. Applied rigorously it will ensure that the right key stakeholders will become aware of effective and implementable messages.

2.2.5.3 Texas – Water Development Board (USA)

A good example of awareness-raising for water-saving in an urban context comes from Texas, where the Texas Water Development Board has published ‘developing a Water Conservation Public Awareness Program: A Guide for Utilities’. This guide is meant to help utilities develop and implement an effective outreach program as part of their local efforts by making use of the mass media[6].

The guide gives a step by step approach and practical tips on how to reach a specific audience through news media (including newspapers, radio, television, local cable channels, magazines, and web sites.), direct communications (including Exhibits, Conferences, Workshops, and Presentations, displays, brochures, bill stuffers, posters, newsletters and billboards) and social media (including blogs, podcast, instant messaging and e-mail). Appendix 3 provides the contents of this program.

2.2.5.4 US EPA WaterSense Program (USA)

Another example of easy ways to save water is provided by WaterSense, a partnership program by the U.S. Environmental Protection Agency, seeks to protect the future of the nation's water supply by offering people a simple way to use less water with water-efficient products, new homes, and services.

WaterSense brings together a variety of stakeholders to:

- Promote the value of water efficiency.

[6] http://www.wateriq.org/texas-water/doc/Public_Awareness_UtilityGuide.pdf

- Provide consumers with easy ways to save water, as both a label for products and an information resource to help people use water more efficiently.
- Encourage innovation in manufacturing.
- Decrease water use and reduce strain on water resources and infrastructure.

The program seeks to help consumers make smart water choices that save money and maintain high environmental standards without compromising performance. Products and services that have earned the WaterSense label have been certified to be at least 20 percent more efficient without sacrificing performance.

Upgrading to more efficient WaterSense labeled products can help to save billions of gallons of water every year. Something as simple as twisting on a WaterSense labelled aerator and upgrading to a WaterSense labelled tap could save a household 11,000 gallons (about 40 m^3) over the life of the tap.

The WaterSense program includes a wide range of materials for water awareness. This is mainly in the context of urban water use, but does include some reference to irrigation (particularly for landscaping) with some specific recommendations. These include better design of irrigation layouts and choice of equipment to achieve uniformity of application; more appropriate schedules (taking account of climate, soils etc); better land management to ensure moisture retention; improved maintenance of equipment; and regular auditing of performance[7].

2.2.5.5 Sydney Metropolitan Water Plan

Huge amounts have been invested in a range of water efficiency programs and initiatives targeting each sector, and now using water wisely is becoming normal behavior and old appliances and fixtures have largely been replaced with water efficient models. Sydney has now seen huge benefits from ensuring an informed community.

By 2006 the achievements included:

- Outdoor water conservation:
  - 93% of Sydney Water customers are aware of the ‘Go Slow on the H_2O’ campaign
  - Water conservation website had 348,000 visitors in 2004-05
  - 100 billion liters reduction in use each year under restrictions
- Indoor retrofits:
  - 75% of Sydney Water customers aware of the program
  - 310,000 homes have participated
  - 6.5 billion liters saved each year
  - A$30-$100 in utility bills saved for each participating household
- Every Drop Counts Business
  - over 7.3 billion liters saved each year
  - 304 participating partners

The prolonged duration of water restrictions in recent droughts, and the introduction of Water Wise Rules have generated a potentially permanent reduction in household water use as well as changed behaviours of customers and manufacturers.

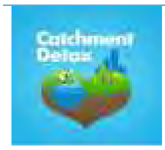
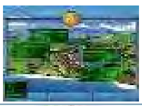
[7] http://www.epa.gov/watersense/commercial/docs/watersense_at_work/#/161/zoomed

Water saving has become second nature to business and residents across greater Sydney. During this time Water for Life has collaboratively delivered community campaigns, innovative on-the-ground water education projects and training and resources for local government. Water for Life is an integral part of the Metropolitan Water Plan and includes four elements:

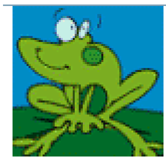
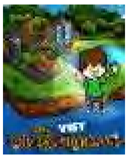
- Communications, including public information and education campaigns using mass media, public relations, events, information materials and the web to reach the wider Sydney community, encouraging them to keep up their water saving efforts and informing them about progress on the range of measures under the Metropolitan Water Plan.
- A capacity building program which provides training, networking opportunities, resources & tools to increase the quality and number of leading practice water education projects across greater Sydney.
- Targeted on-the-ground education projects to engage priority sectors of the community and those that are hard to reach to use water wisely, such as non-English speaking communities, teachers and schools, the property sector and 18-35 year old householders.
- A coordination framework and overarching Water Education Plan for greater Sydney which sets the priorities and maximizes effectiveness and efficiency across the NSW Government, as well as for the local Government, and formal and community education sectors.

The water awareness campaign in Australia extends far beyond urban water use into all aspects of water management and conservation, and uses a wide range of innovative techniques. For example, a range of water-related educational videos and games have been used, as listed from the 'healthwaterways.org' website below[8]

Table 2.1: Insert Table Title here

	ABC Catchment Detox Play Catchment Detox to see if you can successfully manage a river catchment and create a sustainable and thriving economy.
	Reef IQ Educational Program A range of interactive learning experiences for school students and young people (including Reef IQ game) in order to increase their knowledge and appreciation of the value of coral reefs to humans.
	Melbourne Water - Floods Explorer Explore how showers and thunderstorms affect different people in different ways... reflect on individual action... learn who's responsible for what when there's a flood.
	Melbourne Water - WaterWorks Adventure In WaterWorks Adventure you will learn about the planning and the resources needed to have clean water
	Weed Wipeout Interactive game, weed wipe-out and a variety of teaching resources on weeds.
	National Water Week 2009 Posters, songs, fact sheets, Water in Australia (914KB) book with facts and figures on topics such as Australian rivers, groundwater and dams, and two games – Mission H20 and Turdlywinks.

[8] http://www.healthywaterways.org/inner.aspx?pageID=331&mainID=417

	Waterwatch Queensland Waterway monitoring and Saltwatch education material, River Journeys, Story of a River and Creek Rescue game.
	Save Our Marine Life Steer Sandy Seal through the maze of hazards to see just how hard life can be in unprotected water.
	ABC Fun and Games: Water The Water Quiz, Chasm and Rattus down the dunny.
	Mangrove Challenge Learn what the Water Mouse needs to survive, and what threatens its survival.
	Visy Enviromaniacs Create characters, register your school and learn cool stuff about the environment, like how to save energy and recycle.
Australian museum	How the water got to the plains When travelling through the arid regions of Australia, Aboriginal people would move from waterhole to waterhole. The Butchulla people of Fraser Island have a story that tells how the water first got to the plains, and it is told for us here by Olga Miller.

2.2.5.6 Public Awareness of Water Issues in Palestine

This Public Awareness program aimed to contribute to increased consciousness among the general Palestinian public about the complicated and unfair water situation in Palestine, and to respect and understanding for the rules and regulations, including tariffs.

This involves mainly non-professionals, including water users who are not professionally or politically engaged in water issues, as school children, women and farmers. Municipality officers are sometimes involved in or support awareness campaigns and are therefore also a target group and partner. Issues of concern are, for example, to teach school children from an early age how to use water with care. Women normally handle the water consumption in the household, and therefore need to be well aware of water scarcity, restrictions, regulations etc. Farmers need to be well informed about the water situation in their district and how to irrigate their land with respect for environment and water scarcity.

Example of methods:
- Visits to schools to inform about the water situation in Palestine
- Workshops /Training/Education + information packages for teachers and students
- Environment camps for students and Environment and water clubs in schools
- Production and distribution of leaflets, fact sheets, booklets, magazines etc. about the water situation in Palestine to schools
- Schedules, stickers, color books etc. for children to use, with message about the water situation

- Competitions for students, in making drawings, stories etc. about Water issues
- Activities during events as the Palestinian Water Day, Arab Water Day and International Water Day
- Training/education + information packages for Health clinic staff
- Cooperation with NGOs
- Media
- Web

3 Key Messages for Water-savings Programs

3.1 Water Resources

An understanding of resource availability is important for appreciating the need for saving water. It is sometimes surprising that water users do not know the limitations of the resources on which their life or livelihoods depends. Participatory Hydrological Monitoring is a valuable tool for building this awareness, which has been tested effectively for groundwater (see, for example, in India – Euroconsult, 2003[9] and Brazil - Mott MacDonald, 2004[10]) and surface water (for example, in Nepal – Mott MacDonald, 2006[11]). Simple methods for mapping sources, undertaking inventories of wells, approximate measure of flows, monitoring rainfall are valuable and can easily be incorporated in school curricula as well as in public awareness programs.

Community-based monitoring and auditing of water resources and uses can help avoid problems of 'free-riders' as it becomes apparent how much water various users are taking and the impact that this is having on resource availability for others.

3.2 Agriculture

Agriculture is the largest user of water, and thus is the sector where the greatest potential for water-saving was noted in the survey. There many references in international literature to the potential for saving water increasing irrigation efficiency. However, despite this potential, as Perry *et al* (2009)[12] highlight, it is not easy to achieve real savings as many of the losses which can be saved are in fact already recovered and reused. There is, however, some scope, and the messages in any awareness-raising program need to be very carefully targeted and locally appropriate to ensure that they are effective – thus public participation is important. However, implementing water-savings measures requires much more than awareness-raising, and there is a need for greater technical knowledge of the techniques.

Agriculture depends on water, which can be supplied by various combinations of direct rainfall, surface irrigation and groundwater irrigation. Storage whether locally (soil moisture retention) or on a larger scale (reservoirs and aquifers) plays an important in coping with short-term deficits. There is almost always a shortage, in the sense that farmers sometimes want more than is available, but this is different from a drought. Irrigation is needed to reduce the risk of a shortage becoming a drought: the better-designed and managed it is the lower the risk of a drought. Most agriculture depends partly on rainfall; where there is irrigation it can supplement water supplies when rainfall is inadequate, but during a drought both the need for additional water increases and the availability declines. There are many techniques for making agricultural water use more productive – getting more value from less water. Awareness raising programs should highlight these methods and objectives.

[9] Judicious Use of Groundwater through Participatory Hydrological Monitoring – a Manual, APWELL project, Hyderabad, India (Euroconsult, 2003)

[10] Sustainable Use of Groundwater in the Semi-arid Ribbon Valleys of Northeast Brazil (Mott MacDonald, 2004) http://r4d.dfid.gov.uk/PDF/Outputs/Water/R8333-EnvironmentalEducation.pdf

[11] Pilot programme for strengthening WUA: s http://r4d.dfid.gov.uk/PDF/Outputs/Water/R8023-Guidelines.pdf

[12] Perry C, Steduto P, Allen RG, Burt CM (2009) Increasing Productivity in Irrigated Agriculture: Agronomic Constraints and Hydrological Realities, Agricultural Water Management 96 (2009) 1517-1524

3.2.1 Groundwater-irrigated agriculture

Water saving from groundwater irrigation should be relatively easy to achieve because it is managed on a small-scale or even individual basis. However, it does benefit from a coordinated community-wide approach as actions by individuals can affect others and some people may reluctant to reduce their water use whilst others continue to be profligate in their use of water. This is the most resilient form of agriculture against to drought, but there is an urgent need to reduce groundwater use because of overuse and declining groundwater levels. Water-saving in a normal situation is thus critically important, so that there is still a buffer available for increased abstraction is possible to offset the impact of short to medium-term droughts. Abstraction permits should recognize this limitation, and they should be monitored and audited accordingly (see www.wrdmap.com). Farmers need to develop cropping patterns and agricultural techniques that optimize their livelihoods whilst abstracting less than the average annual recharge of the aquifer. This will ensure that it is possible to over-pump in drought years without adversely affecting the long-term water balance.

As MetaMeta[13] (p46) have stated in the context of a program in Shanxi *"addressing water productivity in agriculture is a main task. Efficient and water-saving agriculture make maximum effective use of natural precipitation and irrigation water. Through a range of measures, in (i) engineering, (ii) crop agronomy, (iii) field water management including soil management, one cannot only reduce water losses, but also increase the output and value of unit water consumption. Better water management not only reduces water use but also makes it possible to get a higher yield and a better quality of crop".* The main techniques were summarized as in the table below.

Engineering measures	Agronomic measures	Management techniques
Sprinkler irrigation	Tillage techniques	Soil moisture forecasting
Micro-irrigation	Mulching	Irrigation scheduling
Conveyance pipes	Soil conditioners	Irrigation monitoring
Plastic mulch	Balanced fertilizer and IPM	
Canal lining	Drought resistant varieties	
Improved field irrigation		

The adoption of water-saving measures should not just be a cost to the individual, but should result in increased productivity despite using less water.

3.2.2 Surface irrigation

Surface irrigation has the potential to reduce drought impacts over large areas, particularly when it is backed by storage reservoir or inter-basin transfers. However there is a need to distinguish between long-term measures which will reduce the vulnerability to water shortage in general, such as construction, modernization or improved management of irrigation, and actions which can be taken in response to a drought triggers. However, in both cases the very scale of the systems and the large number of individual users brings management challenges. It is also much more difficult to introduce efficient modern irrigation techniques such as sprinkler and drip irrigation into large-scale surface irrigation than it is into small groundwater systems. Reducing plot size, with better land levelling is a more effective medium-term approach in this situation.

[13] http://metameta.nl/wp-content/uploads/2013/11/Grant_Project_0188-PRC_Final_Report_SF.pdf

Despite these constraints, there are still many options available: for example better scheduling, with more flexibility for diversified crops and responding to soil moisture conditions rather than following a fixed timetable. Agronomic techniques are equally applicable as for groundwater irrigation. Abstraction permit management is different from groundwater as a surface scheme will have a single permit for many thousand users.

The amount allocated amount may be reduced in anticipation of a drought, in response to drought triggers, but it will be for the scheme managers, in consultation with the users (probably through a water users' association) to decide how this total amount is distributed fairly amongst the individual users. The actions that farmers can take in this situation will depend on the magnitude and timing of the reduction. Before the season, they can take decisions on crop areas and types, cultivation techniques, mulches and so on, but if the drought emerges during the season there are fewer options available. Small reductions in water supply can be accommodated with little impact through careful management at system and farm level, but larger reductions may require abandonment of growing crops which will need to be offset by compensation or insurance pay-outs.

3.2.3 Rainfed agriculture

Rainfed agriculture, by definition does not rely on abstraction of water resources, but it is highly vulnerable to drought as it has no alternative, back-up source of water to protect affected crops. It can also affect runoff and hence the availability of water for downstream irrigated or urban areas (Batchelor, 2003[14]) However, in the context of drought it is a very important form of agriculture and there is scope manage it to mitigate the impact of drought. MetaMeta[15] have developed an approach called 3R which stands for Recharge, Retention and Reuse. This is described in a range of papers, publications and other materials on www.bebuffered.com, also with reference to videos on www.thewaterchannel.tv. These approaches have been applied in various ways in many countries, and in the PRC they have been introduced to Shanxi by MetaMeta and others[16] - see Appendix 4 for a summary of the findings.

> *"The main objective of the 3R approach is to retain and reuse water whenever feasible and recharge as much as possible in order to achieve maximum infiltration, minimum surface runoff and to allow for optimal circulation of water within a (sub) catchment. Water harvesting at landscape scale for flood control, water shortage mitigation and disaster prevention is a decentralised way to adapt to changing and unpredictable rainfall patterns, and, at the same time, enhance ecosystem services, such as water supply for multiple use services (MUS), erosion regulation and soil improvement. It is cost effective, as it involves rather simple, low tech and low cost technical solutions. By storing rainwater in small but a variety of numerous 3R solutions within a catchment or landscape, peak runoff is reduced while the time to peak flow is delayed. It ensures that surplus water in the rainy season is not lost in forms of floods. In fact, it helps to turn the flood hazard into an opportunity to improve livelihoods".*

A summary of the range of techniques for water retention is provided as in the following table.

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[14] Batchelor CH, Rama Mohan Rao MS, Manohar Rao, S. Watershed development: A solution to water shortages in semi-arid India or part of the problem? Land Use and Water Resources Research Volume 3, 2003

[15] http://metameta.nl/

[16] http://metameta.nl/wp-content/uploads/2013/11/Grant_Project_0188-PRC_Final_Report_SF.pdf

Technique	Component methods
Moisture conservation	Pre-season ploughing Tillage techniques Mulching Field bunds Composting
Spreading methods	Infiltration ponds and basins, Soil aquifer treatment Controlled flooding, Incidental recharge from irrigation
In-Channel structures	Percolation ponds behind check dams Storage dams, Subsurface dams, Leaky dams and recharge releases
Well, shaft and borehole recharge	Open wells and shafts, Aquifer storage and recovery (ASR) Sometimes supplemented with injection devices
Rainwater and runoff harvesting	Roof top rainwater harvesting Field bunds, trenches, Spate irrigation
Induced bank infiltration	River bank infiltration Inter-dune infiltration

Reuse of water is a key element in managing water in the soil buffer: scarcity is resolved not only by managing demand through reduction in use, but also by keeping water in active circulation. Management of (non-beneficial) evaporation is critical: if water evaporates it ‘leaves’ the system and can no longer circulate within it: there is a fine balance between keeping good soil moisture and avoiding non-beneficial evaporation losses from the soil. Water must also be kept in an area where it can be re-used: water which is recharged to a dry unsaturated buffer is difficult to retrieve, but when the buffer is saturated it can be readily retrieved.

3.3 Industry

Industry is a high value consumer of water and thus it can afford to pay a higher price than agriculture for water savings and efficiency measures. Much of the responsibility for implementing this will depend on industrial leaders who need to understand the issues, methods and reasons for water saving (including recycling and reuse), but members of the public as well as employees can have a significant impact on industrial practices. Pressure from stakeholders can have a positive impact on practices by industry leaders.

These issues include:

- Understanding the full water footprint of an industrial process – thus most of the water required for brewing beer is used for growing the barley to make the beer. Choice of sources for raw materials can have an important impact on water resource availability for others.
- New industries should adopt water-efficient technology from the outset, but established industry to improve water efficient technology, as well as increasing the proportion of recycling and reuse
- Compliance with abstraction and discharge permits, and enforcement of these procedures

- The need to audit water use and benchmark against peers in the same industry: the Xiliang brewery in Wuwei (Gansu) used about 10 liters water to brew 1 liter beer in 2009, but it has started a program to reduce consumption to meet the global industry target of 5 liter water per liter of beer

In the longer term, the benefits of water efficient industry are generally greater than the costs of implementing them. Apart from the direct financial benefits of reduced costs of abstracting water and discharging waste, there are indirect benefits of reduced risk of plant failure at times of shortage or drought, reputational advantages of being known as a water-aware ‘good citizen’, and secondary benefits from introducing modern water-efficient technology.

In addition, some management tools could be employed to achieve water-saving and benefit more than one sectors while tackling part of the financial constraints, for example industry could pay for some water saving measures to be implemented by others and then gain the benefit of the water saving. This has potential but does need to be managed carefully - see Box 3.1

Both employees and the general public should be aware of the water use and potential for savings by industry so that they can have some influence over the key decision-makers who will need to implement the main water-savings measures. However, individual water-saving is also important in the workplace: employees spend up to a third of their day at work, and thus many of their domestic needs such as toilet flushing and hand washing will be partially met at work rather than at home. Measures to encourage economical use of water amongst staff include:

- Make sure staff are fully aware of the importance of water minimization
- Appoint a water monitor to undertake periodic site walk-overs to identify water reduction opportunities
- Train employees how to use water efficiently and establish a recognition and reward program for employees and teams who do an outstanding job
- Where the firm operates several sites encourage the sharing of best practice

Box 3.1 Collaboration of agriculture and industry on water-saving: Experience from Hangjin Irrigation District, Inner Mongolia

In order to address water shortages experienced by downstream industrial users on the Yellow River, the Office for Water Transfers Affairs under the Water Resources Department of Erdos City has initiated a novel water transfer project. Beginning in 2004, the office has overseen a program in which irrigation returns saved through channel lining in Hangjin Irrigation District are transferred to downstream industries, with the costs of lining met directly by industrial beneficiaries. The outcome is a transfer of 78 million m^3 of water to downstream users. Although the transfer program is a new one, its effects on different stakeholders are already becoming apparent. In particular:

- *Impact on industry*. The willingness of industrial enterprises to invest in channel lining indicates that this is a least-cost supply option for them, at least in the short to medium term.
- *Impact on farmers*. Farmers have benefited from reduced irrigation fees as they no longer have to pay for unlined delivery (and therefore leakage) to WUA purchase points. Farmers are also likely to benefit from reduced soil salinity as waterlogging in some areas is a serious problem.
- *Impact on the irrigation agency*. Hangjin Irrigation Management Bureau has seen its financial position undermined by the channel lining program, with losses of around 1 million CNY/year anticipated by project completion. This is because farmers are no longer paying for leakage.
- *Impact on other uses/users*. Some wetlands toward the tail of the irrigation district have dried up, and
- *Impacts on groundwater levels* within and outside the district are uncertain. Questions remain over whether leakage reduction programs in water-stressed basins generate “real” savings

Source: WET (2007)[17]

[17] Water Entitlements and Trading Project (WET Phase 2). Final Report, December 2007. Beijing Ministry of Water Resources

3.4 Urban Use

The messages for urban domestic water saving are the most familiar and the most easy to implement. These are generally well-covered in existing water awareness programs. Some are implemented by the supply companies and others by individuals. Although the emphasis of the public awareness program should be on actions by individuals, water companies will also need to be active as it is not realistic to expect individuals to save water unless the supply companies are also active – and take measures such as leakage control.

All urban water supply demand management measures should be accompanied by a long-term public education program to generate and sustain consumer awareness of the need for sensible water use to achieve national objectives on water conservation. A public education program can use various communication channels, such as leaflets distributed with water bills, WSC and other web sites, TV and radio messages, posters or public notices in newspapers.

Actually reaching the target audience and successfully influencing their behavior is a difficult task when most urban water users are in an environment where they are constantly bombarded with advertising and information. To catch and hold their attention requires a professional approach to communications, including a thorough evaluation of the success, or otherwise, of all dissemination activities.

In the UK, for example, although the Environment Agency stress the *need for people to value and use water more efficiently, t*hey recognize that this is not easy to achieve. Highlighting the connection between water and energy is now regarded as a promising approach – a large part of energy bills in the UK cover the cost of heating water. Thus a combined approach is now being promoted. Communication between a WSC and its customers is central to encouraging water saving. Metering saves water and also makes customers more likely to engage in demand management activity. Therefore directing information on demand management opportunities to metered customers with their billing is particularly effective. Smart metering is particularly useful for improving awareness of water use (and hence costs), and relating this to payments for water. Such meters can provide detailed information about patterns of water use in the household. These can have a direct impact on water use, by stimulating an understanding of how water is used and where it can be saved.

The internet is a powerful tool in awareness-raising because of the ease with which anyone seeking information can move from site to site via directed links. A WSC customer may access the WSC's web site and from there be directed to the national standards organization or to firms selling water efficient appliances or to the water resources agency for drought status reports etc.

Women are the main water users in the home and often have responsibilities for managing household finance: water saving publicity campaigns should focus on this target audience. Messages used in the UK may include

- A humorous poster campaign featuring a well-known television personality to get people to take quicker showers to save water.
- Only use your washing machine when you have a full load, to make the most efficient use of the machine and save money.
- Wash food items under a running tap and collect the water into a basin to be recycled as grey-water.

These same activities are usually promoted more strongly by WSCs during droughts. Experience in some drought-affected areas such as mid-western USA and Australia, has shown people respond well to

appeals to save water provided they are kept well informed of the situation and appreciate the need to conserve water. However, such appeals must be used for limited periods (a few months at most) and water supply companies must be open and honest with their customers.

Education and publicity are two key components of a demand management policy. School children, who are effective at taking the message of the importance of saving water home to their parents, are a key target audience. However, it is also important to explain to adults why it is necessary to save water, how they can contribute to savings and how using water carefully can help reduce their water and wastewater bills. This is effective when combined with increases in tariffs and the imposition of new tariff structures that penalize unduly high consumption.

Education campaigns can cover:
- The importance of not wasting water, including replacing washers on leaking taps, not leaving taps running, not washing-up under running taps, etc.
- Advice on purchasing water saving washing machines
- Advice on plants with a low water consumption for the garden
- The implications of excessive water use for the environment and levels of service that can be provided to all customers.

3.5 The Importance of Public Participation

Public participation has several benefits and should lead to more sustainable water management in all senses: economic, environmental and social. More specifically, it can result in water demand management through several processes, such as:
- Better-informed and more creative decision-making, on the basis of better knowledge of local conditions.
- Greater public acceptance of decisions, fewer delays and more effective implementation since the public has had an opportunity to have its say, even if this does not change the decision.
- Social learning and 'water awareness,' so that the public, government and experts can manage a complex river basin and deal with conflicting views and interests.
- More open and outward-looking government and enhanced democracy.

3.5.1 Water User Associations

Water user associations are an important form of public participation for irrigation management, following the subsidiarity principle. Analogous organizations are commonly adopted for rural domestic water supply and, less often, for urban water supply. These are widely expected to result in water savings.

In surface irrigation, WUAs should improve management, make it more responsive to needs, and reduce water consumption reducing the 'management losses' which can occur when there is weak management which delivers the right amount of water but to the wrong places or at the wrong times.

Groundwater irrigation can be saved by restricting excess abstraction, which can be partly achieved by administrative methods and technology such as IC cards, but it is difficult to enforce this control unless there is some local involvement in management by a WUA which will be involved in tasks such as:
- decisions on entitlements
- management of permits and related tasks
- monitoring water use and groundwater level

3.5.2 Awareness of water resources, permits and other management tools

Construction of a water saving society depends very heavily on building an awareness of water. This requires actions to:

- Stimulate wide public understanding of issues, through information campaigns and involvement in relevant management activities
- Ensure that expectations are realistic
- Ensure wide knowledge of methods for water saving
- Ensure information on water use and water saving is widely and freely available
- Monitor changes in behavior, knowledge and provide feedback so that the water saving society plan can be improvement.

It is only if people understand the availability of water and the constraints to its use that they will appreciate the need to manage it economically. Facilitation participation in monitoring water resources and uses is an important way of encouraging people to use less (APWELL, 2003, *op cit*).

These management tools include water rights, abstraction permits, discharge permits, resource fees, public participation, norms, quotas, etc. There needs to be a carefully designed package of measures, such as was developed from the Zhangye Water-Saving Society – see box 3.2.

BOX 3.2 Defining, Allocating, and Trading Rights in the Heihe Basin

Zhangye City in the water-stressed Heihe (Black River) basin of Gansu Province was chosen by the MWR as the first pilot project to build a water-saving society and establish a system of water rights administration. A sequenced approach to improving water resources management has been implemented, focusing initially on data collection and analysis and the definition and allocation of water rights. Following this, various demand management measures were implemented, including water use controls, quota management, water pricing, and the introduction of water markets.

- Water allocation and quota management. Water rights were defined and clarified with quantitative targets for water consumption determined in the Water Allocation Plan for the Black River. Local governments at district or county levels and their water bureaus allocate water among reservoirs, irrigation, urban water supply, and other water uses.
- Water ticket and trading system for irrigation. A water ticket system was established for the irrigation area of the Liyuan River, with WUAs purchasing group tickets from the water administration on behalf of farmers based on their water use permits.
- Farmers' water user associations (WUAs). WUAs were established at the village level to promote voluntary participation in water management. Water user groups were then formed within the WUAs. Authorized by the government, all or part of the rights in maintaining, managing, and using engineering facilities were granted to water users for self-management.
- Institutional arrangements. Various institutional systems and administrative rules were established to support water rights management, such as Measures on Water Resources Administration, Rules on Water Rights Transaction Administration, Conventions on Water Affairs Consultation, and Measures on Management of Pumping Wells.

Source: Addressing China's Water Scarcity, World Bank, 2009

3.5.3 Environmental education

The problems of water management are long-standing and will continue long into the future. It makes sense, then, to include these issues into the school curricula for those who will have to grapple with these problems in the future – whether as users or as future water managers. Moreover, the understanding gained at school through such an educational program can be quite profound even in the short term, since

children can influence their parents. Such approaches have been tested and found effective in many countries.

For example, in the Brazilian Northeast a recent program (Mott MacDonald, 2006) aimed to improve on the present low levels of community organization and limited experience with communal management of water resources. Although, in the past, there had been good local knowledge of traditional methods of land management, this had faded after introduction of modern irrigation technology and this led to overuse of the limited groundwater resource.

The project was based on the principle that improved rural community understanding of their water and land resources is fundamental to improved livelihoods and long-term community stability (including a reduction in out-migration). The approach was a participative environmental education program, targeted at younger as well as older community members and with a major focus on water and land in three municipalities in Pernambuco region. Although implemented through the existing school systems, it involved local farmers, who worked with the teachers in the dissemination of knowledge to the students. Such participation not only empowered the farmers, but it acknowledged the importance of local knowledge.

3.5.4 From awareness to behavior

Water demand management needs broad public support and understanding, and creating water awareness is increasingly seen as important. Information is a powerful tool for raising awareness and empowerment through engaging the public. People are unlikely to be willing to save water unless they believe that others are facing the same restrictions. Water campaigns can use a number of communication methods such as

- Direct use of conventional media (printed media, TV, radio, brochures, slogans)
- non-conventional media (messages on water bills, games, comic books, etc)
- Organization of large events and specific awareness programs.
- Use of street theatre, local festivals etc
- Use of existing networks (religious networks, social movements, NGO networks, business associations)

It should be remembered, however, that information and awareness is not sufficient – people must have the knowledge, skills and incentives to act on the information. This usually requires specific technical support and training. Awareness without follow-up is unlikely to yield significant benefit.

4 Work Program

This public education and awareness program presents includes suggestions on target groups, educational contents, public education and awareness methods as well as budgeting for education and public awareness activities. Proposed contents outlines are listed in tabular form with recommendations on ways to implement the program by others.

4.1 Objectives

The public awareness program will promote the importance of conserving water and achieving water-savings in both normal and drought years. Building awareness of the need and methods for water saving should not only have a direct impact on water use but it should ensure that good, locally appropriate ideas for water saving are identified. Importantly it should encourage local 'ownership' of the concepts of water saving, and an appreciation of the need to share risks during droughts.

4.2 Target groups

There is a need to improve the awareness of water-saving of the whole society. Society can be divided into groups of people with different water use behavior and different water-saving methods to be targeted. Awareness-raising on water conservation needs a specific approach and content for each group. For the public awareness program, we have identified four target groups: children and students; farmers; urban residents; and business managers and workers of industrial enterprises.

From a long-term perspective, children and students are an important target group because they are not only an essential part of the current society, but also a major part of society in the future. Once their water-saving awareness has been raised, it will influence and affect people around them.

From a practical point of view, the improvement of farmers' awareness of water conservation is very important. China is still a big agricultural country; currently more than 50% of the population lives in rural areas. China has a large agricultural water-saving potential, but whether this potential can truly be fulfilled, depends largely on the extent of farmers' awareness of water conservation methods and benefits. As mentioned in section 1.4, agricultural water-saving is a complicated issue, and methods need to be suited to the location and infrastructure. The impact of water-saving measures need to be carefully considers as although saving water in one location should increase availability for others, agricultural losses often return to rivers or aquifers and are available for reuse by others.

In the context of the rapid development of China's cities, it is necessary to improve water conservation awareness of urban residents. Although the level of urbanization in China is still far below the level of the developed countries, China's urbanization is accelerating fast. Within the next 20 years, more than 60% of the population will live in cities. Over the past decade, the use of urban domestic water has shown a rapidly increasing trend. Guaranteed water supply has always been the highest priority in urban areas and thus urban residents in the past have rarely suffered from water deficit and their awareness of water-saving needs and measures is still weak. However, with increasing water scarcity, growing urbanization and societal expectations, much greater attention to water-saving by urban users will be needed to ensure that they continue to have access to a reliable water supply and gain the benefits from this.

Finally, 23% of the country's total water consumption is industrial water use and there is a huge potential for water-saving. It is important to improve the awareness of water conservation methods and benefits of

managers and workers of industrial enterprises. Unlike agriculture, new industries and new demands for water are emerging all the time; they must use increasingly efficient methods of water use. Existing industries must save water through better processes, with more recycling and reuse.

4.3 Content

Raising public awareness of water conservation can be achieved primarily through publicity and education, covering four components:

1. water-related scientific knowledge, including basic functions of water, water cycle, water pollution, water-saving and soil and water conservation knowledge;
2. drought-related scientific knowledge, including temporary drought, severity, periodicity, contingency, etc.;
3. water-saving knowledge and technology, including agricultural, domestic and industrial water-saving knowledge and technology and tips for water use in daily life, all carefully targeted at locally specific problems and solutions; measures to be taken normally and additional measures for drought
4. water-related policies and regulations.

The water-saving education content in each of these components is different for each of the four target groups. The specific water-saving education contents are outlined in the public awareness program table in Chapter 5. In designing the programs it is important to recognize the risk of 'awareness fatigue'. Whilst repetition of messages can reinforce them, it may also induce boredom, cynicism and frustration unless it is really possible for the recipients to apply them meaningfully. Both the affordability of the recommendations and the incentives to apply them need to be carefully considered. In some cases, the ability to implement some water-savings techniques will depend on actions by others – for example water-saving on surface irrigation is not only a matter of public awareness, but this needs to be linked to changes in irrigation system management by water resources bureaus (and with greater participation by water users).

The distinction between water-saving in general and water-saving to cope with a forecast or on-going drought is critically important. 'Normal' water-savings actions – improved irrigation management, additional water infrastructure, water-efficient industrial processes etc - will increase resilience in the face of a drought, but additional drought-related water-savings are still needed. These include, for example, awareness of the need to reduce irrigation supplies during the season; to reallocate water to high priority uses; to ration urban water use; to make arrangements for providing emergency water supplies; to understanding the need for abstraction permits and how they are managed; to understand the triggers for initiating these actions; and so on.

4.4 Materials

In order to raise public awareness effectively, specific education materials are needed for each water-saving target group, including education materials for primary and secondary schools, advertisements, television programs, brochures, booklets and manuals are required. Propaganda materials for water-saving such as short films, brochures, flyers, manuals etc. are available from previous public awareness programs. However, these are not well-connected with water-saving measures related to drought risk management so they need to be revised. It is proposed that the provincial related department and research institutions compile these materials with the guidance from water-saving education center based on the actual situations of water resource and drought in the province to raise public awareness of water-saving.

4.5 Methods

The main media for public awareness raising are through television, internet, mobile phone applications, emails, letters, newspapers, journals, brochures, education programs and campaigns.

Currently campaigns are mainly being held together with the World Water Day and China Water Week. The water resources department would compile brochures and distribute these in urban areas, mainly on the streets in major cities. Also they would use media including television, newspapers to educate the public about water-saving. In order to enhance these campaigns it is proposed to add activities such as a water-saving knowledge quiz with prizes, a youth water-saving competition and / or workshops on water-saving to promote the public awareness of and attention for water-saving practices. Also, to increase the impact of these activities it is proposed to repeat certain activities throughout the year and to have structured education programs in schools. Water-related issues including water-saving should be integrated into the regular curriculum. Low cost activities such as social media, websites, targeted emails and bill inserts can be used all year round to inform people about water-saving.

Specific forms and methods to enhance public awareness of water conservation for different target groups have been identified:

1. **Children and students:** to raise water-saving and drought risk awareness through education programs at primary and secondary schools. Knowledge about water-saving can be included in regular school textbooks. In addition to formal transfer of knowledge in classrooms, excursions and quizzes can be organized. Posters can be prepared to advertise water-saving and drought risk management and to stimulate discussion on this topic. Children will be encouraged to raise the topics at home to inform their parents and others.
2. **Farmers:** to raise both water-saving and drought risk management awareness through television programs and advertisements, brochures and technical manuals. The most efficient way to reach farmers is through television as many farmers do not have easy access to other media. This should cover the main issues related to drought risk management in an agricultural context – including drought risk and triggers; reallocation of supplies; compensation if supplies are diverted; drought insurance; damage limitation when crops need to be water-stressed. Another method to raise awareness to farmers is the distribution of more detailed water-saving and drought risk manuals and/ or brochures on agriculture water-saving techniques. However, introduction of many of the techniques requires more than a simple awareness-raising program. Some can be supported by more detailed capacity-programs for farmers and water resource bureau staff to achieve significant water-savings and involvement in drought-risk management. The program should focus on techniques and actions that are realistic in the present context
3. **Urban residents:** to raise water-saving awareness through newspapers. Most urban residents have the habit of reading a daily newspaper. Regular columns providing information about water-saving especially knowledge and tips applicable in daily life would raise the public awareness of water-saving. Other methods are television programs and advertisements, social networking media, websites and targeted emails and bill inserts from water companies. The messages need to be sufficiently detailed that interested households can easily see the value and apply them, or at least know how to find out the detailed information necessary.
4. **Business managers and workers:** to raise water-saving awareness through company briefs, journals and online columns. Again this should provide sufficient information for businesses and industries to understand and apply the techniques. The awareness should cover the relevant regulations and also help build the motivation to comply voluntarily with these regulations

The proposed target group specific public awareness methods are listed in detail in the public awareness program table in Chapter 5.

4.6 Program organization

In order to increase the public awareness of water-saving, various methods and communication channels are needed. The materials of the program need to have the proper contents and the program including the materials need approval of the corresponding administrative agency and government.

In general, the government needs to designate related departments and institutions to implement the program.

1. **Students (primary and secondary school):** the water-saving public awareness program for students could be implemented through daily classes, which calls for the government designating education institutions and related research institutions to organize. Research institutions should help develop the programs and materials
2. **Farmers:** water-saving and drought management education for farmers could be developed based on television and brochure advertising, which calls for government designating agriculture administrative department, drought research institutions, and broadcasting institutions to prepare water-saving television program and brochures for farmers. Broadcasting institutions could arrange specific channels and broadcast time for water-saving television program.
3. **Urban residents:** water-saving public awareness program for residents could be implemented through television and newspaper, which calls for government designating broadcasting institutions, press companies, and drought related research institutions to implement. Drought related research institutions could prepare water-saving and drought advertising materials for residents. Broadcasting intuitions and press companies could prepare television program and newspaper column advertising.
4. **Business managers and workers:** the water-saving education for business managers and workers of industrial enterprises could be implemented through journals and internet, which calls for government designating related sectorial organizations and drought related research institutions. Drought related institutions could prepare the technical contents, national and local water-saving regulations, etc. Sectorial organizations could arrange the water-saving advertising contents on internet and related journals.

4.7 Funding sources

The public awareness program on water-saving needs both regulatory and financial support. Water-saving education is a community program. Although the benefits are long lasting from both social and environmental perspectives, this is not an immediately profitable activity. Therefore, the government must issue related policies and develop financial support means to guarantee the implementation of water-saving publicity and education in order to improve the public awareness of water-saving. Funding sources would be from budgets at different levels. Whilst a special project would be valuable for developing the ideas and materials in detail, the long term programs should be relatively low cost and managed from routine budgets.

5 Contents of Public Awareness Program on Water-saving

5.1 Contents of public awareness program on water-saving

The overall contents and methods for the programs for the various stakeholders are listed below, although not all components will be included in each case.

Focus Group		Methods/Media	Contents
Student	Elementary school (5-12 years)	• Class • Quiz • Posters • Excursions	• Basic functions of water • Basic knowledge of water cycle • Basic knowledge of water pollution • Basic knowledge of water uses
	Middle school (12-18 years)		• Basic functions of water • Basic knowledge of water cycle • Basic knowledge of water pollution • Basic knowledge of water uses and efficient ways of managing these uses • Basic knowledge of water and soil conservation • Basic knowledge of drought
Farmers		• TV program • Agriculture water-saving techniques brochures • Technical manual	• Basic knowledge of water-savings in general • Basic knowledge of drought risk management and DMPs • Understanding of drought triggers and actions • Agricultural actions to be taken when a drought is forecast or occurring • Water demand for different crops, including knowledge of water demand during key growth periods and the impact of water stress at different growth stages • Agricultural techniques for water-saving and water conservation • Irrigation techniques for water-saving • Basic knowledge of irrigation system management and irrigation scheduling to maximize water use efficiency
Urban residents		• TV program • Campaign • news column • internet • social media • targeted emails • bill inserts from water companies	• Basic knowledge of water cycle and the limitation of total resources • National and local water resources situation • basic knowledge of water-saving in an urban context • domestic water-saving knowledge and tips • water-saving equipment in kitchen and washroom • basic knowledge of water pollution • water-saving regulations and policies
Managers in company		• Company brief • Journals • Internet • Related documents	• water price information • knowledge of water-saving techniques • wastewater treatment techniques • grey-water reuse techniques • water reuse techniques • related innovation in water-saving • national and international advanced water-saving techniques • national and local water-saving regulations and policies

Appendices

Appendix A. Water Conservation: A Guide to Promoting Public Awareness (UNESCAP, 2006)

A.1 Background

This appendix was adapted from: UNESCAP. Water Conservation: A Guide to Promoting Public Awareness. Water Resources Series No. 81 http://www.unescap.org/enrd/wmrs/publications/wrs/81.htm [Accessed 24 July 2006]

This guidebook was the outcome of a UNESCAP programme on Public Awareness on Water Conservation and Water Efficiency

Public information and education is a critical water conservation priority. A multi- stakeholder and participatory approach involving water users and service providers, governmental agencies and non-governmental organizations needs to be encouraged. Raising awareness of water issues at all levels is deemed critical in the successful implementation of water conservation programs and activities.

It is anticipated that water conservation activities, such as water loss reduction programs and public awareness campaigns for rational water use could result in significant water-savings. The saved water could then be made available to the under privileged people who lack sustainable access to water supply services, while new and expensive projects for developing additional water supply sources could be cancelled or postponed for at least several years.

To sensitize and generate a greater degree of awareness to the strategic importance of water conservation in ESCAP member countries a guidebook on the promotion of public awareness of water conservation is being prepared. It is a collaborative effort involving ESCAP and the experts from several countries of the region under a project funded by the Government of Japan.

The outline of the guidebook was discussed and agreed upon at a seminar held on 23-25 May 2000, while at the other seminar, held on 9-10 November 2000, a draft of the guidebook was discussed and amended by participants. The guidebook is planned to be published in May 2001.

A.2 Introduction of the Guide

Security of freshwater is emerging as a global issue owing to steadily increasing use of limited resources by a growing population, coupled with diminishing availability due to inadequate management, deforestation and increasing pollution. To achieve a secure and sustainable water future, the efficiency of current water supply and usage needs to be improved.

In the Asian and Pacific region, with one or two notable exceptions, it is common to find up to 50 per cent of treated and piped water either lost during distribution or wasted during use. Developing a culture of water conservation that utilizes existing supplies more efficiently would enable expensive new source development projects to be cancelled or at least postponed for several years.

Water conservation refers to action taken to use water efficiently and has two parts: water resources conservation - efficient management, storage, allocation and transfer of raw water; and water supply conservation - distribution with minimal losses and consumption without wastage.

Water conservation awareness (WCA) is an understanding of the need to use water efficiently at all stages from capture to consumption, in order to promote change in attitudes and behavior with regard to water management and use. Except in a few countries that are successfully promoting WCA, overall awareness in the Asian and Pacific region is alarmingly low.

This Guide explains the importance of WCA in integrated water resources management before focusing on a framework for promoting WCA to users of piped water supplies. It does not address in detail water conservation in agriculture, which is the largest water-user category, although most of the proposals can be adapted and applied to that sector. The Guide advocates a multi-step framework for preparing an overall strategy and designing WCA promotional activities, implementing the activities and monitoring and evaluating their effectiveness.

Countries will need to adapt the proposals to suit their social, economic and cultural circumstances.

The Guide is aimed at three broad groups of readers: politicians and policy makers; water planners and managers; and social marketers and educators. The objective is to help these groups to understand the need for water conservation in the potable water supply sector and how it may be approached, so that they can take part in WCA promotion to society as a whole.

A.3 WCA strategy preparation

Governments should first develop a broad national strategy for water conservation. This might acknowledge, for example, that sustaining water resources requires a nationwide effort in conservation to achieve a balance between supply and demand. It might also commit to integrated water resource management (IWRM) and to conservation promotion - improving supply-side management to reduce losses and introducing demand-side management to limit wastage.

Eleven steps in a top-down approach are recommended to prepare a detailed strategy for promoting WCA, as follows.

> **Step 1** - Set up a managing committee (or board) to manage WCA promotion. Persons with skills in social marketing, public relations, education and communications are required in addition to water professionals.
>
> **Step 2** - Identify stakeholders. The effectiveness of promoting WCA will be improved by taking account of the views of those with direct interests in both preparation and implementation of the strategy, and its success or failure.
>
> **Step 3** - Analyze policy issues. Issues regarding political commitment, institutional strengths and weaknesses, reasons for water shortages and the affordability of the true cost of water should be analyzed to assist in developing the WCA strategy.
>
> **Step 4** - Review local factors. The WCA strategy recommended in this Guide should be adapted to local political, socio-economic, cultural, legal, environmental and geographic factors.

Step 5 - Identify target groups. WCA should initially be promoted to main target groups such as politicians, water professionals, community leaders, teachers, the media and non-governmental organizations (NGOs), who will then assist in promoting it to the public.

Step 6 - Identify partners and sponsors. Partners and sponsors may include: government agencies; water supply utilities; NGOs; similar campaign organizers; professional associations; multilateral agencies; and private companies keen to promote a socially-responsible image.

Step 7 - Agree on aims and key messages. The committee should prepare aims and key messages for promoting WCA as a first step in designing specific campaigns, which will usually have two stages: raising awareness, and triggering behavioral change.

Step 8 - Identify WCA promotion activities. Detailed activities can be planned using a logical planning framework - what are the issues to raise with each audience, which messages are important to deliver, and what are the most appropriate ways to deliver them.

Step 9 - Set communication targets and timetables. Five years should be allowed for a WCA promotion program to achieve a good level of awareness, within which several short-term campaigns for behavioral change can be scheduled.

Step 10 - Set budget and secure funding. A budget and financing plan should be prepared on economic cost-benefit grounds and discussed with government, partners and potential sponsors to secure funding. Annual campaigning usually costs a few per cent of a water utility's budget.

Step 11 - Set up project teams. When funding has been committed, the committee should recruit an overall project manager and establish project teams to implement specific WCA activities. The optimum team size is usually four to eight people.

A.4 WCA program implementation

Organizational initiatives. Several initiatives are required to launch implementation of the WCA program. An essential prerequisite is that responsibilities of the three tiers of government - national, provincial and local - be resolved in matters affecting WCA promotion.

- National government should demonstrate commitment to WCA by, for example, publicly launching the campaign and giving high-profile leadership to key events. It should also commit to stronger water law and ensure that its own departments and agencies adopt good housekeeping and use water efficiently.
- To the extent that provincial and local governments have responsibilities for water, they too must be seen to embrace and actively promote conservation.
- Conservation starts at water sources and river basin management authorities must actively support WCA.
- Water supply utilities must reduce and control levels of non-revenue water (NRW) in supply networks. Demand-side conservation is unlikely to be successful if water users perceive their supply utility to be inefficient and wasteful.
- Community initiatives are necessary to develop a successful bottom-up approach for promoting WCA at grass-roots levels. Communities need to define local water issues and establish channels of communication with local leaders.

Community involvement adds value to a WCA promotion program by building local perspectives, values and expectations into decision-making. It also encourages long-term commitment of the community to program ownership and a desire for its success. A proactive member of each community should act as facilitator and host agencies such as NGOs should be identified to provide administrative support.

Education and information programs are central to promoting WCA. This Guide focuses on three categories of people - water providers, water users, and children and students - but the methodology can easily be adapted to promote WCA to agricultural water-users.

1. Water providers are those having responsibility for planning and managing water supply. They should understand that freshwater is a limited resource and important to a country's overall economic development. Education should be based on seminars and workshops organized by the WCA managing committee, with selected staff sent to short- and medium-term technical and professional development courses in countries with a strong conservation culture.

2. Water users in the context of this Guide are the public customers of water supply utilities, whose behavior in using water must be changed to adopt conservation and efficient use. Household customers should be given practical tips for water-saving in the home, details of water-saving devices and information on the real cost of water services, either enclosed with their water bill or sent as separate mailings. Water audits should be provided free of charge to large consumers.

   Industrial customers should be shown the effect of potential cost savings on product price and competitiveness. Examples should be distributed and individual visits made to the larger water-using industries to carry out water audits and advise how water can be saved. Waste minimization programs may also be promoted, showing that more water-efficient plant and better housekeeping can reduce water consumption and wastewater quantities.

   Commercial customers should be shown that business cost savings from reduced water consumption can be significant. Water audits should be carried out and information distributed on water-saving devices. Waste minimization programs can also be effective.

   Institutional customers should be exhorted to set an example in a government-led WCA strategy. Water audits and advice on water-saving devices should be used to support the message given by government under its organizational initiatives.

3. Educating children and students inculcates a future society with a water conservation culture. It also helps to educate present society when children return home and show their families what they have learned. Formal and informal curricula in schools, colleges and universities provide the medium and several considerations are required as follows:

   Curricula development and finding ways to introduce the subject must be addressed jointly by the managing committee and education officials. Experience shows that water awareness and conservation education is best designed to relate to existing subjects being taught and that an interactive and hands-on approach is effective for young children.

   Material development is best managed as a subproject by water professionals and education specialists, assisted by graphic designers. Jigsaws, board games, quizzes, audio tapes, CDs, slides and stories with popular TV or comic-strip heroes can be effective.

Teachers must undergo preparatory, in-service training and be provided with a curriculum guide, background information, student worksheets and other material for class work.

Support from water utilities is valuable. They can provide teacher and student packs, establish student visitor centers and mobile exhibitions, organize educational visits to water facilities and provide guest speakers to schools. They can also offer short-term training courses for teachers and provide holiday working experience for older children.

Special techniques and skills are required in WCA promotion, principally social marketing and communications. Social marketing is adapted from commercial marketing when there is a message to sell, as opposed to a product. It requires a high level of social awareness and depends on finding the right communications tools to suit each marketing context - selling the message successfully to a specific audience. Each marketing context must be analyzed so that the right communication method is used.

Communication tools include: word of mouth; publicity and public relations; education; information dissemination; sales promotion; merchandising with eye- catching packaging and presentation; advertising; exhibitions; and building corporate identity and brand image.

Skill and experience in working with the media are needed, since a badly-projected WCA campaign will probably fail. Public relations departments of governments and water utilities should spend time enlisting media support by educating their executives about water and the need for WCA.

Implementing a WCA program presents water utilities with an opportunity for capacity building. Most utilities will initially need to recruit external social marketing and communication skills but will be able to develop their own capabilities through transfer of know-how.

The role of women in WCA programs can be significant since they are often household water managers and can bring improved potential for family economic and social development. Women's organizations in many Asia-Pacific countries have an extended reach into community life to help in disseminating WCA messages.

Reaching illiterate groups requires techniques that rely more on interpersonal communication and extensive use of graphics in information material. Children who have learned to read can be a good source of WCA information to illiterate parents.

Enforcement of mandatory standards and regulations relating to water conservation is needed to support voluntary conservation. Laws must be marketed to all water users with simple, illustrated information sheets in layman's terms, so that they are fully understood, and complete regulations should be available for public inspection. The public should be left in no doubt that, after a grace period, regulations will be enforced if there is insufficient voluntary conservation.

A.5 Monitoring and evaluating effectiveness

To maintain political and financial support for WCA promotion, it is necessary to monitor and evaluate program inputs and outputs to demonstrate a positive trend. The cost of monitoring and evaluation should be included in the starting budget.

Two interrelated aspects need to be monitored and evaluated: delivery of the program itself; and results achieved. The former is part of program management and will enable logistical adjustments to keep the program on track, while the latter takes more effort but is needed to demonstrate program success. Results depend to a large extent on delivery and this is where the two aspects of monitoring come together.

Monitoring and evaluating results requires establishment of pre-program benchmarks. Quantitative benchmarks - water supply and consumption figures - can usually be established from historic data, while qualitative benchmarks - levels of awareness, attitudes and behavior of water-users - must be assessed by a baseline socio-economic survey. Follow-up surveys should be conducted annually to measure changes in qualitative indicators. Quantifying reductions in water usage may need special techniques, such as monitoring consumption of a sample of metered premises, to eliminate the effects of legitimate increases in consumption and seasonal variations.

Performance indicators should be used to measure supply-side efficiency improvements by water utilities. NRW levels, unit production costs and the number of customer complaints are typical of indicators that can be used.

A.6 Recommendations

1. At a time of increasing stress on water resources, governments and water supply utilities should adopt and promote a water conservation culture to all water providers and water users.
2. Water conservation starts with development of water resources and an integrated approach should be adopted for their efficient and sustainable management.
3. Government and public and private water utilities should lead in promoting WCA.
4. Together with water professionals, people skilled in social marketing, education and communication are required in designing and delivering WCA program activities.
5. Monitoring and evaluation of WCA campaigns should be built into the overall strategy.
6. Supply-side conservation must not be forgotten and the achievements of water service providers should be monitored through evaluation of performance indicators.
7. Guide provides a framework that should be used in preparing, implementing, monitoring and evaluating a WCA promotion program, or in reviewing the content and approach of ongoing programs.

Appendix B. US EPA WaterSense Programs

The WaterSense program includes a wide range of materials for water awareness. This is mainly in the context of urban water use, but does include some reference to irrigation (particularly for landscaping) with some specific recommendations.

B.1 For Educators

http://www.epa.gov/watersense/our_water/learn_more.html

Drops to Watts: Water & Energy Nexus
- Shower Better Learning Resource (PDF) (2 pp, 545K)

Fix a Leak Week Learning Resources
- Teacher's Guide to Using Fix a Leak Week (PDF) (4 pp, 509K)
- Fix a Leak Week: Worksheet #1 (PDF) (4 pp, 891K)
- Fix a Leak Week Family Fact Sheet (PDF) (2 pp, 176K) | En Español (PDF) (2 pp, 650K)
- Fix a Leak Week Activity Sheet (PDF) (2 pp, 1.61MB)

A Day in the Life of a Drop
- Teacher's Guide to Using A Day in the Life of a Drop (PDF) (4 pp, 289K)
- A Day in the Life of a Drop: Worksheet #1 (PDF) (3 pp, 221K)
- A Day in the Life of a Drop: Worksheet #2 (PDF) (6 pp, 1.3MB)
- Water Use Table (PDF) (1 pp, 105K)
- Student and Family Pledge to Filter Out Bad Water Habits (PDF) (1 pp, 160K)

B.2 Media Resources

http://www.epa.gov/watersense/about_us/media_tools.html

The Importance of Water Efficiency

Water is vital to the survival of everything on the planet and is limited in supply. The Earth might seem like it has abundant water, but in fact less than 1 percent is available for human use. While the population and the demand on freshwater resources are increasing, supply remains constant. In fact, a government report (PDF) (1 pg, 132K) found that water managers in 36 states expected to face water shortages by 2013.

Managing water is a growing concern in the United States. Communities across the country are starting to face challenges regarding water supply and water infrastructure.

Get the Facts

These statistics and facts about WaterSense and water efficiency can help you enhance your article.

Saving Water for Future Generations

WaterSense makes it easy to find and select water-efficient products and ensures consumer confidence in those products with a label backed by third party, independent testing and certification. Certifying

organizations help maintain the WaterSense integrity and credibility by verifying and testing products for conformance to WaterSense specifications, efficiency, performance, and label use, as well as by conducting periodic market surveillance.

WaterSense also recognizes water-efficient new homes and some professional service programs that meet WaterSense specifications by incorporating a strong water efficiency component.

For more information about WaterSense, please see the Every Drop Counts fact sheet.

We're for Water

WaterSense launched "We're for Water", a national outreach campaign to encourage Americans to try at least one simple water-saving behavior around the house. Consumers are encouraged to take the I'm for Water Pledge and to "like" the WaterSense Facebook page.

When Do I Use The WaterSense Label or WaterSense Program Logo?

If you are reminding readers to look for the WaterSense label, please review the Media Label Use Guidelines.

If you are talking about the WaterSense program in general, please review the Media Logo Use Guidelines.

B.3 Technical: Specification Development Process

http://www.epa.gov/WaterSense/partners/develop.html

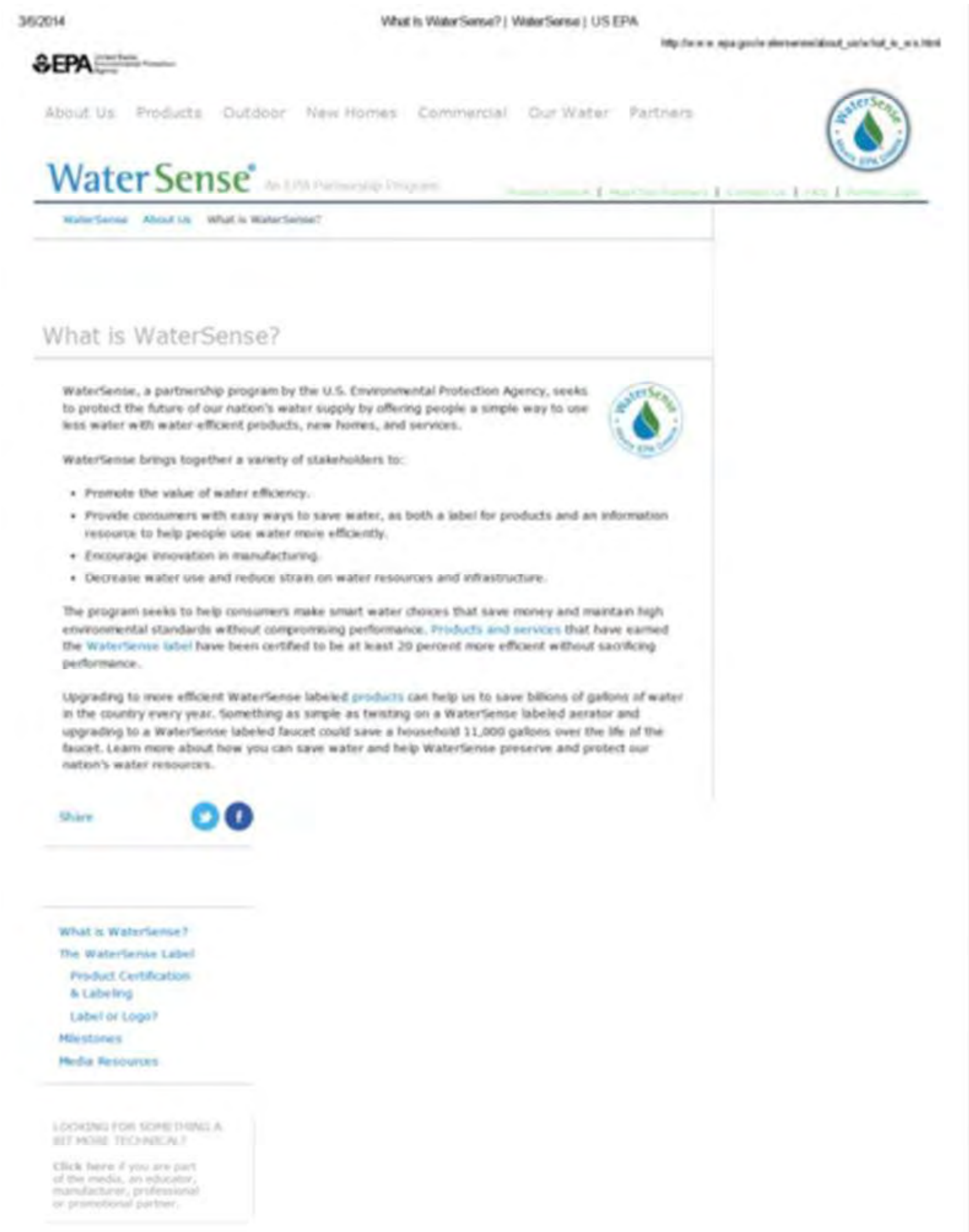
EPA considers both technical and market factors when identifying product categories that are good candidates for the WaterSense product specification and labeling process. These evaluation factors include:
- Potential for significant water-savings on a national level.
- Equal or superior product performance compared to conventional models.
- State of technology development—product categories that rely on a single, proprietary technology will not be eligible for the label.
- Ability to measure and verify water-savings and performance.
- Cost-effectiveness.

In addition, EPA needs data to demonstrate that product categories meet the criteria above. If you are a manufacturer or stakeholder group who would like WaterSense to develop a specification for a particular product category, please review the WaterSense Data Needs page to see what data are needed for specification development.

In developing a specification, EPA undertakes the following steps:
- Conducts technical analysis and market research to evaluate water-savings potential and environmental and economic impacts.
- Announces intention to develop specification for a product to stakeholders, providing for input at the outset of the process.
- Assesses existing test methods and determine the type of testing necessary for label consideration.

- Releases draft product specifications for review and solicit input and comments from stakeholders and the general public. Stakeholder meetings and outreach are an integral part of this process.
- Posts comments on the WaterSense Web site and revise the specification as necessary.
- Announces final product specification.
- Reviews existing specifications periodically to assess whether or not to update them.
- Monitors the market to determine whether or not to develop specifications in new product areas.

For an overview of current and proposed standards and voluntary specifications, please see the National Efficiency Standards and Specifications for Water-Using Appliances and Equipment (PDF) (10 pg, 212K, About PDF) table.



3/6/2014 What is WaterSense? | WaterSense | US EPA

EPA

About Us Products Outdoor New Homes Commercial Our Water Partners

WaterSense

WaterSense About Us What is WaterSense?

What is WaterSense?

WaterSense, a partnership program by the U.S. Environmental Protection Agency, seeks to protect the future of our nation's water supply by offering people a simple way to use less water with water-efficient products, new homes, and services.

WaterSense brings together a variety of stakeholders to:

- Promote the value of water efficiency.
- Provide consumers with easy ways to save water, as both a label for products and an information resource to help people use water more efficiently.
- Encourage innovation in manufacturing.
- Decrease water use and reduce strain on water resources and infrastructure.

The program seeks to help consumers make smart water choices that save money and maintain high environmental standards without compromising performance. Products and services that have earned the WaterSense label have been certified to be at least 20 percent more efficient without sacrificing performance.

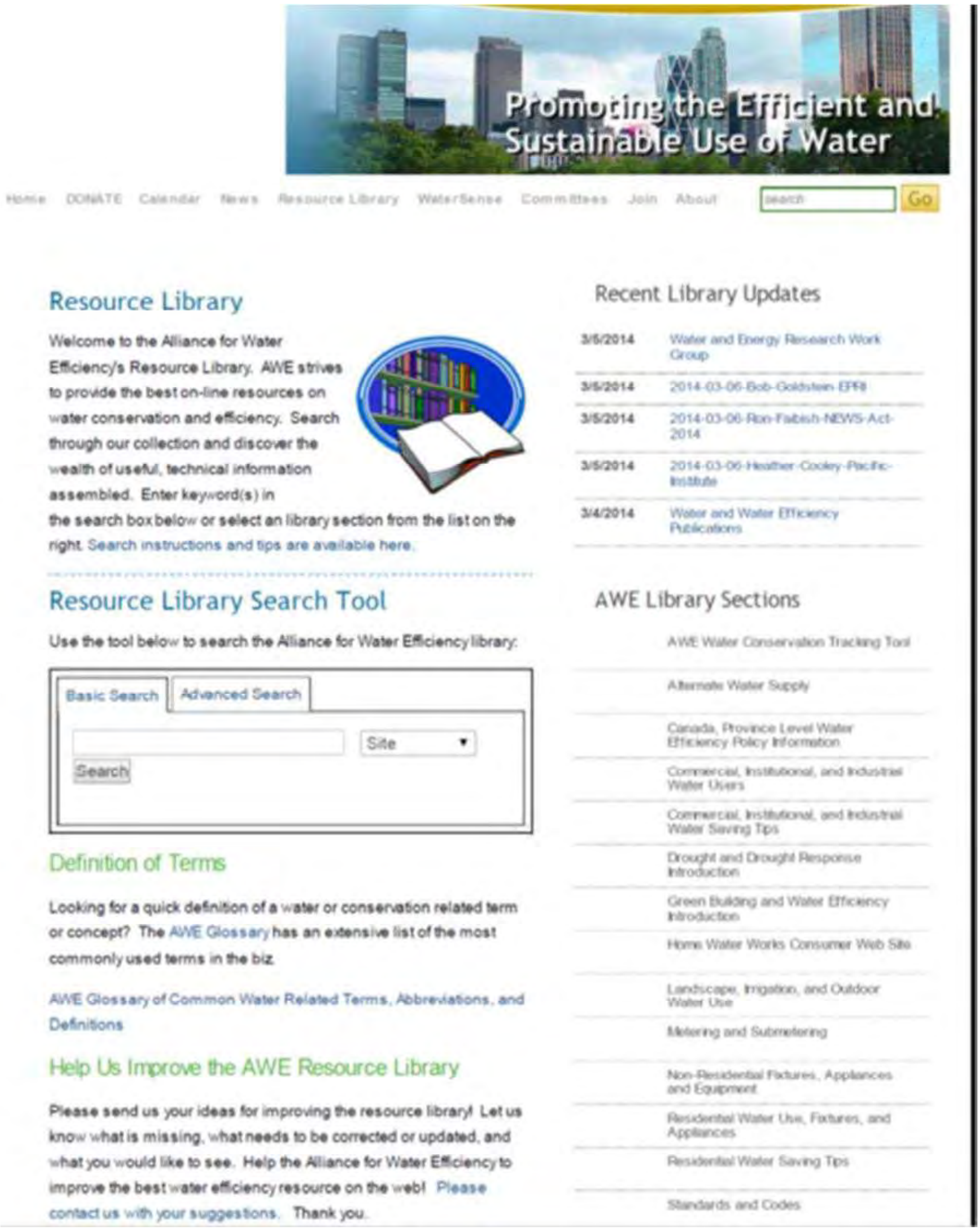
Upgrading to more efficient WaterSense labeled products can help us to save billions of gallons of water in the country every year. Something as simple as twisting on a WaterSense labeled aerator and upgrading to a WaterSense labeled faucet could save a household 11,000 gallons over the life of the faucet. Learn more about how you can save water and help WaterSense preserve and protect our nation's water resources.

Share

What is WaterSense?
The WaterSense Label
Product Certification & Labeling
Label or Logo?
Milestones
Media Resources

LOOKING FOR SOMETHING A BIT MORE TECHNICAL?

Click here if you are part of the media, an educator, manufacturer, professional or promotional partner.


Promoting the Efficient and Sustainable Use of Water
Home DONATE Calendar News Resource Library WaterSense Committees Join About
Go
Resource Library
Welcome to the Alliance for Water Efficiency's Resource Library. AWE strives to provide the best on-line resources on water conservation and efficiency. Search through our collection and discover the wealth of useful, technical information assembled. Enter keyword(s) in the search box below or select an library section from the list on the right. Search instructions and tips are available here.
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Appendix C. Texas Water Conservation Public Awareness Program Guide for Water Utilities

WATER IQ

Developing a Water Conservation Public Awareness Program: A Guide for Utilities

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Developing a Water Conservation Public Awareness Program:
A Guide for Utilities

Appendix D. Potential Application of Water Conservation Techniques in Shanxi, PRC

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Table 2.5 Overview of Different Techniques for Water Buffering

Recharge and retention technique			Special characteristics		
#	Main category		Slope	Rainfall	Locational features
1	A	Contour soil bunds	3-15%	A-SA-SH	Along the ridge area. Not on black cotton soil and preferably on well drained soils. Built staggered along contour lines. On steeper slopes trenches must be preferred. Higher density of bunds on agricultural land than on grazing land. Smaller distance between bunds on steeper slopes, less permeable soils, and higher rainfall areas.
2	A	Grass strips	<8%	SA-SH-H	All soils. Often integrated with bunds especially on slopes up to 15%. The grass strip may provide fodder and host beneficiary insects for integrated pest management. Less suitable for mechanized agriculture.
3	A	Gully plugging	<10%	All	All soils – in rills and gullies. Most effective with re-vegetation and when applied in series along the whole length of the gully. In moist areas live checkdams can be used. In moist areas is important to safely dispose excess water. Construction material according to local availability.
4	A	Terraces	15-55%	All	Deep soils. Various shapes according to use and agroclimate. In wetter areas a lateral gradient is needed to dispose excess runoff. In dry areas the spacing can be augmented to collect extra water for cultivation on the bench. In the first years after construction grazing should be supervised and/or avoided to avoid breakage.
5	A	Stone bunds	<35%	A-SA	All soils where stones are available. It helps the farmer in getting rid of stones from the field. More stable than soil bunds. It needs less space than soil bunds and terraces. Discourage free grazing or provide passageways for animals movement.

6	A	Trapezoidal bunds	0-2%	A-SA	On gentles slopes for crops and fodder production. Should be avoided on steeper slopes that would require massive earthwork. It requires a catchment area to concentrate and divert runoff to the structure. Avoid too extensive catchment or provide the bund with cut-off drains.
7	A	Tied ridges	1-5%	A-SA-SH	All soils. In semi humid areas preferably on well drained soils. Preferred with row crops such as Corn and Sorghum. Row and ties spacing depends on rainfall pattern, slope and soil texture. Also practiced under spate irrigation before the arrival of the rains.
8	A	Demi lunes	<5%	A-SA	Not on cracking clay. Often used on Sandy and sandy loamy soil with thin crust that inhibits infiltration. In staggered lines for more efficient rain harvesting. Mostly for crop production in arid areas (Kolla), but also used for grazing land improvement. On slopes steeper than 5% small stone-faced demi-lunes are used to grow individual trees.
9	A	Tal ya trays	Gentle	A-SA	Arid and semi-arid agro-climate. Used to grow trees or high value annual cash crops. Often combined with drip irrigation and brackish water irrigation.
10	A	Swales	<15%	SH-H	Where excess runoff must be disposed safely. On deep and permeable soils.
11	A	Compos-ting	-	All	On any soil to increase organic matter content and decrease fertilizers use. It traps water in the soil making any associated water buffering technique more efficient. In areas were organic material is available (crop and kitchen residues, manure, etc). Compost production needs a source of water to maintain the compost heap humid and active. Preferably close to household for easy management and close to kitchen garden for easy and fast use of the compost. Its use is especially important were soils have serious physical problems such as compaction and lack of structure.
12	A	Bio-char	-	All	All soils – especially on poor soils to improve microbiological life and organic matter content. Where left-over from kitchen stoves and/or charcoal making are available.

13	A	Organic mulching	-	SA-M	All soils – in too arid areas it attracts termites and in moist areas might host pests. A copious amount of biomass is needed. Often applied localized around high value crops such as banana and coffee.
14	A	Plastic mulching	-	A-SA-M	All soils – and mostly used for high value cash crops. Colour of the plastic material changes according to the local agro-climate.
15	A	Making use of inverte-brates	-	-	Specific agro-ecology can particular improve poor sandy soils. In moist areas practice that favour the presence of earthworms are suggested. In Dry areas sawbugs favour infiltration and recharge of the aquifer. Vermiculture is a way to produce high quality compost in a short time.
16	A	Planting pits	2-8%	A-SA	On gentle slopes were surface runoff is evenly spread due to topography or thanks to stone lines. Common in sandy, sandy loamy soils that tend to develop a superficial crust. For trees and crops such as sorghum and maize.
17	B	Contour trenches	<30%	All	On pervious soils – really effective runoff control especially when in staggered lines. The steeper the slope the closer the lines need to be.
18	B	Tube recharge	<10%	All	Where shallow groundwater is at reach and natural infiltration in the soil is slow. Preferably in natural depression close to a well that runs dry for part of the year. All soils - >5-10 m from abstraction point
19	B	Subsurface dams	<5%	A-SA	Dry river bed (<30 mtr width) with underlying impermeable bedrock and a considerable amount of sand able to hold water. Often preferred to sand dams when the banks of the river are far apart, and or unstable, and/or low. Location to be chosen according to community needs and were less earthwork is needed for maximum amount of storage
20	B	Sand dams	<5%	A-SA	Dry river bed (<30 m width) with impermeable bedrock, high and stable river banks. Stones and sand need to be in the immediate proximity of the sand dam location in order to keep costs acceptable. Location to be chosen according to community needs and were less earthwork is needed for maximum amount of storage

21	B	Infiltration ponds	-	All	Pervious soil/sub-soil, where enough runoff can be collected using local slopes and depressions. Can be used at the foothill to collect and infiltrate excess runoff from the upper slopes.
22	C	Harvesting water from roads	-	-	In Proximity to asphalt and/or dirt roads. The runoff can be collected from culverts or by diverting the flow fro m side drains. The water can be stored in simple ponds built on clay soils, or used on adjacent fields.
23	C	Small hill-side storages	-	-	Built in small valleys and depressions on the hillsides where enough runoff can be collected from the upper catchment area. On impermeable clay otherwise lining is required
24	C	Water harvesting ponds	-	A-SA-SH	Impermeable clay otherwise lining is required. In a position where enough water can be collected from slopes, roads and channels.
25	C	Harvesting water from rock outcrops	-	-	A rocky and sloping surface such as rock outcrops or rocky hillsides. The shape of the rock formation must allow the water to flow to one side where storage must be put in place. Gutters can be used to maximize water collection.
26	C	Harvesting water from roofs	-	-	Topography independent. Suitable on any kind of roof that have a smooth lining. Most common on institutional building, schools and health centers
27	C	Spate irrigation	-	A-SA	Water is diverted from seasonal stream floods over large areas for agricultural and other productive uses. The intake from the river must be on the flatter portion of the river to avoid rushing water damages.
28	C	Cisterns	-	-	All soils – above or underground.

29		Controlled sand and gravel mining	-	-	Where policies and local bylaws allow formal/informal agreement for the limitation/ban of sand harvesting. Sustainable sand mining in specifically designed areas.
30		Protection of springs and recharge zones	-	All	The recharging area upstream of the spring eye is protected with fences and/agreement to impede polluting activities and constrain access.
31		Protection of footpaths	-	-	Especially on erosion prone soils and on sloping paths used by livestock for daily movements.
32		River bank plantation	-	-	On weak banks and/or where sediments/nutrients pollution of the water bodies is a threat.
33		Protecting wetlands	-	-	Seasonal or permanently flooded wetlands that are threatened by encroaching human activities.
34		Intensive controlled grazing	-	-	Crusted clay - all soils. Possible where there are extensive grazing areas in dry savannah environment.
35		Farm forestry and wind-breaks	-	-	All soils – around homesteads and on farm boundaries. Trees can also coexist with annual crops
36		Conserva-tion agriculture	-	-	On farmland. Particularly important on erosion prone soils and to favor an optimal use of water.

Drought Risk Management Guidelines

TA8185: Pilot Implementation of the Drought Management Strategy

June 2014

Asian Development Bank

ADB

Mott MacDonald

Drought Risk Management Guidelines

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Asian Development Bank

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Boxes

Abbreviations

ADB	Asian Development Bank
BP	Basin Plan
DID	Drought Information Dissemination Team
DMI	Drought Management Implementing and Drought Damage Assessment Team
DMP	Drought Management Plan
DRA	Drought Risk Assessment Team
DRM	Drought Risk Management
DRR	Drought Relief Regulation (2009)
DST	Drought Specialist Team
DWR	Department of Water Resources, Province Level
EA	Executing Agency
FCDRH	Flood Control and Drought Relief Headquarters (various levels)
IA	Implementing Agency
IWRM	Integrated Water Resources Management
O&M	Operation and Maintenance
M&E	Monitoring and Evaluation
MoA	Memorandum of Agreement
MoU	Memorandum of Understanding
MWR	Ministry of Water Resources
NCC	National Climate Center, PRC
POM	Program of Measures (Spain)
PRC	People's Republic of China
RRP	Report and Recommendations for the President
SFCDRH	State Flood Control and Drought Relief Headquarters
SPI	Standardized Precipitation Index
TA	Technical Assistance
TAO	TA Management Office
WAB	Water Affairs Bureau (local government MWR offices)
WB	World Bank
WMS	Water Management Station
WRDMAP	Water Resources Demand Management Assistance Project

Executive Summary

Background

Drought is a perennial feature of China and there have been many activities over the years to help cope better with drought, especially in relation to relief of drought impacts. Many drought management plans, guidelines, rules, and regulations have been prepared by the PRC national, provincial, and local governments. The major shortcoming of these measures has been that drought-relief actions are generally passive responses to crises caused by droughts after they have occurred, although there is some pre-planning for drought relief (such as preparing emergency supplies, stockpiling of relief materials, setting up drought service groups, etc. There is, however, a recognition in the drought relief agencies that a more risk-based and early warning system is necessary but insufficient action has been taken to put these concepts into practice. Proactive drought risk management is a critical component of moving the PRC towards integrated water resources management (IWRM).

The PRC has also been primarily focused on supply-side water infrastructure development (including supply-side emergency water supplies) but, as drought impacts become more severe, the traditional approach of using structural supply-side measures becomes less practical or economically feasible. Structural measures cannot meet all requirements for drought management; other measures such as drought monitoring, forecasting and warning, and water conservation and reallocation remain to be fully explored and implemented. These non-structural measures are not as easy to understand as structural supply-side measures, nor is it easy to appreciate that they may be more cost-effective over structural relief measures. Drought risk management also aims at avoidance of potential impacts rather than providing relief once a drought is underway.

The Technical Assistance Project

The ADB Technical Assistance Project (TA No. 8185-PRC, Pilot Implementation of the Drought Management Strategy) provided support to the Ministry of Water Resources (MWR) and related provincial and local government agencies for managing potential droughts proactively using a risk-based approach. It follows an earlier ADB TA project (TA7261: Strategy for Drought Management) which ended in 2011 that introduced drought risk management concepts and ideas to the MWR.

The project was designed to strengthen the capacity of the FCDRHs in the three pilot provinces, as well as the State FCDRH, to manage drought risk proactively. The technical assistance (TA) was designed to:

1. review historic and current activities for managing drought risk and for water saving at both national and provincial levels;
2. assess the comprehension of relevant staff on integrated water resources management, risk management and corresponding management tools;

3. assess the awareness of and enthusiasm for water saving by water end-users in pilot provinces on application of these techniques;
4. prepare institutional capacity building and public awareness-raising programs on related topics and implement the program in three pilot provinces;
5. establish a data sharing system and a protocol between different agencies for inter-agency cooperation, based on established methodologies for analyzing drought hazards, drought risk mapping and drought forecasting system in three pilot provinces;
6. based on the output and product from TA7261: Strategy for Drought Management, prepare targeted drought management plans specific to each pilot province and generic guidelines for implementing risk management across China, and
7. assist the executing agency in organizing a study tour, training and workshops, and disseminating outputs of this project.

Project findings and outputs

Although there is a willingness to change from a relief to a risk-based approach for drought management, there are many constraints in the short term – including institutional, financial and human capacity-related issues. In order to address these, several outputs have been prepared. Major outputs include:
- Guidelines for drought risk management
- Prototype drought risk management plans at provincial level with actual plans for the three pilot provinces as well as a prototype municipal/county level plan
- Public awareness programs
- Capacity-building programs

These drought risk management guidelines are a key output of the TA program and summarize the findings relevant for the pilot provinces and for broader application in the PRC. These guidelines introduce the approaches, and provide a basis for understanding the context within which the provincial drought management plans have been produced.

The TA project also produced DMPs for the three pilot provinces using the risk-based approaches outlined in these guidelines. The full Liaoning DMP complements the guidelines to illustrate the detailed contents of a risk-based drought management plan. The DMPs themselves provide details of how these principles and approaches can be applied in practice, and it is important for a reader to simultaneously review the actual DMP as the guidelines are reviewed. The Liaoning DMP, in particular, provides a good example of drought risk management for the PRC as there is a relatively good availability of data and local understanding of DRM.

As will be evident from these guidelines, the awareness-raising and capacity building programs are also important for ensuring a wide understanding both in government and in the general public. This will help ensure high-level commitment to the institutional reforms and financial

arrangements needed, and an appreciation of the value of this approach. In addition, the decision-makers and their technical staffs at various levels will need new skills to develop and implement these new approaches, and all stakeholders including the public will have an increased participatory role in the process.

Proposed approach for drought risk management

The approach for drought risk management is set out in more detail in the DMPs, and essentially involves the following steps for provincial level DMPs:

- Establish goals and objectives for the plans;
- Prepare an integrated database for monitoring, using SPI, river flow and reservoir levels, with defined trigger points including data sharing with Meteorology Department;
- Organize a daily reporting/warning system from province to local jurisdictions using provincial indicators, to inform potentially affected municipalities/counties of potential or actual drought conditions;
- Prepare drought risk maps and vulnerability assessments of province to understand where and how drought impacts have occurred and where potential damages may happen;
- Implement standard protocols for pre-drought, drought (Levels IV to I) and post-drought stages including pre-identification of appropriate risk reduction, mitigation and water reallocation methods to be employed for each stage;
- Normal stage
  - Optimize water allocation and improve infrastructure
  - Monitoring and reporting on drought indices
  - Preparedness (risk reduction, mitigation and water reallocation methods developed for Pre-drought and all drought stages)
  - Education
- Pre-drought
  - Triggers
  - Preparation and application of risk reduction, mitigation and water reallocation methods;
  - Restrictions/ reallocation
- Drought
  - Triggers
  - Preparation and application of risk reduction, mitigation and water reallocation methods;
  - Essentially in accordance with current guidelines relative to drought relief requirements
- Post-drought Assessment and recovery

Current approaches assume that drought is managed at provincial level, but IWRM principles require that detailed decisions are taken at local levels (municipal and county), and in accordance with sectorial DMPs. The approach used for municipal and county level DMPs follows essentially the same steps except that local monitoring and indices are substituted for the provincial integrated drought database. In the future, the provincial and local monitoring may be

accessible at all levels but this is not currently available. In addition, the local level DMPs should be orchestrating the production and integration of the sectorial DMPs of urban water companies, agriculture and industrial sectors.

Recommendations for Implementing Drought Risk Management in PRC

Although the concept and importance of drought risk management is understood to some degree at the national level in China, it has not been fully implemented because of constraints embedded in current institutional structures and operational mechanisms, as well as human and financial resources. A greater appreciation of the concept of drought risk management at National and Provincial levels is necessary, combined with resolution of the critical constraints to implementation. Drought risk management is an essential component of the PRC move toward Integrated Water Resources Management (IWRM) and it requires a complete re-assessment of the current reactive drought relief protocols and operations.

Implementation of drought risk management should be promoted from the National and Provincial level, down to municipality and county levels. Drought risk management work involves many sectors and departments and calls for cooperation and coordination and should not solely rely on drought management departments. Currently, there is a level of collaboration and cooperation during actual drought emergencies but less during Normal day to day operations. Therefore, the administration must truly accept the concept of drought risk management and re-evaluate current institutional structures.

Drought risk management implies a managed sharing of risk and involvement in risk management activities at various levels by water use sectors, other stakeholders and the general public. Unlike drought relief which is a top-down state government activity, drought risk management involves everyone in the assessment of the problem and the implementation of potential solutions.

Based on the work conducted on the TA project, the team has prepared a list of issues that must be addressed for the drought risk management approach to be fully implemented in the PRC. It is recognized that some of these issues may take longer than others, and all are well beyond the scope of this TA project. The guidelines contain a discussion of these issues which are categorized below:

- <u>Institutional and regulatory arrangements</u>
  - Institutional structure and operational mechanisms – determining appropriate roles for the FCDRHs and the MWR in moving from drought relief to drought risk management, at all stages of the drought cycle (including normal operations).

- New policies and regulatory needs for drought risk management to cover the expanded scope of drought risk management; there should be consideration of a Drought Management Law.
- Improved data sharing and collaboration on drought - proactive drought risk management including drought monitoring and prediction, early action risk reduction and mitigation measures which all imply a much more aggressive and regular program of data sharing, prior to actual emergency situations.
- Enabling environment for drought service groups (DSGs) which have been the emergency drought relief teams established by local water resources management departments to provide equipment maintenance and technical guidance, etc. for local people in the area affected by drought. It may be important to re-structure DSGs and keep them involved as the PRC moves from drought relief to integrated drought risk management. The types of activities conducted by DSGs could easily become drought risk reduction and mitigation as well as relief in many cases

- <u>Technical aspects of drought risk management</u>
  - Improved technical methods for drought management planning - The production of drought risk maps and vulnerability assessments should be undertaken in all locations using readily available data, and expanded with more scientific systems (such as IWHR Liaoning research protocols) as time allows. A more long-term suggestion is to make more use of remote sensing and GIS methods.
  - Use of drought insurance - PRC's mode of temporary emergency support during natural disasters has for many years provided some compensation for disaster losses but it has not been sufficient. There is an urgent need to develop a drought disaster insurance system to share the risk of disaster loss between the insured, the insurance company and the government.
  - There need to be arrangements for reallocation of water to higher value uses, with compensation, when droughts are forecast or emerging. Applying such a water allocation system during droughts implies a high degree of technical and management competency in the issuance and management of water abstraction permits, which will need significant strengthening.
- <u>Human and Financial Resources</u>
  - Current budgets and funding streams for drought work in the PRC are tied to drought relief work during emergencies, with little funding for drought prediction and risk reduction activities prior to actual declaration of a drought – additional funds are needed for disaster risk management, although in the long-term this should be a more cost-effective approach than drought relief.
  - Additional capacity building and training of FCDRH and water management staff in the tools and methods of drought risk management in order to develop and manage

comprehensive drought management plans at provincial, municipal and county levels, as well as orchestrate integrated management of sectorial DMPs.

- <u>Public awareness and involvement</u> <u>in drought risk management</u>
  - The drought risk management approach involves all levels of society in the development and implementation of the DMPs and related risk reduction and mitigation measures. As such, awareness of drought issues is critical in all stakeholders and the general public.

1 Drought Risk Management Approach

1.1 Past and Ongoing Provincial Drought Relief Activities

Drought management has been centered on drought relief measures at all levels in the PRC with a focus on structural measures and supply side infrastructure. There is pre-planning work related to the development of emergency water supply sources and provision of drought relief measures, but little focus on predicting the onset of drought and taking pre-emptive risk reduction and mitigation measures to reduce the impact of drought as it increases in scope and scale. Table 1-1 provides a chronological history of drought relief planning over the past few years in the PRC:

Table 1.1: Chronological Summary of PRC Drought Management Activities

Year	PRC Drought Relief Activity
2003	Ministry of Water Resources proposed “two transformations on flood control and drought relief“, i.e., shifting from flood control to flood management and changing from single drought relief to comprehensive drought relief. Comprehensive drought relief referred to expanding the scope and content of drought relief according to requirements of social and economic development.
2003	FCDRH at all levels started to promote the drought relief planning system.
2005	General Office of the State Council published “The State Flood Control and drought contingency plans” in 2005.
2006	China Meteorological Administration published the national standard “Classification of meteorological drought (GB/T20481-2006)” in 2006.
2008	Ministry Of Water Resources published the first drought related industry Standard of Classification for Drought Severity, which has been enacted [SL24-2008]
2008	Comprehensive "national drought planning" work was carried out throughout the country for the first time since the establishment of New China
2009	Drought Relief Regulations (DRR) at the national level were released in 2009, supported by Drought Classification Rules in 2009.
2011	"National drought planning" in effect by formal approval of the state council of the PRC. Drought planning in various provinces was planned for the province related drought demands, focused on drought engineering and non-engineering measures, and specifically included four aspects: ▪ The drought emergency water project construction plan, ▪ Drought monitoring and early warning system construction planning, ▪ Drought dispatching system planning, ▪ Drought mitigation management system planning.
2013	The industry standard “Compilation Guidelines for Drought Response Plan” , which provide a comprehensive planning tool for managing droughts once they are underway, was enacted and put into effect ((SL 590-2013)).
2014	National drought planning entered the implementation stage.
2014	The industry Standard of Classification for Drought Disaster is enacted and put into effect.(SL663-2014)

The TA project’s three pilot provinces (Liaoning, Gansu and Sichuan) rely on both engineering and non-engineering facilities in their long-term comprehensive drought relief plans, with a total budget of the three pilot provinces at 7.935 billion Yuan, 18.899 billion Yuan and 182.04 billion Yuan, and the planning and construction completion time is by 2020. Most of the investment relates to supply side drought planning as

well as structural drought relief activities. There is significant work done on these supply side measures during Normal operations but there is little activity to pre-plan drought risk reduction and mitigation measures during Normal operations.

In the Pilot provinces, the major drought risk management operations are moving in recent years in the direction to address three aspects:

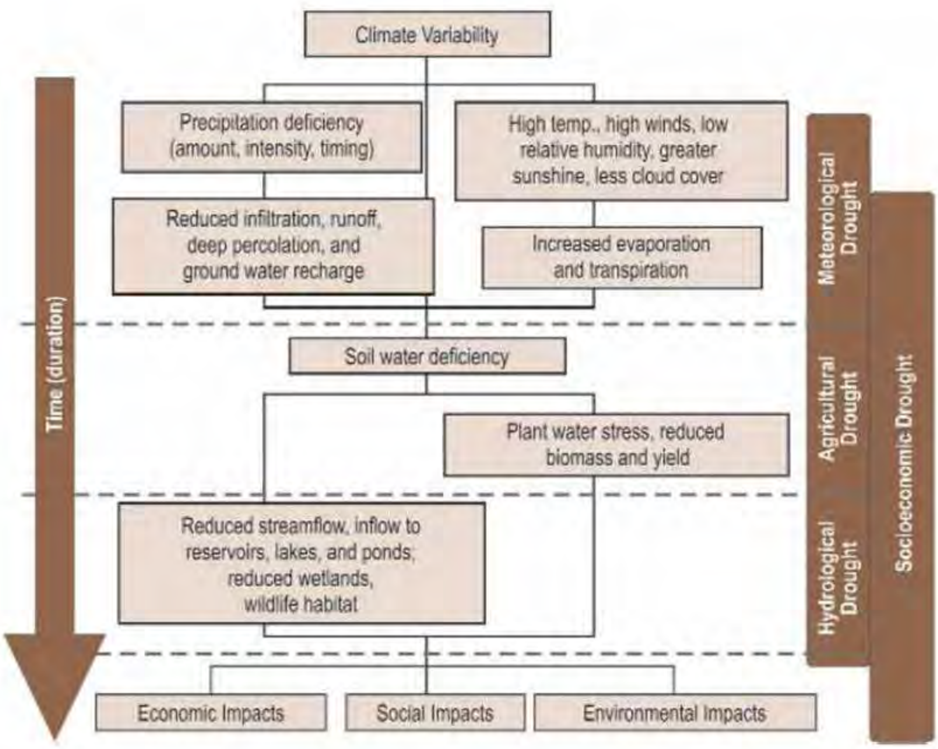
1. Formation of the drought response plan system. Province, municipal and county levels all have their respective response plans to respond to the drought, to decrease the impact before the drought response; [It appears that most of these drought relief plans have yet to fully be updated to comply with the requirements of the 2013 standards.]
2. Comprehensive planning including drought resistant engineering and non-engineering measures (structural and non-structural);
3. Increased emphasis on the drought monitoring and early warning work, and initiate very preliminary drought monitoring and early warning system.

The current drought response coordination between national level and provincial level, provincial and municipal level, municipal and county level lies in the following aspects: (1) command and control, meaning the commanding system during actual drought periods; (2) connections and differences between drought emergency plans and drought management plans on different administrative levels. The FCDRH structures at various levels are tiered but mainly result in reporting on drought response activities, rather than linked responsibilities related to drought forecasting and drought risk reduction and mitigation. There is little activity during Normal or Pre-Drought stages other than the pre-planning of emergency drought water supplies and stockpiling of drought relief materials.

Comprehensive drought risk management requires covering the whole social and economic society, not only focusing on agricultural benefits but also considering social, economic and ecological benefits. This is a new strategy of drought management in China that requires to changing from passive drought relief to proactive drought prevention, management and reduction of potential impacts in order to minimize economic losses and impacts on environment.

1.2 Drought Conceptual framework

Drought should not be viewed as merely a physical phenomenon or natural event. Its impacts on society result from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand people place on water supply. Human beings often exacerbate the impact of drought. Recent droughts in both developing and developed countries and the resulting economic and environmental impacts and personal hardships have underscored the vulnerability of all societies to this “natural” hazard. This chapter reviews some of the theoretical background work related to the drought risk management approach to allow a better understanding of the approaches used in the TA.



Source: National Drought Mitigation Centre, University of Nebraska-Lincoln, USA

Vulnerability analysis provides a framework for identifying the social, economic, and environmental causes of drought impacts. It directs attention to the underlying causes of vulnerability rather than to its result, the negative impacts, which follow triggering events such as drought. For example, the direct impact of a lack of precipitation may be reduced crop yields. The underlying cause of this impact, however, may be that farmers did not use drought-resistant seeds because they did not believe them to be useful, the costs were too high, or because of some commitment to cultural beliefs. Although drought is a natural hazard, society can reduce its vulnerability and therefore lessen the risks associated with drought episodes, as described below.

In addition to drought planning at the state and national level, planning has also become more prevalent at the regional and local levels. These entities use information provided by scientists, and combine it with their own knowledge and experience to produce a drought plan that meets their needs. Preparing for drought before it strikes will make them less vulnerable to it when it does eventually occur.

1.2.1 Components of Drought for Risk Management

A new paradigm for drought management uses risk as the driving factor as follows:

RISK = HAZARD (Natural Event) X EXPOSURE X VULNERABILITY (Social Factors)

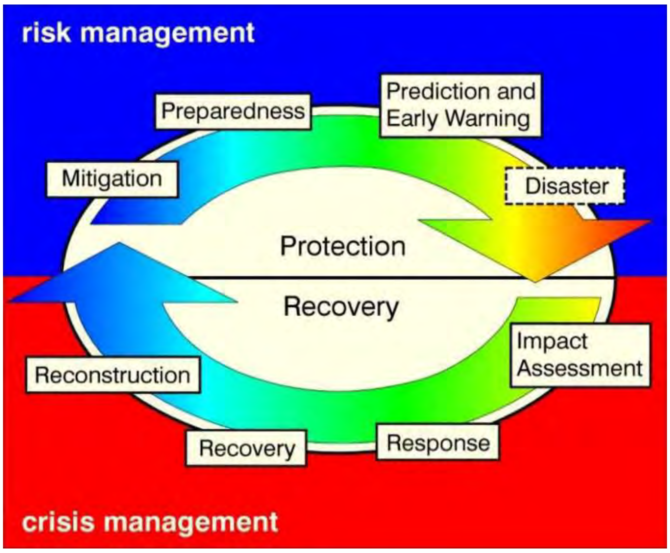
The hazard aspect of the risk could involve several factors including:

- Severity or magnitude
  - Intensity and Duration

- Frequency—probabilities
- Spatial extent
- Trends
  - Historical
  - Future projections
  - Impacts

The Exposure represents the probability of drought occurring and the number of people and resources affected. It is sometimes shown as a factor of the Hazard.

The vulnerability side of the equation involves the complete list of social factors previously outlined and requires the production of drought risk maps and vulnerability assessments. Drought risk is based on a combination of the frequency, severity, and spatial extent of drought (the physical nature of drought) and the degree to which a population or activity is vulnerable to the effects of drought. The degree of a region's vulnerability depends on the environmental and social characteristics of the region and is measured by their ability to anticipate, cope with, resist, and recover from drought. The following figure shows the relationship between risk management and crisis management:



1.2.2 Vulnerability Assessments

Society's vulnerability to drought is affected by (among other things) population growth and shifts, urbanization, demographic characteristics, technology, water use trends, government policy, social behaviour, and environmental awareness. These factors are continually changing, and society's vulnerability to drought may rise or fall in response to these changes. For example, increasing and shifting populations put increasing pressure on water and other natural resources—more people need more water.

Although drought is a natural hazard, society can reduce its vulnerability and therefore lessen the risks associated with drought episodes. The impacts of drought, like those of other natural hazards, can be reduced through mitigation and preparedness (risk management). Planning ahead to mitigate drought gives decision makers the chance to relieve the most suffering at the least expense. Reacting to drought in "crisis mode" decreases self-reliance and increases dependence on government and donors.

People's vulnerability to drought is complex. Drought results in substantial effects in both developing and developed countries, but the characteristics of these effects differ considerably. The ability to cope with drought also varies considerably from country to country and from one region, community, or group to another. Therefore, a vulnerability profile, including analysis of vulnerability factors, is an invaluable tool in assessing local risk. The vulnerability profile is a cornerstone of drought risk reduction planning. "Vulnerability" consists of a variety of social factors such as:

- Population growth
- Population shifts
- Urbanization
- Technology
- Land use practices
- Environmental degradation
- Water use trends
- Government policies
- Environment awareness

The pilot province DMPs first employed drought risk analysis which is the study of potential effects on the drought-threatened areas based on likely drought probabilities and drought intensity. In general, when the intensity of meteorological droughts is greater, the frequency is higher, which means the greater hazard, the risk is also greater.

1.2.3 Drought Indices and Triggers

In principle, drought indices provide a measure of the difference between needed and available water resources and can be part of the "decision support systems" relating to drought. A local water company might use a drought index to trigger water use restrictions and to inform the public about the availability of water supplies. A river basin authority might use an index to inform about and coordinate the use of water throughout a basin. A province might use an index to measure the availability of water resources in entire province. At each of these levels indices can be used for reporting, research or management actions. Different users of indices will have different decision support requirements. In general, water managers need indices to measure climatic and hydrologic trends and fluctuations.

To water managers drought means problems in meeting demand. In that sense, drought means not having sufficient water to meet demands because supplies fall below expected levels. The "expected levels" are socio-economic because expectations can be adjusted. Due to this linkage with socio-economics for a drought index to be useful to management it must incorporate aspects of demand; that is, how adequate are supplies to meet demand?

A key aspect of drought risk management is the setting of appropriate "triggers" for action based on monitoring of indices such as the application of pre-identified risk reduction and mitigation measures, including potential reallocation of available water supplies to higher value uses with compensation.

1.3 Strategic Framework for Drought Risk Management

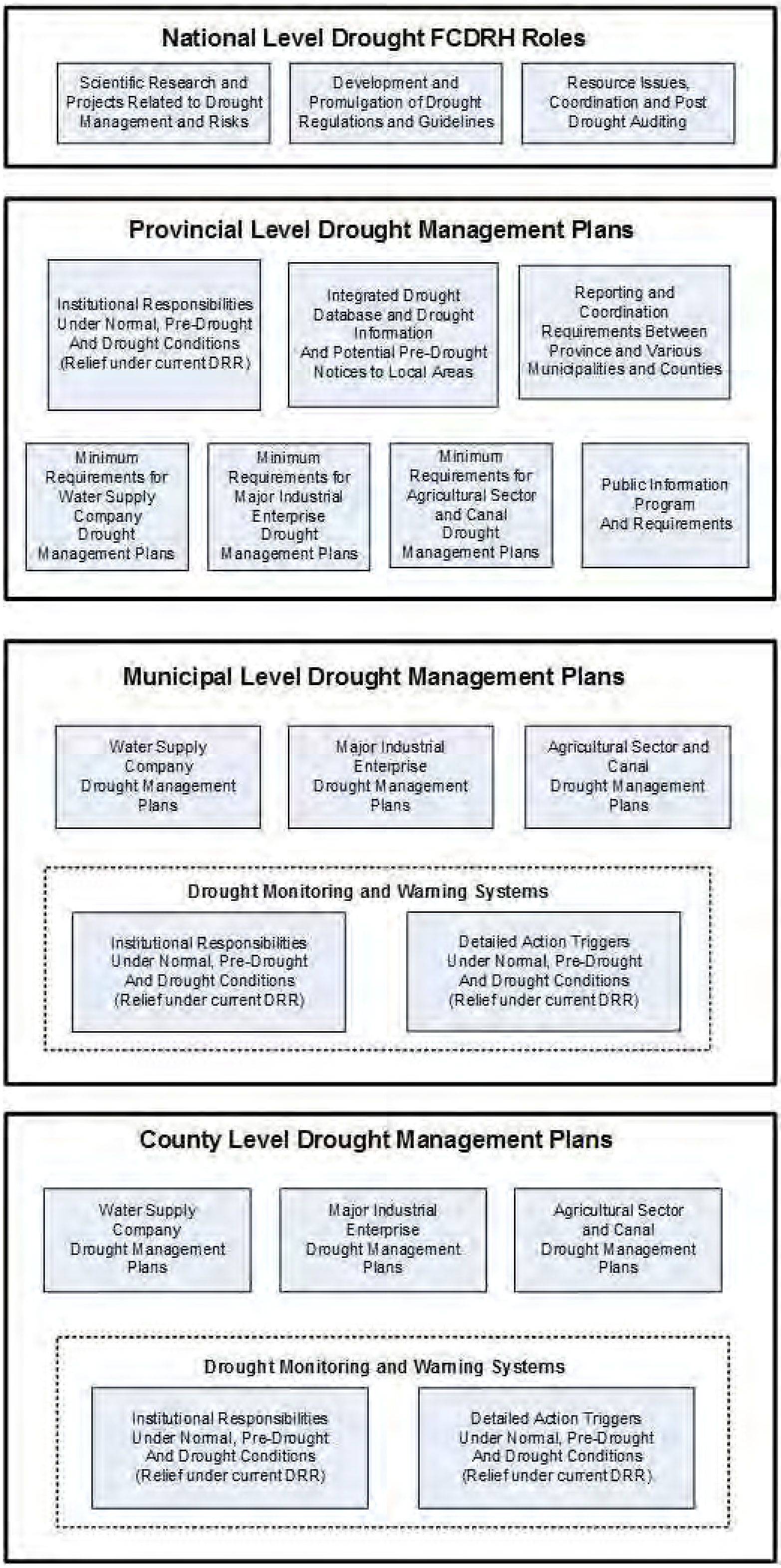
1.3.1 Outline of Proposed Tiered Drought Management Planning Responsibilities

Drought risk management theory (as well as IWRM generally) implies that water management decisions be performed at appropriate levels, usually more local than central. Given this background as well as the organizational structure of national, provincial and local FCDRHs in the PRC, the TA developed a strategic approach to drought risk management in the PRC.

The TA pilot province drought management plans were developed under a presumed future tiering of drought management responsibilities with linked and specific roles and responsibilities at each layer of the process. Given the system proposed by the TA, the provincial plan and local municipal/county plans are part of an overall hierarchy of drought planning. The lowest level would be water companies, industries and agricultural interests. Their drought management activities are coordinated by county level and municipal level drought planning. The county and municipal level drought planning is managed and coordinated by these provincial plans, and the entire process has had guidance and oversight from the national level drought management process. Provincial plans need also to address the management and coordination of large scale droughts affecting multiple municipalities and/or counties.

Figure 1.1 on the following page illustrates this conceptual framework and tiered responsibilities at each level.

Figure 1.1: Suggested Tiered Drought Management Planning Responsibilities



- Develop research, regulations and guidelines or drought risk reduction and management
- Coordinate planning and response levels on major multi-province or widespread concerns
- Determine resource needs with PRC State Council

- Send provincial meteorological information/ indices
- Review and coordinate area monitoring, triggers, and risk reduction and mitigation measures found in DMPs of all municipalities and counties
- Coordinate and report activities to province and public, as well as SFCDRH

- Receive provincial meteorological information/ indices
- Coordinate area monitoring, triggers, and risk reduction and mitigation measures found in detailed DMPs of major water user groups
- Coordinate and report activities to province and public
- Manage risk reduction activities for major water user groups under municipal level control
- Coordinate and oversee work of county level DMPs under their jurisdiction

- Receive provincial meteorological information/ indices
- Coordinate area monitoring, triggers, and risk reduction and mitigation measures found in detailed DMPs of major water user groups
- Coordinate and report activities to province and public
- Manage risk reduction activities for major water user groups under municipal level control

The proposed framework for drought management in the PRC uses a set of standard protocols for drought management plans (DMPs) based on China law and international best practices. The TA DMPs have been developed to provide an effective and systematic means for the pilot provinces to reduce the impacts of water shortages over the short or long term. The DMPs outline a mechanism for coordinated drought monitoring, impact assessment, response to emergency drought problems, and mitigation of long term drought impacts.

There are three major components of the DMPs: mitigation, response and risk assessment. [Refer to Liaoning DMP triggers as example.] Since the PRC practice has been to develop drought response or relief plans at various levels, there will need to be some phasing in of the concept of drought management planning at all times, even during normal conditions. There may be an interim period where drought management and drought relief plans exist simultaneously for the local level, with the idea that the drought management plans should eventually supersede the need for separate drought relief plans.

Local municipal and county level officials will also require time to work with the various sector water management officials (urban water supply, industry, agriculture) on their sectorial DMPs so that they can be connected/coordinated in the municipal/county level DMPs. Based on this constraint, the draft pilot provincial DMPs may be more of command and control DMPs for local areas using the integrated drought database for the interim period, until the municipalities and counties develop adequate local DMPs and improve their technical capacity to manage drought. The provincial FCDRH and MWR should provide additional resources and technical assistance to the local levels in the interim period. As such, the pilot DMPs recommend both a long-term strategy of tiered drought management between the provinces and the local jurisdictions and a short-term strategy of using the new integrated drought database for overall risk based drought management at the provincial level.

The TA has also recommended a layered decision-support early warning framework that uses the combined NCC and MWR meteorological drought forecasting at the provincial level FCDRH (as well as available hydrologic and agricultural monitoring) to establish triggered notices to affected local areas (basins, municipalities, counties). Once the triggered notices of potential drought are received at the lower level FCDRHs, the use of the current hydrologic indices and other hydrologic data is expanded to evaluate the probability of drought based on the provincial warning. Depending on these combined meteorological and hydrological assessments and probability analyses, the local level DMPs are triggered for early action water reductions, water conservation measures, water reallocations and other pre-planned mitigation activities.

Many of the local indicators can be found and used directly from SL424-2008, and complementary triggered risk reduction and mitigation measures are required. Depending on the severity of the potential drought, additional triggers for re-allocation of water abstractions may be considered with the Water Affairs Bureau based on the drought risk assessments and triggers outlined in the local DMPs. Although there appears to be somewhat comprehensive reporting during Normal operations, in the PRC little is actually triggered or done with this information unless the drought damages begin and an actual drought level declaration is declared (slight level IV moving up to I).

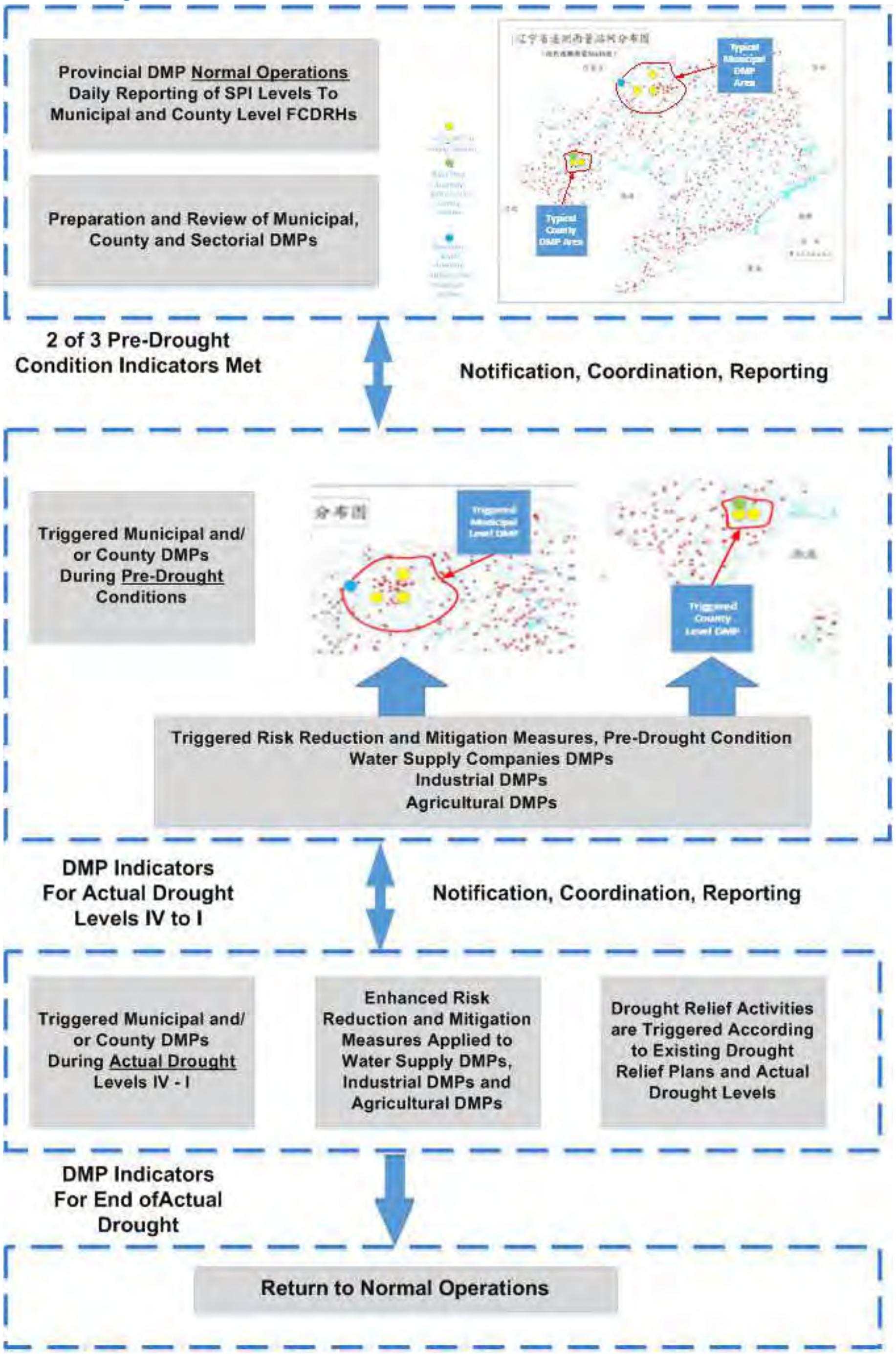
The key aspect of the approach is the pre-planning of appropriate risk reductions, mitigation measures, and potential water reallocations during Normal Operations that are ready to be employed at various Pre-Drought and Drought levels. In this way the potential or actual drought impacts can be greatly reduced as well as the drought response activities required.

Currently, the FCDRHs at various levels are doing early action drought relief planning work but little in the way of monitoring drought indices, predicting droughts and taking early action risk reduction and mitigation measures based on the predictions. Given this background, the TA is not proposing improvements to an existing decision support framework for drought relief but proposing a completely new way of doing business with drought management activities at all stages of the drought cycle (Normal, Pre-Drought, Drought, and Post-Drought).

Municipal levels both report the early warning result to the provincial level, and simultaneously convey the result to their county levels. Meanwhile, the municipal level can take actions according to the forecasting results. Similarly, the county level will make drought early warning and triggering on the basis of the municipal level warnings. Key water use sectors should also be considered. With respect to the triggering action, the municipal and county levels should take appropriate measures according to their drought early warning results, including release of information, compressed water entitlements and allocate goods, and so on. All of the municipal, county and sectorial drought planning should be conducted using standardized methods and protocols developed by the provincial FCDRH, with regular updating and reviews.

Figure 1.2 provides an illustration of how the tiered drought management plans are expected to be operated in the future between the provincial DMP, local municipal and county DMPs and the sectorial DMPs coordinated by local FCDRHs. The provincial DMPs are using the integrated drought database and appropriate indicators to track the emergence of potential droughts during all times. Since the potential droughts are unlikely to affect all parts of the province simultaneously, the provincial DMP warning is sent to the potentially affected municipalities and counties. The municipal and county level DMPs are also working full time on Normal operations and tracking local indicators, but the warning from the province may trigger additional monitoring or other actions. As the local jurisdictions move into actual Pre-Drought or Drought levels, pre-identified risk reduction and mitigation measures are triggered. These also involve the orchestration and coordination of DMPs produced by urban water companies, agriculture and major industrial sectors.

Figure 1.2: Schematic Diagram of Tiered DMPs Under This TA



For the proposed tiered provincial and local drought management plans, objectives that should be considered include the following typical DRM objectives:

- Collect and analyze drought-related information in a timely and systematic manner.
- Establish criteria for declaring drought emergencies and triggering various mitigation and response activities.

- Provide an organizational structure and delivery system that assures information flow between and within levels of government.
- Define the duties and responsibilities of all agencies with respect to drought.
- Maintain a current inventory of government programs used in assessing and responding to drought emergencies.
- Identify drought-prone areas and vulnerable economic sectors, individuals, or environments.
- Identify risk reduction and mitigation actions that can be taken to address vulnerabilities and reduce drought impacts, including potential for reallocation of water to higher value uses with compensation.
- Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
- Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and internet).
- Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation.
- Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state or region.

The TA project produced DMPs for the three pilot provinces using the risk based approaches outlined in these guidelines. As mentioned, the full Liaoning DMP illustrates the detailed contents of a risk-based drought management plan.

1.3.2 Drought Risk Assessment

The pilot province DMPs first employed drought risk analysis which is the study of potential effects on the drought-threatened areas based on likely drought probabilities and drought intensity. In general, when the intensity of meteorological droughts is greater, the frequency is higher, which means the greater hazard, the risk is also greater. The provincial DMPs make hazard analysis from meteorological or hydrological aspects such as:

- Meteorological factors such as precipitation contours.
- Drought frequencies
- Dry season frequency analysis
- Water resources availability, in total and per capita by sector

Following this review, the DMPs explored drought exposure analysis. This section assessed provincial drought history and issues such as:

- Changes in cropping patterns over time.
- Drought impact distribution against various drought years, by sector including agriculture, urban water supply and rural water supply.

Based on this background the drought vulnerability assessment was conducted. Vulnerability analysis is the core content of drought risk analysis, focusing on drought-resist capacity against drought hazard from the natural environment and the socio-economic environment. The level of vulnerability to drought have a "enhance" or "attenuate" effect on the disaster, and can objectively reflect differences in drought response, mitigation and resilience. In general, when the vulnerability is larger, the risk of disaster is higher. This assessment looked at:

- Socioeconomic capacity to resist drought.
- Water Infrastructure capacity to resist drought

- Other capacity to resist drought (such as drought information collection infrastructure, inadequate station network deployment, and low degree of automation)
- Drought preparedness and mitigation systems

Based on the drought hazard analysis, exposure analysis and vulnerability analysis, the provincial DMPs then performed a drought risk assessment. The DRA included factors such as:
- Historical record of droughts
- Drought risk mapping

[Refer to Liaoning DMP example for the full description of the procedures used.]

1.3.3 Drought Prediction and Early Action

To determine the beginning of drought, operational definitions specify the degree of departure from the average of precipitation or some other climatic variable over some time period. This is usually done by comparing the current situation to the historical average, often based on a 30-year period of record. The threshold identified as the beginning of a drought (e.g., 75% of average precipitation over a specified time period) is usually established somewhat arbitrarily, rather than on the basis of its precise relationship to specific impacts. For our TA, operational drought definitions are used for the setting of triggers for early action risk reduction and water conservation in drought management plans at various levels of FCDRHs.

[Refer to Liaoning DMP triggers as example.]

The Ministry of Water Resources issued at the end of 2008 the new Water industry standard "Standard of Classification for Drought Severity SL424-2008", implemented in March 2009. This standard applies to most parts of the country, including assessment methods and grading criteria for agricultural drought, pasture drought, urban drought, difficulty in drinking water caused by drought, and also indicators for regional drought assessment. The proposed planning framework uses Standardized Precipitation Index (SPI) and river and reservoir anomalies for early warning of potential drought to initiate early action risk reduction and water conservation measures, while these SL424-2008 indices are recommended as triggers in drought management plans during various levels of actual drought.

Agricultural drought assessment indicators include relative soil moisture, precipitation anomaly percentage, crop water stress ratio, and number of days without water. Livestock drought assessment indicators include precipitation anomaly percentage and the number of consecutive days without rain. Urban drought assessment indicators are water deficit rates for cities. Drinking water drought assessment indicators are basic drinking water consumption and drought duration. The classifications in SL24-2008 are different for some indicators in accordance with the different divisions of the North and South in China, or in accordance with the different levels of the national, provincial, municipal and county.

The three pilot provinces all have daily drought monitoring and drought indicators currently used in the daily work. The project applied the SL24-2008 indicators which were screened modifications and additions to current practices. However, provincial administration does not currently take advantage of these drought prediction analysis indicators to establish an early warning system, but they are reportedly used in daily work. The TA has recommended an interlinked system of provincial indicators at all stages including Normal, Pre-drought, and Drought (levels IV to I) using these SL24-2008 indicators plus international best practice for short-term drought forecasting, more or less as a decision-directed drought aid means. How

these indicators are used to trigger actions will be discussed in the section on DMPs, as well as the related goals of provincial triggers and warnings to local level DMP triggers and actions. [Refer to Liaoning DMP triggers as example.]

1.4 Capacity Building and Public Awareness

The development of drought risk management (DRM) capacity building and public awareness programs were key outputs of TA8185 and these programs should be implemented immediately. As DRM is expanded beyond the pilot provinces, similar capacity building and public awareness programs will be necessary for all provinces in the PRC.

1.4.1 Capacity Building Programs

There are many institutional and capacity constraints which impede implementation of DRM. A capacity-building programme is needed; this has been planned on the basis of surveys in pilot provinces. It should be stressed that:

- There is weak capacity, especially at low levels. Most training has been related to general aspects of water management, with little detailed attention to droughts and little capacity even to implement current guidelines let alone DRM;
- There are many other institutional and other constraints, but even if these are relieved, the desired impact will not be achieved until capacity is raised;
- Funding for capacity-building is critical, as training is under-resourced. Additional training is needed and yet this will have to be funded from existing budgets;
- Implementation of guidelines and DMPs will not be possible until these constraints are resolved.

Provincial workshops have had a significant impact on high level understanding of some key aspects of drought risk management, and the changes needed to implement it.

The objectives of the capacity development program are to promote understanding and knowledge of the following topics, and to ensure that FCDRH staff are capable of using this knowledge in their daily work:

- Drought policies and regulations; technical standards
- Drought vulnerability and risk assessment
- Drought prediction and early action
- Proposed tiered drought management planning responsibilities
- Co-operation between agencies for managing drought risk

It is anticipated that a rolling program of 10 days training for around 600 people in the three provinces will be required. In order to avoid disruption to daily work, it should be undertaken in two day blocks. This should later be extended to other provinces.

There are several training methods which could be adopted. Online training could be used for some aspects, but most will be covered by formal training courses. Separate training materials could be prepared by water professionals, but in some cases it may be sufficient to add drought-related material into existing courses. The presentations used during this TA should be useful material, and other material can be developed from the guidelines and DMPs. In addition to the formal learning, training programmes provide a good opportunity for people from different counties and municipalities to come together to share experience.

It is anticipated that the full course would be broken down into around 5 or more blocks of 1-2 day training in order to ensure that it can be fitted around other commitments and pressures on staff time. The local staff would assemble in either the capital of the province or major cities to take the training courses. The training methods would be largely lecture-based using centrally prepared material as a starting point. These would be adapted to the local context as there is considerable variation across the provinces. Participatory methods would be used to the extent possible to ensure effective learning outcomes.

1.4.2 Public Awareness Programs

The distinction between water saving in general and water-saving to cope with a forecast or on-going drought is critically important. 'Normal' water-saving actions – improved irrigation management, additional water infrastructure, water-efficient industrial processes etc - will increase resilience in the face of a drought, but additional drought-related water-savings are needed. Awareness of the reasons for this is important, and should be the focus of any public awareness program.

There needs to be public awareness of topics such as: drought risk management; the triggers for initiating drought actions; actions when trigger levels reached (such the need to reallocate water from low to high priority uses; to reduce irrigation supplies during the crop season; to ration urban water use; to make arrangements for providing emergency water supplies; etc.); the need for abstraction permits and how they are managed; and so on.

Water education in schools will have a long term impact through ensuring a wider understanding of water issues in society as a whole. It should also have a short-term impact by influencing parents through their children. Translating this knowledge into action is, however, constrained by other factors - such as lack of specific skills, the affordability of water savings techniques, and the difficulty for individuals to take action because of the large-scale nature of infrastructure and the number of stakeholders. Awareness programs should focus on what is achievable in the short term.

As the concepts of drought risk are either new or subtly different from current practice for drought management, awareness raising and capacity-building amongst government personnel and technical staff at all levels is also important to ensure a common understanding and awareness of the issues and how they can be resolved. This is required not just in the FCDRH, but also in other related departments and levels of local Government (and indeed in national Government). This is addressed in the capacity-building program.

Raising public awareness of water conservation can be achieved primarily through publicity and education, covering four components:

1. water-related scientific knowledge, including basic functions of water, water cycle, water pollution, water saving and soil and water conservation knowledge;
2. drought-related scientific knowledge, including temporary drought, severity, periodicity, contingency, etc.;
3. water-saving knowledge and technology, including agricultural, domestic and industrial water-saving knowledge and technology and tips for water use in daily life, all carefully targeted at locally specific problems and solutions;
4. water-related policies and regulations.

2 Prototype Provincial Drought Management Plans

2.1 Current Provincial Drought Response Regulations and Guidelines

Drought Relief Regulations (DRR) at the national level was released in 2009, supported by Drought Classification Rules issued by Ministry of Water Resources in 2009. The industry standard "Compilation Guidelines for Drought Response Plan (SL 590-2013" was issued by Ministry of Water Resources on 22 January of and came into force on the 22 April 2013. This guidance provides a blueprint for comprehensive planning and managing droughts once they are underway. Since this guidance is relatively new, the existing drought relief plans of the three pilot provinces have not yet been updated to comply with all the new guidelines, nor have pilot province local level plans. This is apparently a common issue in other provinces. The TA team proposes to overlay a drought risk planning approach on the front end of the existing drought risk planning protocols, not propose immediate replacement of these existing systems. As the drought risk management processes mature, some of the triggered actions in these plans will also focus on risk reduction, but this is a long term proposition.

2.2 Drought Risk Management Plans for Pilot Provinces

As outlined in the previous chapter, the TA is not proposing improvements to an existing decision support framework for drought relief but proposing a completely new way of doing business with drought management activities at all stages of the drought cycle (Normal, Pre-Drought, Drought, and Post-Drought). Currently, PRC drought management is focused on actual drought and post-drought stages and management of relief and response activities.

Drought is unlikely to occur equally over an entire province. At the provincial level, the basic indicator monitored during Normal Conditions is the Standardized Precipitation Index (SPI) for early indications of a potential drought. When SPI levels show problems, the additional indicators of runoff anomaly and reservoir level anomaly are evaluated. Depending on the province, when one or more of these additional indicators show potential drought concerns, operations move from Normal to Pre-Drought stage. Local DMPs may use their own suite of indicators as well as manage implementation of the sectorial DMPs (water supply, industry, agriculture). There is no standard protocol for establishing the risk reduction and mitigation measures prescribed at pre-drought and various levels of actual drought, as these are based on experience, vulnerability and risk assessment and other factors. This guidance and the DMPs provide ideas and examples of such measures as appropriate to the sector.

These provincial early warning results will be provided promptly to the municipal and county levels in Pre-Drought conditions moving into actual drought level IV up to level I conditions. The local levels can adjust the indicators or add local indicators based on local monitoring systems and local conditions such as: 1) Adjusting the threshold interval of SPI; 2) Add more soil moisture monitoring stations for relative soil moisture computation; 3) Snowpack measurements, etc. The variability of local conditions and environments dictates that these local indicators should be site-specific.

Using the techniques outlined previously relative to development of the integrated drought database and drought risk assessment, the TA produced draft drought risk management plans for the three pilot provinces. These drought risk management plans were customized to the conditions found in each province, but they contained the same general structure for managing drought during all stages including Normal, Pre-Drought, Drought, and Post-Drought.

In summary, the provincial drought management plans include the following aspects:

- Integrated drought database to allow for continuous monitoring of MWR and NCC data on meteorology using SPI, river flows and reservoir levels.
- Vulnerability assessments in the province coordinated with local jurisdictions.
- Development of standard protocols and minimum requirements for municipal, county and sectorial DMPs prepared in the Province.
- Coordination of local DMP responses especially where drought affects multiple municipal areas or major sectors.
- Provide an organizational structure and delivery system that assures information flow between and within levels FCDRHs.
- Manage drought relief planning and implementation on provincial level according to existing PRC regulations.
- Report on activities upward to National FCDRH and downward to local FCDRHs.

[Refer to Liaoning DMP as example.].

2.2.1 Drought Planning Goals and Objectives

The DMPs produced under the TA were performed by the TA team and reviewed with provincial officials at workshops. They are currently academic in nature and have not had full institutional or stakeholder participation as necessary to fully implement the DRM approach, nor do they have implementation structures fully in place. To move forward with DMPs that fully involve all important stakeholders will involve a process of setting goals for the plans. Some typical goals might include issues such as:

- Improve Water Availability Monitoring and Drought Impact Assessment
- Increase Public Awareness and Education
- Augment Water Supply Through Mechanisms to Transfer Water from Areas of Surplus to Areas of Shortage During a Drought
- Coordinate and Provide Technical Assistance for Province, Local, and Watershed Planning Efforts
- Reduce Water Demand/Encourage Conservation
- Reduce Drought Impacts to China's Economy, People, Assets, and Environment
- Develop Intergovernmental and Interagency Stakeholder Coordination
- Evaluate Potential Impacts from Climate Change

Other potential goals could include specific loss reductions in hazard mitigation such as:

- Reduce the loss of life and personal injuries from natural hazard events
- Reduce damage to province critical, essential, and necessary assets
- Reduce damage to local government assets
- Reduce province and local costs of disaster response and recovery
- Minimize economic losses
- Reduce damage to personal property

The goal setting process can vary from provincial level FCDRHs to local FCDRHs as well as based on regional and local differences.

2.2.2 Drought Management Phase And Trigger Points

Each of the pilot provinces had specific monitoring requirements and trigger points established. Table 2-1 outlines the trigger points established for Liaoning Province as described in the full Liaoning DMP.

Table 2.1: Liaoning Drought Management Phase

Management Phase			Indices And Triggers		Potential Drought Impacts
			Indices	Triggers	No drought
Before Drought		Normal	Standard Precipitation index (SPI)	SPI⩾0	No drought
		Pre-Drought	Standard precipitation index (SPI) River flow anomaly D_F Reservoir level anomaly D_L	-0.5⩽SPI<0 -15%⩽ D_F <0 -10%⩽ D_L <0 Two conditions are met	No drought impacts
During Drought	Actual Drought Period	Slight Drought	Regional agriculture drought index Ia	0.1⩽Ia<0.5	Water shortage in agriculture
		Medium Drought	Regional agriculture drought index Ia population ratio under drinking water stress Pa	0.5⩽Ia<0.9 Or 2.0⩽Pa One condition is met	Increasing shortage on agriculture water use, some livestock and resident may be stressed for drinking water shortage in distant area
		Serious Drought	Regional agriculture drought index Ia population ratio under drinking water stress Pa Percentage of urban water shortage Pg	0.9⩽Ia<1.5 Or 5.0⩽Pa<7.0 Or 20⩽Pg<30 One condition is met	Serious shortage on agriculture water use, increased difficulty on drinking water supply in distant area, urban water use may be affected
		Severe Drought	Regional agriculture drought index Ia population ratio under drinking water stress Pa Percentage of urban water shortage Pg	1.5⩽Ia⩽4 or7.0⩽Pa or 30⩽Pg one condition is met	Agriculture, rural drinking water and urban water use are all significantly affected
Post Drought	Recovery				The direct impact is relieved

Note: the percentage of urban water shortage means one third of the cities met the ratio

Note that Sichuan and Gansu have slightly different indicators based on local conditions but the principles remain the same between provincial and lower level DMPs.

2.3 Provincial DMP Activities at Various Drought Stages

2.3.1 Overview

The TA has proposed a layered decision support early warning framework that uses the NCC and MWR meteorological drought forecasting at the provincial level FCDRH (as well as available hydrologic and agricultural monitoring) to establish triggered notices to affected local areas (basins, municipalities, counties). Once the triggered notices of potential drought are received at the lower level FCDRHs, the use of the current hydrologic indices and other hydrologic data is expanded to evaluate the probability of drought based on the provincial warning. Depending on these combined meteorological and hydrological assessments and probability analyses, the local level DMPs are triggered for early action water reductions and water conservation measures. Given this framework, Table 2.2 shows the aspects undertaken as part of the provincial DMP at various points in the drought cycle:

Table 2.2: Provincial DMP Technical Activities at all Stages of Drought Cycle

Stage of Drought Cycle	Technical Activities, Provincial DMP and Provincial FCDRH
Normal	▪ Collect and analyze drought-related information in a timely and systematic manner. ▪ Establish criteria for declaring drought emergencies and triggering various mitigation and response activities. ▪ Provide an organizational structure and delivery system that assures information flow between and within levels of government. ▪ Define the duties and responsibilities of all agencies with respect to drought. ▪ Maintain a current inventory of government programs used in assessing and responding to drought emergencies. ▪ Identify drought-prone areas of the province and vulnerable economic sectors, individuals, or environments. ▪ Identify mitigation actions to address vulnerabilities, reduce drought impacts. ▪ Provide a mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas. ▪ Keep the public informed of current conditions and response actions by providing accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the internet). ▪ Establish and pursue a strategy to remove obstacles to the equitable allocation of water during shortages and establish requirements or provide incentives to encourage water conservation. ▪ Establish a set of procedures to continually evaluate and exercise the plan and periodically revise the plan so it will stay responsive to the needs of the state or region. ▪ Integrated drought database to allow for continuous monitoring of MWR and NCC data on meteorology using SPI, river flows and reservoir levels. ▪ Vulnerability assessments in the province coordinated with local jurisdictions. ▪ Development of standard protocols and minimum requirements for municipal, county and sectorial DMPs prepared in the Province.
Pre-Drought	▪ Based on Integrated drought database for continuous monitoring of MWR and NCC data on meteorology using SPI, river flows and reservoir levels, notify potentially affected municipal FCDRH of potential drought conditions. ▪ Oversee implementation of standard protocols and minimum requirements for municipal, county and sectorial DMPs prepared in the Province. ▪ Coordination of local DMP Pre-drought responses especially where drought affects multiple municipal areas or major sectors. ▪ Report on activities upward to National FCDRH and downward to local FCDRHs. ▪ Coordinate public information on risk reduction activities.
Drought	▪ Based on Integrated drought database for continuous monitoring of MWR and NCC data on meteorology using SL24-2008 identified drought indicators, notify affected municipal FCDRH of actual

Stage of Drought Cycle	Technical Activities, Provincial DMP and Provincial FCDRH
	drought conditions. ▪ Oversee implementation of standard protocols and minimum requirements for municipal, county and sectorial DMPs prepared in the Province and begin drought relief activities as specified in PRC regulations. ▪ Coordination of local DMP drought responses especially where drought affects multiple municipal areas or major sectors. ▪ Report on activities upward to National FCDRH and downward to local FCDRHs. ▪ Coordinate public information on risk reduction activities as well as drought relief activities.
Post Drought	▪ Based on Integrated drought database for continuous monitoring of MWR and NCC data on meteorology using SL24-2008 identified drought indicators, notify potentially affected municipal FCDRH of end of actual drought conditions. ▪ Oversee implementation of standard protocols and minimum requirements for municipal, county and sectorial DMPs prepared in the Province and continue drought relief activities as specified in PRC regulations. ▪ Coordination of local DMP drought relief especially where drought affects multiple municipal areas or major sectors. ▪ Report on activities upward to National FCDRH and downward to local FCDRHs. ▪ Coordinate public information on risk reduction activities as well as drought relief activities. ▪ Determine end of drought relief following end of drought and return to Normal conditions.

2.3.2 Normal Stages of Drought Management

Drought management, in essence is the management of water shortages in times of drought. However, this does not intimate that it is required only in times of drought. Effective and coordinated drought risk management and response to the drought requires that the effort must be conducted at all times. In other words, the Normal stage of drought management is the cornerstone of drought risk management. For a long time, the focus of China's drought management has been concentrated in the emergency phase of the actual occurrence of drought, while ignoring the Normal stage of drought management.

The Normal stage of drought risk management is important for two reasons: First, from the nature of drought risk management point of view, it is not a passive response to actual drought damages, but active prevention and/or reduction of drought risk. Risk reduction and mitigation measures are carefully planned and crafted during Normal operations so they can be quickly applied in Pre-Drought or Drought stages. Second, unlike flooding, the onset of drought is relatively slow process which might take a few months, seasons or even years. Therefore, drought risk management is developed in the Normal stage with attention to the planning activities of drought risk management. Overall, the Normal stage of drought risk management should focus on the following aspects:

2.3.2.1 Risk prevention

a) Engineering Solution

The pilot provinces have installed many water infrastructure projects of various types including wells and other project-based drought preparedness and mitigation systems. But in general, the water allocation pattern has not always been optimized and in some cases the drought-resistant water supply capacity cannot meet demand, leading to lower agricultural resilience in some areas. Some urban and rural water

supplies are also at risk. Therefore, in order to improve the water supply capacity of drought and drought periods, it requires long-term planning, strengthening the construction of water conservancy infrastructure.

b) Non-engineering solution

Compared to the engineering system, the system of non-engineering construction has not been given sufficient attention, as non-structural measures have lagged behind structural measures. In recent years, provincial drought management authorities are now beginning to employ the non-engineering measures for drought prevention, and their importance and cost effectiveness to mitigate drought. The top-down system of drought organization has been formed to carry out the policies and regulations developed gradually, drought plans and planning, information technology and other drought-resistant non-engineering systems.

2.3.2.2 Risk assessment

Taking into account the theory on risk management and vulnerability outlined earlier, the risk assessment aspects proposed in the DMPs contain the following elements:

- County as an application unit, a comprehensive history of drought collected data and system storage is utilized.
- Organized relevant scientific research, with the use of fuzzy comprehensive evaluation methods based on disaster system theory, using theory of random probability and statistics, research progress on drought frequency and potential loss of drought risk assessment methods based on the PRC IWHR research project analysis carried out in Liaoning province's drought risk.
- According to drought risk analysis results, the completion of drought risk zoning in provinces was completed on various aspects.
- Diagrams of a typical complete different years or drought risk level year.

[Refer to Liaoning DMP as example.].

2.3.2.3 Drought monitoring

The following drought monitoring aspects should be recognized, based on assumed collaboration and cooperation between departments, especially MWR and Meteorology:

- Unified planning, covering the whole province, rational layout, the information is complete, drought monitoring network resource sharing, including weather monitoring, hydrological monitoring, soil moisture monitoring, water quality monitoring, remote monitoring.
- Strengthened meteorological monitoring, including precipitation, evaporation, temperature and other information.
- Strengthened hydrological monitoring, including rivers, lakes, water reservoirs, flow, storage capacity and other surface water and ground water level information, such as groundwater information.
- Enhanced soil moisture monitoring, divided into fixed station, mobile station, and three types of test stations.
- Strengthened water quality monitoring, involving water diversion control section, major rivers, lakes, boundary waters, and an important source of water supply to the water quality monitoring.
- Strengthened remote sensing, using satellite data to calculate specific drought indices.
- Established for water monitoring, inter-departmental information sharing mechanism, a drought monitoring data information sharing network.

2.3.2.4 Education on disaster prevention and mitigation

Education and capacity building are important aspects of improved drought risk management such as:

- Strengthen drought mitigation culture. The drought mitigation culture is an important part of strengthening the construction of socialist culture. The culture of service as a national drought mitigation public cultural service system is an important component of the drought disaster reduction into the national education system, strengthening the knowledge of primary and secondary school education and drought mitigation.
- Carry out publicity and education activities and drought mitigation. Combining national "Disaster Prevention and Reduction Day", "International Disaster Reduction Day", "World Water Day", "China Water Week", organized various forms of publicity and education activities and drought relief, the whole society to participate in creating a culture of disaster prevention and mitigation atmosphere. Development and Drought Mitigation series of popular science books, wall charts, and audio-visual products, publicize relevant laws and regulations, the daily water-saving techniques, and disaster prevention and mitigation measures to enhance the whole society's ability to adapt to drought, to raise awareness of disaster self-help skills.
- Organize relevant personnel to the drought emergency training drills. According to previous drought reviews, test readiness preparations, formulate action if there are problems.

2.3.3 Drought Management in Pre-Drought stage

A key drought risk management stage is Pre-Drought, with the potential to move toward actual drought, and identified by selecting a set of corresponding drought early warning indicators. These include changes in hydrological and meteorological factors and runoff and water conditions in the target area to monitor for early identification of potential drought, drought early warning and timely information dissemination through various channels to the relevant government departments, various social organizations and the public to make early preparations to deal with the process. In short, Pre-Drought management requires judgment, and accurate and timely warning information to the relevant institutions and personnel in order to implement plans and actions. Pre-identified risk reduction and mitigation measures are employed in an attempt to prevent drought or reduce the societal impacts from the drought. In most cases, it is more cost-effective to prevent or reduce damages than to provide relief for damages after they occur.

2.3.3.1 Drought triggering

- Early recognition. Based on meteorological, hydrological and agricultural drought monitoring data, calculate the value of drought early warning indicators to determine whether the drought early warning trigger condition has been met.
- Meteorological and hydrological forecasts. Based on the short-term climate prediction, Provincial Meteorological Bureau and the provincial Bureau of Hydrology Hydrological predictions, forecasts, the next period of time may be forecasted.
- Triggering declarations. The early warnings should be issued to the potential affected areas based on the meteorological and hydrological monitoring results. This information should be disseminated to a broader audience rather than just the drought management organizations to keep everyone involved and prepared in the early stage.. Drought Warning is issued for local flood control and drought relief headquarters organizations, released under special circumstances by the local people's government. These can be documents, radio, television, newspapers, Internet, SMS, etc.

2.3.3.2 Drought preparation

- Mental preparation. Strengthen publicity and enhance people's awareness of self-protection and the prevention of drought, good drought mental preparation.
- Organizational structure. Improving the drought management system, implementing drought management responsibility system and nominating the responsible people, and promoting the development of the drought service groups. FCDRH institutions at all levels should strengthen drought service network, encourage and support social forces to participate in the construction of drought service organizations.
- Drought inspection. Implemented to organize engineering, plans, materials, grading monitor as the main content censorship, solve weaknesses to clarify responsibilities, limited rectification. Focus on examination of organizational leadership, accountability, water projects, drought measures are in place.
- Supplies ready. Levels of responsibility in accordance with the principle of reasonable reserves must be provided for drought supplies.
- Water sources scheduling and potential reallocations previously developed and ready to implement at various stages of drought schedule.
- Water restrictions initial program development. Promote water-saving irrigation techniques in agricultural production and farming techniques, develop water restriction program; develop rural and urban domestic and industrial water conservation, water restrictions, restrictions for dryland development of high water consumption, high pollution projects focus on the development of water-saving industries and services.

2.3.4 The Actual Occurrence of Drought Management Drought Stage

Depending on the severity of the drought, the drought classified as mild (IV), moderate drought (III), serious drought (II) and severe drought (I) in four grades. Different levels of drought stress and drought management key management actions are different for the various stages of Slight Drought to Severe Drought. The requirements are essentially same as in existing drought response guidelines but with the addition of improved risk reduction and mitigation measures at each stage, the impacts will hopefully be reduced. In addition, the existing requirements for drought relief measures in drought relief plans are also implemented to manage unavoidable impacts.

2.3.5 Recovery Phase of Drought Management

After the lifting of the province's drought, drought management into the recovery phase.

2.3.5.1 Post-drought assessment

- Drought rating. FCDRHs at various levels report upward in accordance with the results of the assessment group verification team organizational disaster, disaster-depth investigation and verification. The final results will be verified with the provincial emergency relief headquarters office (located in the provincial Civil Affairs Department) after coordinated reported to the provincial Government and the State Flood Control and drought Relief Headquarters. Meanwhile, according to "drought grading standards" (SL663-2014) to determine the province's actual drought levels.
- Drought assessment. Evaluation carried drought and lessons learned and practical problems of drought acquired.

2.3.5.2 Post-drought recovery

- Rescue victims. After verification of the disaster, flood control and drought relief headquarters at all levels of the affected areas rescue object to register bailout.
- Resume production after the disaster. Governments at all levels and related organizations should help local communities to repair damage and resume production as soon as possible.
- Hydraulic repair. Water administrative departments shall be checked for water projects evaluated and promptly suffered drought tissue repair damaged water conservancy, construction or repair of priority included in the annual plan. Drought-damaged water conservancy projects generally include irrigation canal, small dams/reservoirs, embankments, lift pump station facilities, water pipelines, and other electromechanical well.
- Supplies, equipment and other restitution. The local governments flood control and drought headquarters shall promptly return of expropriated drought emergency materials, equipment, means of transport, etc., and be compensated in accordance with relevant laws and regulations.

2.3.6 Decision Processes

Figure 2.1 shows the general and simplified decision process diagram at various drought stages developed in the TA DMPs which are somewhat of a hybrid between the existing drought relief processes with DRM added. Since the TA only produced actual provincial DMPs at this point, the figure refers to the provincial decision-making process but mentions the triggering of local municipal and local level DMP actions. The actual decision making processes with indicators, triggers and pre-identified actions at the local levels will be prepared as part of the local level DMPs. For now, the TA has provided a template (example) local level DMP as part of the work, but the creation of an actual local level DMP was beyond the TOR scope.

As outlined previously, the decision diagram illustrates the following concepts:
- Normal stage - use the integrated drought database to track indicators and report daily to local jurisdictions on status of potential drought.
- Pre-drought – notify potentially affected municipalities and counties of emerging potential drought and when triggered, have local DMPs initiate appropriate risk reduction and mitigation measures.
- Drought – same actions as in Pre-drought with enhanced or additional risk reduction and mitigation measures as well as following current guidelines relative to drought relief requirements
- Post-drought Assessment and recovery

The focus of all stages is drought risk prevention, risk assessment, disaster prevention and mitigation of drought monitoring and education, and in the pre-drought stage, the focus is conducted potential drought early identification, early warning and drought before release preparations. The steps outlined on the bottom of the diagram are the standard processes used for drought relief plans in the PRC and we have merely added the early action activities on the head end of the process.

When in different stages of drought management, the focus on drought management action measures are different as shown in detail in the guidelines and provincial DMPs. Figure 2.2 shows the cyclical nature of the drought processes schematically and the work that is necessary at all stages.

Figure 2.1: Provincial Decision Making Process

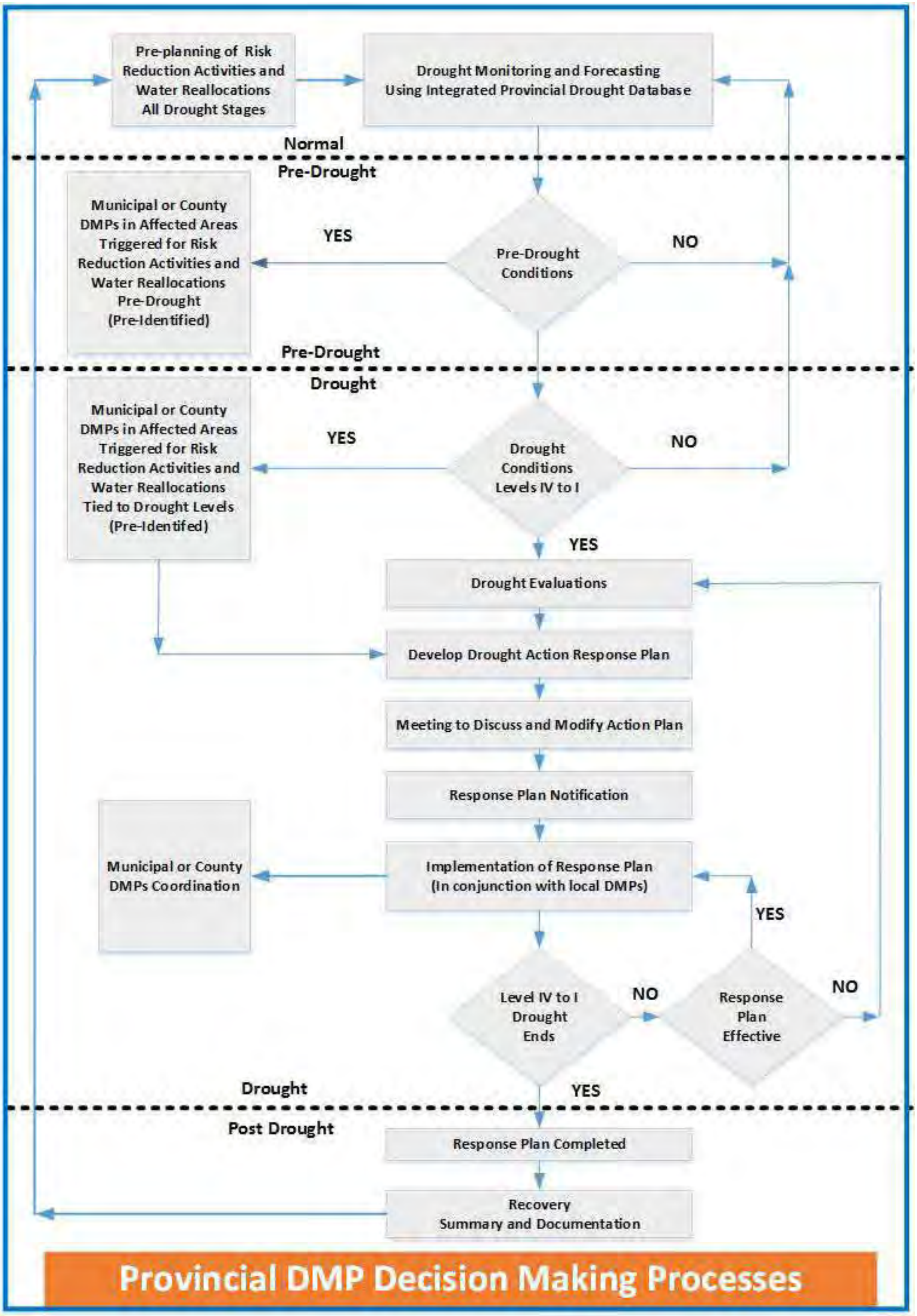
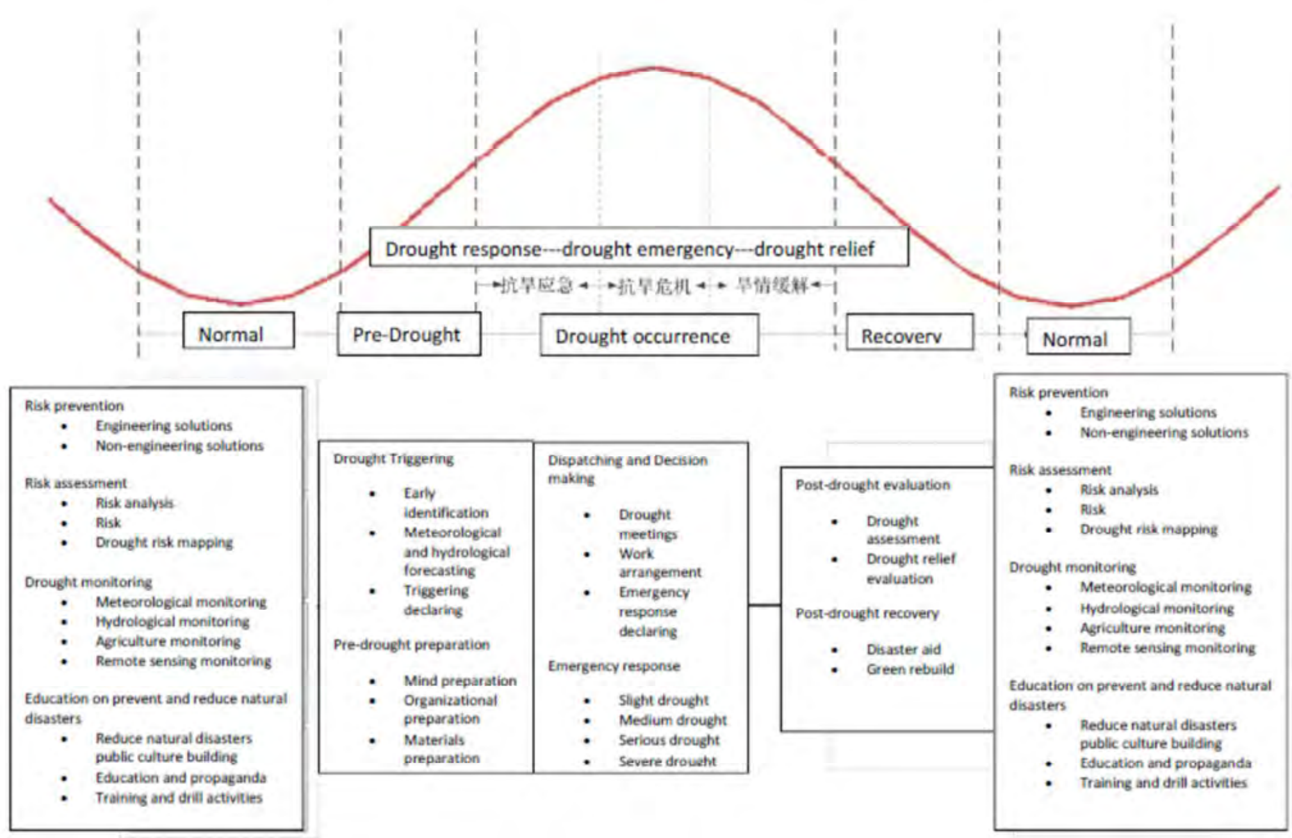


Figure 2.2: Drought Management Activities in Different Phases



2.4 Liaoning Drought Management Plan

The full Liaoning Drought Management Plan produced under the TA complements these draft guidelines, and is a reference for moving forward to risk based DMPs in the PRC.

The TA also produced a prototype outline provincial DMP (Appendix K) based on international best practices that contains valuable ideas that could eventually be incorporated into PRC DMPs over time. The Liaoning DMP was based in this format but was adapted to suit the local context and stage of development of DRM.

3 Prototype Municipal and County Level Drought Management Plans

3.1 Introduction

As previously outlined, the provincial DMPs have been developed under a presumed future tiering of drought management responsibilities with linked and specific roles and responsibilities at each layer of the process. Detailed water management decisions in IWRM are made at the lowest practical water management level. Given this framework, the provincial DMPs and local DMPs are part of an overall hierarchy of drought planning. The lowest level would be water companies, industries and agricultural interests. Their drought management activities are coordinated by county level and municipal level drought planning. The county and municipal level drought planning is managed and coordinated by these provincial plans, and the entire process has had guidance and oversight from the national level drought management process.

Since the PRC practice has been to develop drought response or relief plans at various levels, there will need to be some phasing in of the concept of drought management planning at drought stages as introduced in the guidelines, including Normal stage. There may be an interim period where drought management and drought relief plans exist simultaneously for the local level, with the idea that the drought management plans should eventually supersede the need for separate drought relief plans.

3.2 Prototype Municipal or County Level DMP

Based on this tiered approach, the TA team has assembled a prototype local municipal or county level drought management plan using a template from the United States as well as lessons learned from the DFID WRDMAP project and the municipal drought management plan produced for Chaoyang Municipality in Liaoning Province in 2009.

This prototype or template form of drought management plan provides examples and ideas for the contents of such plans using approaches that are common in the USA and the UK while taking into account PRC institutional arrangements. Although this municipal/county level DMP was not a requirement of the project TOR, the TA team considers it a vital link in the risk based drought management planning process proposed for the PRC. Detailed risk reduction and mitigation measures, including potential reallocations of available water supplies, are more appropriately made in local DMPs. Once these local level DMPs are in place, the provincial DMPs will serve more of an early warning and coordination function for droughts affecting multiple local jurisdictions.

3.3 Contents of Local DMPs

International best practices were used as a basis for a DMP produced under the MWR/DFID WRDMAP project in 2009 (for Chaoyang Municipality in Liaoning Province) to produce a suggested framework and contents for the local DMPs. According to IWRM and drought risk management principles, decisions on risk reductions and mitigation measures should be made lower levels, and this framework is consistent in this approach. As outlined in the example in the previous chapter, the provincial early warning system is supplemented by additional monitoring and indicators at municipal and county levels during initial indications of an impending drought from SPI calculations.

It is recognized that municipal and county levels in the PRC already have Drought Response Plans for measures when the drought is in place. The concepts in this model plan will ultimately need to be integrated into the existing drought response plans under PRC methods. This integration of plans at local level was beyond the project scope of work.

This prototype contains some suggested contents from Chaoyang DMP and USA model, as ideas for consideration in any local level DMP in the PRC.

Box 3.1: Example Contents of Municipal or County Level DMP

Executive Summary (covers all aspects below)
1.0 INTRODUCTION
1.1 Plan Objectives
1.1.1 Process of Setting Goals and Objectives
1.1.2 Plan Objectives
1.2 Introduction to Drought Risk Reduction, Mitigation and Response Planning
1.3 Drought Planning and Water Conservation
1.4 Water Abstraction Permits
2.0 DROUGHT VULNERABILTY ASSESSMENT
2.1 Profile of Municipality (or County)
2.2 Existing Water Demands
2.2.1 Water Supply Companies (WSCs)
2.2.2 Industrial Enterprises
2.2.3 Irrigation
2.3 Historical Assessment of Drought, Available Supplies and Demands
2.4 Drought Hazard Analysis and Drought Exposure Analysis
2.5 Water Supply Reliability and Drought Management Planning
2.6 Drought Impact Assessment
3.0 DROUGHT STAGES, TRIGGER POINTS AND RESPONSE TARGETS
3.1 PRC Standard of Classification For Drought Severity, SL424-2008
3.2 Drought Stages and Trigger Points
3.3 Drought Management Under Various Scenarios
4.0 DROUGHT TEAM AND RESPONSIBILITIES
4.1 Brief Description of DMP Structure and Connection to Provincial DMP
4.2 Drought Team, Responsibilities and Provincial Coordination
4.2.1 Introduction
4.2.2 Provincial Drought Management Center
4.2.3 Drought Management Team and Responsibilities
4.2.4 Administrative Procedures
4.3 Final Responsibility for Decisions
4.4 Resourcing
4.4.1 The Need for Extra Resources
4.4.2 Financial Resources
4.4.3 Appointment of Consultants
5.0 DROUGHT MONITORING
5.1 Introduction
5.2 Hydrometric Monitoring
5.2.1 Hydrometric Monitoring under Normal Conditions
5.2.2 Hydrometric Monitoring under Potential Drought Conditions
5.2.3 Hydrometric Monitoring during Drought Conditions
5.2.4 Ecological Monitoring
5.2.5 Drought Monitoring by Water Users and Stakeholders
6.0 DROUGHT RISK REDUCTION AND MITIGATION AND RESPONSE STRATEGIES
6.1 Drought Risk Reduction and Mitigation Measures

3.4 Sectorial DMPs

The main water user sectors will eventually be required to develop drought management plans for their respective sectors. The municipal and county level DMPs will then coordinate the interaction of these sectorial plans and potentially some reallocations from one sector to another.

Provincial level drought planning processes should provide templates and example sectorial level DMPs so that they are done consistently throughout the province in local DMPs. There should also be a provincial role to review completed sectorial plans as part of the review of local municipal and county level DMPs.

There are a wide variety of example sector level DMPs in various countries which can provide ideas for such sectorial plans. The TA team has downloaded many of these examples and the following are a few examples:

- Agriculture Sector - Alberta's Agriculture Drought Risk Management Plan, May 2010. The ADRMP is a pro-active, effective, and risk management approach to mitigating the effects of drought on Alberta Province Canada agricultural areas.
- Water Companies – The City of Boulder Colorado (USA) Drought Plan is one of many municipal level DMPs that have requirements and contents applicable to PRC water companies in urban areas. In addition, the TA has shown many UK water company DMPs which are under the oversight of the Environment Agency.
- Industrial Sector – The Best Management Practices for Industrial Water Users, produced by the Texas Water Board in 2013 contains a variety of water saving and water conservation methods to be employed by industry including their cost effectiveness.

Many of the example risk reduction and mitigation measures provided in the next section are actually most applicable to the sector level DMPs, especially water companies and agriculture.

3.5 Local Level DMP Activities at Various Drought Stages

The TA project is presenting a long-term vision for provincial DMPs in this document and has also suggested a template for local level DMPs. The proposed tiered approach to drought risk management assumes that the municipalities and counties are provided the funding and capacity building to both develop quality drought risk management plans as well as manage the process. In the short term until this occurs, the provincial drought management plans may be the most practical way to manage drought risk management using the integrated drought database, drought risk mapping, and the meteorological indices.

3.5.1 Overview

There are comparable pre-determined sets of technical activities at each stage of the drought cycle in the municipal and county level DMPs as well as in provincial DMPs. However, beyond the higher level planning aspects, these plans are much more focused on the detailed risk reductions and mitigation measures of the major water users and sectors in their jurisdictions. This follows IWRM and DRM practice of making such water management decisions at the lowest practical levels. The local DMPs will also provide oversight and coordination between the DMPs produced by the various major sectors such as water supply companies, industry and agriculture.

3.5.2 Local Level and Sectorial Risk Reduction and Mitigation Measures

The pilot province DMPs contain a mitigation strategy to identify, evaluate, and prioritize cost effective, environmentally sound, and technically feasible mitigation actions and activities the province is considering, and an explanation of how each activity contributes to the overall mitigation strategy. Local input will also be included when available. Additionally, with each update cycle the DMP must be reviewed and revised to reflect changes in development, progress in provincial mitigation efforts, and changes in priorities. The mitigation actions take into consideration the vulnerability and capability assessment, and are intended to address areas of high vulnerability or where capabilities should be strengthened.

The following general categories of approaches to drought mitigation may be considered in the DMPs (various levels):
- Technical Assistance
- Administrative
- Financial
- Public Education
- Studies, Publications, Planning efforts
- Projects to Reduce Impacts to Provincial Assets
- Natural Resource Protection
- Structural Projects
- Emergency Services
- Monitoring and Prediction
- Training and Exercises

Potential mitigation measures will be identified and assessed by official stakeholders and major private entities based on questions such as:
- Social: Does the measure treat people fairly?
- Technical: Will it work? (Does it solve the problem? Is it feasible?)

- Administrative: Is there capacity to implement and manage the project?
- Political: Who are the stakeholders? Did they get to participate? Is there public support? Is political leadership willing to support the project?
- Legal: Does the organization have the authority to implement? Is it legal? Are there liability implications?
- Economic: Is it cost-beneficial? Is there funding? Does it contribute to the local economy or economic development? Does it reduce direct property losses or indirect economic losses?
- Environmental: Does it comply with environmental regulations or have adverse environmental impacts?

Other criteria used to recommend what actions might be more important, more effective, or more likely to be implemented than another may include:

- Does action address hazards or areas with the highest risk (from Risk Assessment)?
- Does action protect assets and/or infrastructure?
- Does action improve the provincial capability to manage and implement mitigation (from Capability Assessment)?

Linking local county hazard mitigation plans and water provider drought management plans to the provincial DMP will be integral to building a more effective mitigation program over time. Implementation and maintenance of the DMPs will be critical to the overall success of hazard mitigation planning. As such, the provincial DMPs will include specific monitoring programs and plan updating requirements.

Table 3.1 and Table 3.2 provide examples of mitigation measures and risk reduction measures that can be considered for DMPs at various FCDRH level or in sectorial DMPs, but are most applicable to the lower level DMP planning where the detailed risk reduction, mitigation and water reallocation decisions will be made in the proposed drought risk framework.

Table 3.1: Example of Possible Mitigation Measures to Reduce Drought Impacts by Sector

Short-term	Sector	Long-term	Sector
Supply management			
Mixing fresh and low quality waters	U,A,I,R	Increase water collection and storage opportunities (reservoirs)	U,A,I,R
Exploiting high-cost waters	U,A,I	Desalination of brackish and saline water	U
Over-drafting aquifers	U,A,I	Treatment and reuse of wastewater	A,I
Diverting water from given uses	U,A,I	Water transfers	U,A,I,R
Decreasing transport and distribution losses	U,A,I	Artificial precipitation	U,A,I,R
Adjust legal and institutional framework	U,A,I,R	Locate potential new resources (standby supplies)	U,A,I
Etc.		Aqueducts and canals	U,A,I
		Groundwater recharge	U,A,I
		Monitoring and forecasting	U,A,I,R
		Adjust legal and institutional framework	U,A,I,R
Demand management			
Restricting agricultural uses (rationing, subjecting certain crops to stress, …)	A	Adopting supplementary and deficit-irrigation	A
Restricting municipal uses (lawn irrigation, …)	U	Water saving irrigation techniques (drip, sprinkler, …)	A
Review operations of reservoirs	U,A,I	Incentives to invest in water saving technology	U,A,I
Water metering and pricing	U,A,I	Water recycling	U,I
Water rationing	U,A,I	Dual distribution networks for drinking water supply	U
Education and awareness creation	U,A,I	Inventory private wells and negotiate their public use	U,I
Provide permits to exploit additional resources	U	Assess vulnerability and advise water users	U,A,I
Provide drilling equipment	U	Elaborate alert procedures	U,A,I,R
Adjust legal and institutional framework	U,I,A,R	Carry-over storage	U,A,I
Negotiate transfer between sectors	U,A	Conjunctive use	A,I
Etc.		Adjust legal and institutional framework	U,A,I,R
Impact Minimization			
Temporary reallocation of water resources (on the basis of assigned use priority)	U,A,I	Development of early warning system	U,A,I
Restrict uses	U,A,I	Reallocation of water resources on the basis of water quality requirements	U,A,I
Emergency supplies	U	Use of drought resistant plants	A
Public aid to compensate loss of revenue	U,A,I	Development of a drought contingency plan	U,A,I,R
Tax relief (reduction or delay of payment deadline)	U,A,I	Mitigation of economic and social impacts through voluntary insurance, pricing and economic incentives	,A,I
Rehabilitation programs	U,A,I	Education activities for improving preparedness to drought	U,A,I
Resolving conflicts	U,I,A,R	Elaborate set-aside regulations	U,A,I,R
Postpone payment of credits	U,I,A		
Implement set-aside regulations	U,I,A,R		

Note: A = Agriculture, I = Industry, R = Recreation, U = Urban

Source: Water Resources Planning and Management for Drought Mitigation, Bazza, M (2002) et al

Table 3.2: Examples of Possible Mitigation Measures to Reduce Drought Impacts (WRDMAP, 2010)

Short Term Mitigation Measures (suitable for consideration in drought management plan)	Long Term Mitigation Measures (suitable for river basin plan, integrated water resources plan etc)
Improve the accuracy of seasonal runoff and water supply forecasts	Reduction in leakage in canals and main pipelines
Develop early warning systems	Reduction in leakage in distribution pipe network
Establish new data collection networks and data sharing arrangements	Agricultural extension to advise farmers on more efficient irrigation, more drought resistant crops, rotations, deficit irrigation etc.
Emergency limitation on abstraction permit holders (prioritized list of users) in accordance with SCD 460	Introduce more efficient water use in industrial processes by introduction of new technologies
Rotational cuts in water supply	Introduce new technology for clean-up of process effluent to improve quality of return flow
Public education and awareness of water saving actions	Take marginal land out of production
Advice to farmers on cropping before planting based on drought forecast	Implement waste water re-use where water quality permits
Avoid high water use crops	Review development plans to avoid new industry with high water use unless committed to new technologies for recycling etc.
Revise reservoir operating rules	Establish protection zones above reservoirs to maintain runoff potential and minimize sediment ingress
Waste water reuse where water quality permits	Artificial recharge
Maintain and use cloud seeding capability	Conjunctive use of surface and groundwater
Emergency borehole drilling	Water transfer from outside (inter-basin transfer)
Step up leakage control activities in urban areas	Construct new storage (dam) or transfer infrastructure
Change any subsidies that promote greater water use (e.g. subsidized electricity for pumping)	Develop water grid to allow internal transfers between sources
Inventory of industrial users with own source of supply to see if this supply could be used for domestic water supply in an emergency	Establish charging mechanisms that discourage wasteful use of water but protect low income users' water for living

Water use priorities have to be agreed, i.e., which users are to be asked to make sacrifices to protect the use by others. This is generally related to drought policy and the vulnerability analysis. Priorities generally rate aspects such as urban and rural domestic water supply as the higher priorities moving downward through environmental flows, agriculture, and industry down to non-essential or luxury water uses. Each province, municipality or county may have their own way to rate priorities relative to proposed reallocation schemes with compensation at pre-drought or actual drought conditions. The following is an example of a priority system developed under WRDMAP for the municipality of Chaoyang to illustrate concept.

Priority	Description
Top	Domestic water use for basic needs (urban and rural), hospitals, schools, livestock
	Minimum flows for the environment and basic needs for downstream water users
	Pillar industries e.g. power stations
	Irrigation for vegetable crops
	Industry
	Supplementary irrigation of field crops
	Mining and other industries needing large quantities of water and discharging polluted waste water
Bottom	Non-essential or 'luxury' use

Table 3-3 shows another example of typical drought mitigation activities that might be considered as the drought level increases, illustrating that the pre-planned risk reduction, mitigation and water reallocations are ready to be employed at various levels of drought.

Table 3.3: Example Using Typical Drought Actions to Illustrate Hierarchy of Actions as Drought Worses

Drought Management Actions / Drought Severity Class	Normal	Slight IV	Moderate III	Severe II	Extreme I
Information to support decision making					
Drought monitoring specified in Section 4	✓	✓	✓	✓	✓
Additional monitoring during drought to guide mitigation measures		✓	✓	✓	✓
Regular drought forecasts	✓	✓	✓	✓	✓
More frequent forecasts during drought to guide mitigation measures		✓	✓	✓	✓
Publish monthly situation reports	✓	✓	✓	✓	✓
Additional reporting during drought to guide mitigation measures		✓	✓	✓	✓
Situation analysis to support decision making					
Review the situation of water supply infrastructures, water abstraction permit, water consumption	✓	✓	✓	✓	✓
Undertake water deficit analysis and scenarios analysis to emergency limit to water abstraction permit for all 30 individual units / sub-catchments in Chaoyang of Upper Daling Basin by Mike Basin Model;					
Long term measures to increase society's resilience to drought					
Adopt water tariff policy (progressive water price) in order to reduce water demand;	✓				
Strengthen water metering management	✓				
Strengthen regulation of waste water treatment management;	✓				
Drill on drought management (review the historical drought condition to make a preparation for drought management and find out the problems of DMP implementation)	✓				
Develop training events and capacity building on drought management.	✓				
Develop training events on water saving for different sectors.	✓				
Build awareness of water saving in households by dissemination and promotion of water saving;	✓				
Public awareness of drought severity and actions that they should take as individuals					
Build awareness of water saving in households by dissemination and promotion of water saving;				✓	✓
Assistance to agricultural water users (especially rainfed agriculture)					
Forecasts targeting agricultural users		✓	✓	✓	✓
Provide local farmers information related to existing/potential price of crops by agricultural economist, particularly providing the price of drought resistant crops and products;		✓			
Provide local farmers trainings related to planting crops techniques with high economic value during drought condition by agricultural specialists or experienced local farmers;		✓			
Produce TV programmes to show drought resistant crops or how to plant these crops by agricultural specialists, agricultural economists, local experienced farmers (or by other medias);		✓			
Advice water saving irrigation to local farmers or irrigation management staff in villages by staff from Hydraulic Stations at townships;			✓	✓	✓
Assistance to industrial, commercial and institutional water users					
Improve water saving in governmental organizations, industrial enterprises, undertaking units, for example, running automatically-flushing toilet cisterns at times when buildings are unoccupied;	✓	✓			
Measures to reduce agricultural water use during the drought					
Set out water saving irrigation norms in drought condition in order to limit water irrigation to crops with high water consumption. Supervise water saving irrigation in drought condition by irrigation management organizations at all levels;			✓	✓	
Maintain and keep logs and filings related to irrigated water volume in drought condition, and examine their compliance. Under existing irrigated water metering, it requires to provide detailed records of irrigation from groundwater (such as the			✓	✓	✓
Measures to reduce industrial, commercial and urban domestic water use during drought					
Supervise units/individuals compliance with the emergency limit to water abstraction permits and the controls to waste water discharge;				✓	✓
Undertake strictly emergency limit to water abstraction permit to ensure urban/rural domestic water supply and important economic sectors water use by limit water uses in low priorities;				✓	✓
Reduce water supply hours in order to reduce amount of water supply;					✓
Emergency measures to mitigate drought impacts on vulnerable communities					
Supply water for basic needs of local farmers and livestock, who suffer from water shortage			✓	✓	✓
Undertake emergency measures by WSCs in order to provide water to hospitals and schools;					✓
Undertake effective emergency measures to deal with domestic water shortage in some cities;					✓

There must be principles for changing the allocation of water resources during drought conditions, and these should be specific, executive and be stated in the DMP. Relative to balancing human and environmental issues in allocations, there is a need to identify the ecological or environmental flows as well as the issue of the dilution requirements for river flows to be accounted for in the allocation process. Deciding the principles is a crucial step in developing the DMP, because these principles will determine the way the DMP will change water allocations as drought conditions get worse. Therefore, the principles must undergo adequate discussion and consultation with stakeholders. This should be done initially within the cross-sector working group and subsequently discussed and agreed at the higher level of the supervisory committee. The concurrent development of compensation programs so that the higher value water users compensate lower value users for the reallocations should also be carefully crafted and ready to exercise at various drought levels.

Under the Water Law (2002) water supply companies, industries, and irrigation use require a permit to abstract. Abstraction permits may be restricted during a drought. See Table 3-4:

Table 3.4: Emergency Limitation on Abstraction, SCD460

State Council Decree No. 460 ‘Regulation for Water Abstraction Permit and Collection and Management of Water Resources Fee’ states the following:
Article 41: In any of the following cases the competent authority may put limitation to the amount of water abstraction by a water abstraction unit or individual:
1. Water resources are inadequate to sustain the normal water supply in the area due to natural conditions;
2. Water abstraction or discharge has created significant impacts on the functions, ecology and environment of water bodies in a water function zone;
3. Groundwater over-abstraction is serious or geological hazards such as land subsidence have been induced by groundwater over-abstraction;
4. Any other special cases needing limitation to water abstraction amount.
5. If a major drought occurs, the competent authority may implement emergency limitation to the amount of water abstraction by units and individuals.

The DMP should set out the principles by which such emergency limitations will be decided. For example, they may be initiated once the drought severity reaches Class II for agricultural permit holders and at Class I for other users. In deciding these principles the working group should consider the findings of the vulnerability analysis. Risk management starts with early warning of impending drought and monitors the situation to provide advice as early as possible to water suppliers and groups of consumers regarding problems. At the same time, water demand management plays a key role in regulating the allocation of water supply to each user group to conserve the water supply and limit impacts over time. Within this context demand management provides a mechanism to for water managers to conserve supplies and spread these over an extended period. This mechanism has to be in place before the drought becomes a problem and must be related to current and changing conditions such as levels of reservoirs, stream flows and soil moisture levels.

4 Summary and Recommendations

4.1 Summary

Drought management has been centered on drought relief measures at all levels in the PRC with an emphasis on structural solutions and provision of emergency water supply. There is pre-planning work related to the development of emergency water supply sources and provision of drought relief measures, but little focus on predicting the onset of drought and taking pre-emptive risk reduction and mitigation measures to reduce the impact of drought as it increases in scope and scale. Drought risk management in China requires changing from passive drought relief to proactive drought management in order to minimize economic losses and impacts on environment. Both supply-side and demand-side approaches are important for risk reduction and mitigation strategies.

The TA8185 project reinforces the recommendations of the ADB Phase 1 TA project that the PRC should move towards drought risk management approaches and away from reactive drought relief as the primary mission of the FCDRHs. Based on international best practice as well as the layered FCDRH structure, the project suggested the implementation of a tiered approach to drought risk management in the PRC with interlinked responsibilities at the FCDRHs at state, provincial and local (municipal/county) levels. Based on this strategic organization, the national level major roles should include:

- Determine resource needs, with PRC State Council, to allow training and capacity building as well as drought risk management activities at all stages of drought cycle instead of only during drought relief.
- Research and develop regulations and guidelines or drought risk reduction and management.
- Coordinate planning and response levels on major trans-river basin and multi-province or widespread concerns.

The various plans at the local level may take some time to develop and implement, and the provincial DMPs may serve more of a command and control function in the interim period. However, once the local planning has been completed, the provincial level FCDRH responsibilities would be revised to include:

- Prepare provincial DMPs.
- Based on provincial DMPs and management of the integrated drought database, send provincial meteorological information/indices to potentially affected local areas to trigger pre-drought and actual drought activities.
- Review and coordinate area monitoring, triggers, and risk reduction and mitigation measures found in DMPs of all municipalities and counties.
- Coordinate and report activities to province and public, as well as SFCDRH, especially for widespread droughts affecting multiple local jurisdictions.

Drought management activities and risk reduction activities under the drought risk management approach are best suited at the level of local water sector users (urban water supply, agriculture, industry). As such, the local level FCDRH responsibilities will mainly include:

- Prepare local level DMPs, including oversight on production of sectorial DMPs.
- Receive provincial meteorological information/indices from provincial FCDRH on potential pre-drought or actual drought conditions and implement local DMP actions including overseeing the implementation of sectorial DMPs from urban, agriculture and industrial sectors.
- Coordinate area monitoring, triggers, and risk reduction and mitigation measures found in local DMPs and detailed DMPs of major water user groups.
- Coordinate and report activities to province and public.

Many of the local DMP indicators can be found and used directly from PRC SL424-2008 (Standard of Classification for Drought Severity), but complementary triggered risk reduction and mitigation measures are required. Depending on the severity of the potential drought, additional triggers for re-allocation of water abstractions may be considered with the Water Resources/Affairs Bureau based on the drought risk assessments and triggers outlined in the local DMPs. Although there appear to be somewhat comprehensive reporting during Normal operations in the PRC, little is actually triggered or done with this information unless the drought damages begin and an actual drought level declaration is declared (slight level IV moving up to I). Current PRC Drought Relief Regulations (2009) call for both provincial and local level drought relief plans, but there has been uneven performance up to now on the production of such plans. The proposed drought risk management planning does not replace the current drought relief protocols but merely adds an early action prediction and mitigation strategy, to attempt to reduce potential impacts that will hopefully reduce the need for relief activities.

The key aspect of the approach is the pre-planning of appropriate risk reductions, mitigation measures, and potential water reallocations during Normal Operations that are ready to be employed at various Pre-Drought and Drought levels. In this way the potential or actual drought impacts can be greatly reduced as well as the drought response activities required.

Based on the project results, the three pilot provinces are ready to implement the program but will need funding and support to expand the detailed requirements of the provincial DMPs further; to develop the municipal and county level DMPs; and to encourage the production of the sectorial DMPs. The pilot province DMPs provide a good starting point for the recommended process, and the model local DMPs produced by the TA project provide a good template for the development of the municipal and county level DMPs. However, this will take budgeting, time and capacity building. As noted above, the provincial DMPs may need to serve a more controlling function until the local DMPs are implemented.

Relative to moving beyond the three pilot provinces, there are many issues and potential constraints to the full implementation of the drought risk management approach in all provinces. It is hoped that this project provides some impetus to move other provinces in this direction. The next section provides some recommendations to address some of the identified constraints to moving toward full drought risk management in the PRC.

4.2 Recommendations

The TA Draft Final Report contains a series of recommendations for moving drought risk management forward in the PRC. Rather than repeat all of the details of these recommendations, the following sections summarize some of these issues.

4.2.1 Moving PRC from drought relief to drought risk management

Although the concept and importance of drought risk management is understood to some degree at the national level in China, it has not been fully implemented because of constraints embedded in current institutional structures and operational mechanisms, as well as because of limited human and financial resources. A greater appreciation of the concept of drought risk management at National and Provincial levels is necessary. Drought risk management is also an essential component of the PRC move toward Integrated Water Resources Management (IWRM) and it requires a complete re-assessment of the current reactive drought relief protocols and operations.

To accomplish such a move requires a re-evaluation of the drought management institutional structure and operational mechanisms. The drought risk management institutional structure should be strengthened to enable effective implementation of regular drought management functions at all phases of drought cycle, normal to pre-drought, various actual drought levels (IV to I), recovery and back to normal. Multi-departmental coordination mechanisms must be established to allow for the early prediction of potential droughts and the triggering of drought risk reduction and mitigation measures which can reduce the social and economic impacts of the potential drought. It is usually more cost effective to minimize or prevent impacts than to provide drought relief.

The workshops held on drought risk management during the TA project indicated a high degree of appreciation and willingness to embrace drought risk management in FCDRH staff at all levels. However, there was a consistent theme that current budgets and funding streams for drought work in the PRC are tied to drought relief work during emergencies, with little funding for drought prediction or risk reduction activities prior to drought declarations.

4.2.2 Improving data sharing and collaboration on drought in PRC

Institutional reforming and restructuring would complement the efforts in trans-agency cooperation in promoting data sharing. However, the incentive for stimulating data sharing needs to be created in FCDRHs and water resources departments. The role of FCDRH is managing and providing guidance on drought management activities without the direct access or control of the data which is held by the hydrological department.

It is recommended that collaborative agreements using MOUs and MOAs relative to data sharing and outlining the respective roles and responsibilities for drought risk management planning at various levels. This includes sector level interactions with local municipal and county level DMP plans.

Proactive drought risk management including drought monitoring and prediction, and early action on risk reduction and mitigation measures all require a much more aggressive and regular program of data sharing prior to actual emergency situations. There are two areas of cooperation urgently needed to facilitate drought risk management in the PRC:

- Provincial Level Integrated Drought Database
- Local Municipal and County Level DMPs

4.2.3 Improving technical aspects of drought management planning

It is recommended that the PRC national government promote research on drought forecasting and early warning, and then systematically emphasize methods and techniques that are found to be both scientifically sound and practical. The production of drought risk maps and vulnerability assessments should be undertaken in all locations using readily available data, and expanded with more scientific systems (such as IWHR Liaoning research protocols) as time allows. The undergoing state FCDRH project to expand soil moisture monitoring systems is a good start for a more comprehensive drought monitoring program that includes real-time data sharing between agencies.

Remote sensing will likely play a much more critical role in drought risk management in the future, especially as drought prediction becomes more mature. Remote sensing techniques have many applications for drought monitoring, for example, the weekly drought map drawn by the US National

Drought Mitigation Centre. The development of the system would be led by the MWR and the outputs would be shared with drought management organizations at river basin and provincial levels, as well as lower levels. In addition, related remote sensing drought indices and technical standards will also be prepared.

4.2.4 New policies and regulatory needs for drought risk management in PRC

The development of related additional technical standards should be initiated. Due to the complexity of identifying features affecting drought and the government pays less attention on the unstructured drought impacts, few studies have been funded in the past. The investment in theory studies and related codes and standards preparing are not sufficient.

In the future, more detailed drought-related technical standards will be required. The technical standards that need to be developed now are:

- Compilation guidelines for drought risk mapping,
- Evaluation guideline for drought management benefits,
- Compilation guideline for hydrological drought indices,
- Compilation procedures for drought management materials reserve allowance,
- Drought emergency contingency water resources management plan,
- Drought service group management plans.

4.2.5 Increasing public involvement in drought risk management activities

The drought risk management approach involves all levels of society in the development and implementation of the DMPs and related risk reduction and mitigation measures. As such, awareness of drought issues is critical in all stakeholders and the general public. Drought management implies the involvement of all stakeholders in the process in a completely different manner than top-down drought relief activities.

In the PRC, one local organization has historically had a great involvement in drought relief activities. Drought service groups (DSGs) have been the emergency drought relief teams established by local water resources management departments to provide equipment maintenance and technical guidance, etc. for local people in the area affected by drought. It is important to keep as many of the public involved in drought management as possible, so it may be important to re-structure DSGs and keep them involved as the PRC moves from drought relief to integrated drought risk management. The types of activities outlined above could easily become drought risk reduction and mitigation as well as relief in many cases.

4.2.6 Use of drought insurance and potential drought banking by urban users

The TA project has identified the potential of drought insurance and drought banking as having important roles in the future of drought management in the PRC. There is an urgent need to develop a drought disaster insurance system according to the characteristics of drought disaster risk and based on insurance theory to support drought disaster prevention and mitigation, to share the risk of disaster loss by the insured person, insurance company and the government.

In theory, the principle that “higher [value] water use sectors (urban and industrial) [should] pay into a fund to compensate lower [value] use agriculture to reallocate water as a risk reduction measure” is very

reasonable and could be applied to the PRC. In addition, the drought management departments on different levels could accept this, but it is not effectively implemented in PRC.

Such a water reallocation compensation plan could be implemented, but for now, it may be only feasible in economically well-developed and the water use sectors to be protected are high enough (urban or industrial). Such a water allocation system during droughts also implies a high degree of technical and management competency in the water permitting system and the issuance and management of water abstraction permits. In some cases, the water abstraction permitting system will need significant strengthening in order to apply such approaches.

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