CHAPTER 3 PROPOSED ESTABLISHMENT OF A REGIONAL NETWORK FOR DSS MONITORING AND EARLY WARNING

3.1 Context for a Regional Network for DSS Monitoring and Early Warning

With the growing social-environmental implication of dust and sandstorms (DSS), the concern to improve DSS monitoring and early warning has significantly increased. In Northeast Asia, countries primarily affected by DSS, such as People's Republic of China (PRC), Japan, the Republic of Korea , and Mongolia, have conducted DSS forecasting and early warning services through their National Meteorological Services. The PRC initiated its forecasting service of DSS and early warning service for severe DSS for the public in 2001. Republic of Korea did the same in 2002 and Japan in early 2004. At present the Mongolian Meteorological Service is trying out similar services for the public.

The partner countries are member states of the World Meteorological Organization (WMO) network that works well with a defined purpose[1]. The national meteorological services of the WMO member nations have agreed to a free and unrestricted international sharing of meteorological data and products. Although meteorological data and services are essential for DSS monitoring and early warning, they are far from being adequate to analyze and predict a complex phenomenon like DSS. Also, the meteorological stations that are part of the WMO network are often those in urban and near urban locations and not many are located in remote areas, which are known to be the source areas of DSS.

Transboundary environmental problems such as DSS can most effectively be solved through regional cooperation. The merit of regional cooperation is that it will be possible to achieve much more through a network than by each country acting alone. There is considerable value-adding when neighbors combine their efforts to establish a regional monitoring and early warning network. Early warning of impending DSS events based on a regional monitoring network will be facilitated by data sharing with rapid communications on the progress and geographic extent of any DSS outbreak.

Based on the review of the current DSS monitoring programs in the partner countries for consideration in establishing a regional network for monitoring and early warning, the following issues and challenges are apparent:

Firstly, the perception, terminology, definition, monitoring method, current capacity, needs and expectation, etc. are all different from country to country. For example, there is a perception gap among the participating countries. DSS is considered as a phenomenon of natural disaster for countries in the source areas (upstream countries) while DSS is a problem of air quality concerning public health for downstream countries. The definition of DSS is also different from country to country depending not only on monitoring method but also threshold value. In addition, needs and expectations are also different from country to country, even from agency to agency within a country. Accordingly, optimization and flexibility with step-by-step approach is needed in formulating a feasible program for a regional monitoring and early warning network.

Secondly, although a few bilateral initiatives are already in place as mentioned chapter 2, these projects are limited to some specific field and national boundary areas. Moreover, these initiatives on DSS between partner countries are presently focused on academic

[1] The WMO is a specialized agency of United Nations with the purpose to promote meteorology and hydrology and facilitate cooperation for the benefit and protection of humans through, among others, the establishment of networks of observation stations, development and maintenance of systems for rapid data exchange, and standardization of observation and processed products.

research and are not designed as operational tools to improve public awareness of impending DSS disasters. Despite these agreements, it is still a hurdle for DSS researchers from other agencies in Northeast Asia to get real-time data, particularly the data across countries in the region. Since DSS is one of the transboundary environmental problems at a regional scale, multi-lateral cooperation mechanisms can solve the problem effectively and this is true for a regional monitoring and early warning network.

Thirdly, although Mongolia is one of the major source areas of DSS, there is no special monitoring site for DSS in the country. Moreover, most meteorological stations in Mongolia do not have any direct relation to DSS. In this regard, from a regional perspective, helping Mongolia develop its national capacity is one of the key tasks in terms of establishing a regional monitoring network, particularly on data sharing among participating countries.

3.2 Selection of Monitoring Indicators

To establish a regional network for DSS monitoring and early warning among the partner countries, there is a need to develop a monitoring indicator system. The establishment of the common DSS monitoring indicators should start with the data that is easily available or can be easily acquired at present. It should take into account the technique and method being used for monitoring in each partner country and the long-term observational data status at the regional level in Northeast Asia, and in particular, in the originating source areas of DSS. Moreover, the initial monitoring indicator system should be adaptable to the evolution of DSS monitoring and modeling techniques and should be able to meet the increasing needs of the forecasting and early warning service.

To provide for early warning services, on the whole, DSS forecasting needs the following data or information on weather and surface conditions:

(a) Information about meteorological observation and analysis covering the following:

- Meteorological observation in the northern hemisphere for the analysis of the atmospheric circulation, which will basically cause DSS in Northeast Asia;
- Detailed meteorological observational data in DSS source area and DSS affected area (such as atmospheric pressure, temperature, rain, humidity, visibility, and wind) and its three-dimensional distribution;
- Diagnosis and analysis on atmospheric thermo-dynamic information based on the weather observation data; and
- Numerical weather prediction products from different meteorological centers.

(b) Geographic information and surface monitoring information covering the following:

- Desert distribution and soil texture information (distribution, grain size, etc);
- Land use/cover change information; and
- Soil moisture status, including snow cover.

(c) Dust related monitoring information as follows:

- Atmospheric optical properties measurement including horizontal visibility (by transmissometers), optical depth and size mode (by solar radiation and sun photometer), vertical visibility and vertical profile (by LIDAR), light scattering (by nephelometer), etc.;
- The mass concentration and size mode of dust including TSP, PM_{10} and dust deposition, etc.; and
- Satellite monitoring and retrieval data for DSS, which can be acquired from a variety of meteorological satellites (as explained in Appendix 4).

All these information belong to the basket of indicators for DSS monitoring, which are currently collected and utilized differently by partner countries. For instance, Japan and Republic of Korea, which are relatively far from DSS originating source areas and where DSS is regarded mainly an air pollution concern, attach great importance to air quality indicators like TSP, PM_{10}, dust deposition, etc. Accordingly, significant efforts have been given in developing the monitoring instruments and techniques that can detect and monitor potential DSS impacts on air quality over a long distance for real-time data transmission like LIDAR. Republic of Korea has also developed a PM_{10} concentration indicator based early warning system for DSS events.

In the PRC and Mongolia, where most of the DSS occurs in Northeast Asia, visibility is considered the most widely used indicator, given the tangible nature of DSS and the meteorological observation capacity in these countries. Collection of relevant meteorological observation started quite early in both these countries and they have established corresponding data sets. Based on such a data set, the PRC has achieved progress in the studies on characteristics and regularities of DSS, which forms the basis of their assimilation and modeling of DSS events and early warning services.

The challenge in establishing a reasonable set of common monitoring indicators rests on the manner of accommodating the different needs (or “preference”) among the partner countries without compromising the technical/operational feasibility of the proposed regional network, particularly at its initial stage. The monitoring indicators included in the core basket for cross-country exchange within the network need to be: (a) relevant to forecast models in all the partner countries, (b) readily available or which can be made available with minimal investment, and (c) capable for real time transmission from one country to another along the identified DSS transport routes in Northeast Asia. With this realization, through extensive and comprehensive discussions by the experts and researchers from the partner countries involved in the project, the partner countries agreed that the initial real time monitoring indicators for the regional network should comprise of: (i) instrument-measured visibility, (ii) $PM_{10,}$ and (iii) LIDAR-based observation data[2]. There are differences in the relative importance each partner country has given to individual monitoring indicators. The existence these differences do not prohibit, however, the partner countries from reaching an agreement on working with such a set of the commonly agreed DSS monitoring indicators for the regional network.

3.3 DSS Regional Network Structure

3.3.1 Organizational Structure

It is without question that there is the need to adjust the institutional system or framework at both the regional and national levels for the DSS regional network. It is important to decide on: (a) the type of organizational structure for the regional network, which can, in theory, be developed either as a centralized system or a decentralized one; and (b) to decide on a single agency within each partner country to serve as the national focal agency.

<u>Centralized Regional System</u>

A centralized system assumes that it is necessary to establish an operational regional center for DSS monitoring and early warning for the region, or at least for all the partner countries. This implies that all the relevant data collection agencies in each of the four countries would be reporting to the regional center, which can be operated by the experts and technicians

[2] An agreement reached during the Second Workshop on DSS Regional Monitoring and Early Warning Network in November 2003.

from the partner countries. Among others, the regional center should be responsible for data processing, DSS model simulation, and forecasting for early warning services for all the partner countries. This would require a centralized regional institution supported by a central facility and special purpose-built infrastructures and equipment to collect, transmit, analyze and store data. To establish a centralized system would be full of financial and administrative challenges. Furthermore, it is not always appropriate and desirable for a regional center vis-à-vis the concerned national authorities to provide early warning services in the form of public advisory for a forthcoming disastrous event like DSS.

Within the notion of a centralized system, however, there is quite a reasonable suggestion that data concerning DSS collected by various domestic agencies flow into a national center for DSS monitoring and early warning services. The national center of each partner country can coordinate all the agencies involved in data collection within the country to avoid overlapping or duplication. Moreover, each national center can then serve as the focal point for participating in and cooperating with the proposed regional DSS monitoring and early warning network. The data on DSS centralized at the national center, including the selected real time monitoring data, may be stored in a national databank and shared with its counterparts in other partner countries through the proposed network.

<u>Decentralized Regional System</u>

Decentralized system does not require a regional operational center for the partner countries. The four countries will continue to have their own independent DSS monitoring and early warning systems, which will be connected to each other through an operational network. Through participating in the regional network, each national DSS monitoring and early warning system expects to receive additional benefits through sharing and exchanging data and experiences in DSS monitoring and modeling for forecasting and early warning. The network does not require the construction of new centralized facilities, except for the additional monitoring and communication facilities that enable all the partner countries to collect and report the required data in a pre-determined manner. Under the decentralized system, there is still the possibility of having bi-lateral agreements between specific partner countries for specific data collection and sharing arrangement(s).

<u>Viable Regional Organization Arrangement</u>

The centralized system with the construction of a regional center does not appear to be a feasible and desirable model for the proposed regional network. A decentralized network can be established as a flexible and informal network for various institutions or agencies in the region to participate on a voluntary basis. Alternatively, it can be established as a formal operational structure that requires mandatory data sharing and reporting among the agencies of the partner countries in accordance with a commonly agreed manner for the forecasters and modelers of the partner countries.

It appears practical that the regional network be established as a decentralized regional network, which is supported with a monitoring system comprising a set of carefully designated DSS monitoring stations in the partner countries. These stations are to collect and report the selected DSS monitoring data under the coordination and supervision of the designated national center for real time sharing and exchanging among the partner countries.

<u>National Focal Point and Inter-agency Coordination</u>

Selection of a single agency to serve as the national focal point for the regional network on DSS could be a challenging issue that needs to be addressed carefully. It should be noted that most countries have mandated their meteorological agency (MA) to make forecasts on weather-related phenomena or providing public advisory or early warnings on the disastrous events like DSS. MA in each country has a wide range of monitoring stations that can provide DSS monitoring for the regional network. The meteorological system has a high-speed cross-country data transmission network that can serve as the basic infrastructures for DSS data sharing among the partner countries. It seems to be difficult to expect an operational network for DSS monitoring and early warning without the participation of the MA in the partner country. For some countries, it seems natural that their MA be nominated as the lead agency to serve as the national focal point for the regional network on DSS.

It should be noted, however, that MA is not the only agency that collects DSS monitoring data and works on DSS forecasting and early warning. Furthermore, the work done by MA has its limitations because the focus of its analysis is on forecasting weather-related adverse effects. Air quality concern and DSS source identification and mitigation are not within the main stream activities of the MA. One specific concern for non-MA agency is that the data collected or reported through the MA systems are not readily available to the non-MA modelers and researchers. These observations are of special importance for Japan where the core DSS researchers and modelers are from research institutes or universities who do not have direct access to meteorological data system. Inter-agency coordination of DSS monitoring and early warning between MA and non-MA agencies at the national level would be essential for the success of the network.

Given the limitations of the MA, it should be recognized that DSS monitoring and early warning could not done by the MA itself. The regional network, which requires free flow of DSS information between partner countries, needs to be established on the smooth collaboration among the DSS concerned agencies within each country first. There are many administrative hurdles to overcome before full and free flow of information between agencies and institutions become routine. There are reasons for this. The principal one is that the monitoring sites that were set up by each institution were designed for its own special purpose. There was little thought been given to how compatible their data sets might be with the others because it was never envisaged that they would be shared for DSS monitoring. Links should be formed between institutions to avoid unnecessary competition and duplication of effort. Institutions working on similar issues may arrange to specialize and to dovetail their activities to enhance cost-effectiveness.

Within the purview of their overall mandate and responsibility, the Ministry of Environment (MOE) of each partner country could stand as the sub-national focal point for the DSS regional network. Its role in the network would place support for the national focal point agencies to improve the environment with emphasis on air quality and health concerns. This public institution would also play a part in the data sharing scheme of the network.

Establishment of the network for DSS monitoring and early warning has offered the possibility for the partner countries to promote integration of the separate and isolated DSS monitoring efforts by the various institutions in their countries into one coordinated and coherent endeavor, not only on a national level, but also on a regional level across countries. Through regional cooperation, the network would be able to develop among the partner countries: (i) a set of DSS monitoring indicators, (ii) a commonly agreeable monitoring techniques equipped with standardized monitoring instruments, (iii) a standardized data sharing, reporting, and exchanging mechanism, and (iv) an agreed operational procedure and supervision mechanism.

Setting up a regional network implies agreement among the four partner countries and their various institutions and agencies to share relevant data for the purpose of facilitating more accurate and reliable forecasts of DSS events and the provision of early warning to reduce hazard. It also suggests the setting up and maintenance of long-term monitoring for the purpose of assessing the success of mitigation efforts.

3.3.2 The Selection of Network Monitoring Stations

Functions of the Network Monitoring Stations

For an improved DSS monitoring, forecasting, and early warning, it is envisioned that the main function of the designated stations within a country for DSS regional network is to provide real-time data of selected monitoring indicators, specifically to their respective national focal agency. This is for purposes of sharing the data with the national focal agencies of other partner countries and for the data assimilation model within their own national forecast system at their respective national focal agencies. Through this arrangement, these regional network stations can play two specific operational functions for the national focal agency in each partner countries: (i) to facilitate an early capture of the breakout and/or movement of DSS events in the region, and (ii) to enable the national focal agencies to have a rolling assimilation of DSS events through timely and repeated updating of the monitoring of DSS events along its transportation route within the region. By comparing the ground-based monitoring data selected with the monitoring indicators obtained through other techniques (e.g. remote sensing data through satellite images), the national focal agencies will be able to verify, on a timely and continuous basis, their assimilation models in their forecast system to significantly improve their capacity in providing accurate early warning services.

Given the long-distance transportation route of DSS from its breakout through dust deposition across the Northeast Asia region, it is most important to make an assessment of the relevance of the existing monitoring stations in each partner country to identify an appropriate group of the network monitoring stations as initial network monitoring stations. Based on assessment of their significance in capturing the breakout and movement of DSS event in the region, these network monitoring stations needs to be classified into two different categories, to be equipped with different monitoring capacity for their expected roles in the regional network. The classification is important because it is neither feasible nor necessary to equip all network monitoring stations with the same capacity at the initial stage of the network development, which is expected to handle a minimum set of the most relevant monitoring indicators for improving the early warning capacity for the region as a whole.

Classification of Monitoring Stations and Specification of Relevant Instrumentation

Based on the geographical locations of the stations and the selected monitoring indicators discussed, the network monitoring stations fall into the following two categories:

1) Class A Stations: are the *key stations* since they are geographically important (e.g., located at the DSS source areas). These stations have (or are going to have) the capability to measure ground surface conditions, meteorological data (as prescribed by the WMO), suspended particles by instrument measured visibility, LIDAR and PM_{10} (and TSP). There are currently a few Class A Stations in the PRC and none in Mongolia. Visibility, PM_{10}, and LIDAR allows Class A Stations to provide real time data on spatial distributions and vertical profile of an ongoing DSS, which have special importance for the remote forecast centers to capture the physical details of a DSS event for simulation and early warning. It is crucial for the regional network to ensure data exchange in real time between the partner countries, or among these stations that are fully equipped. It is an urgent priority to upgrade the capacity of the station(s) that have been designated as Class A Station.

2) Class B Stations: comprise of the *general stations* in the regional network that can monitor and report PM_{10} data in real time over a long distance, in addition to reporting visibility data. The important feature of these stations is their capability to measure suspended particles like PM_{10} (and TSP by batch sampling). PM_{10} data is essential to measure air quality. The data from these stations together with those from the Class A stations are vital for DSS simulation and modeling at remote forecast centers because it can be monitored and reported in real time. Not all the designated Class B stations in the network have the capacity to measure dust particle concentration. It will take time to upgrade the monitoring capacity of these existing stations, particularly those in Mongolia where there are none capable of monitoring PM_{10}.

It should be noted that in this two-layer hierarchy, there is a relatively large number of Class B Stations at present that can offer visibility data and PM_{10} data. Likewise, very few Class A Stations at geographically important locations have LIDAR equipment.

To develop the network monitoring stations, different strategy should be adopted for the instrumentation of stations. The widely applied naked-eye-based observation of visibility should be replaced with instrumented data. It is expected that instrumental measured visibility data would allow standardization of monitoring operation, and provide a more solid basis for cross-country reporting and comparison. The main constraints to successful operation of Class A Stations will be the availability of LIDAR monitoring equipment and the operating capacity including the required support infrastructure facilities. The key for successful operation of Class B Stations is to ensure the availability of instrument-measured visibility and PM_{10} monitoring equipment and a standardized monitoring operation for real time reporting.

In addition, it should be noted that the network monitoring stations downwind of the DSS source areas, such as those on the coastal areas of the PRC, in Japan and the Republic of Korea are usually well equipped. They have a very important role to monitor the impact of DSS, analyze deposition process of DSS, and provide early warning services. The existence of these stations provides a greater possibility for the modelers and researchers in the region to establish, by incorporating the monitoring data collected from these stations, a full simulation cycle of DSS event from its outbreak to deposition.

Phased Development of the Regional Network

Taking into account the financial and technical (including human capacity) constraints, a phased approach is necessary for the development of the network of monitoring stations in each of the partner countries. The partner countries need to identify a set of designated network monitoring stations and reach a consensus on their classification, based on their significance in DSS monitoring and early warning for the region. Upon commencement of the operation of the regional network, monitoring data available from the existing monitoring stations in each partner country could be shared immediately. Continued efforts should be made through cooperation by all the partner countries to improve the network gradually but steadily, by standardizing the monitoring operation, data reporting and sharing mechanism, and upgrading both the human resource and equipment capacity at a later stage or phase, probably along with the necessary expansion of the network. Moreover, the phased development should carry the experiences of the ongoing cooperation between the PRC-Korea and the PRC-Japan and need not be thought of as a rigid sequence where each phase needs to be completed before the next phase begins.

The phased development should include upgrading selected network monitoring stations along the hierarchical structure over the short- to medium-term. The salient features of the envisioned three phases of development are as follows:

- **In Phase 1** (short term) The emphasis of this phase is on *data sharing and capacity development for monitoring and early warning and data transmission.* The forecasting result sharing is encouraged whenever possible. The agreed DSS monitoring data will be shared among the partners. A system of network monitoring stations will be established to comprise 25 stations in the PRC and 6 in Mongolia plus the stations in Japan and the Republic of Korea. These stations are expected to form a chain of key monitoring stations from the DSS source areas to the depositional areas along the main DSS transportation route across the region. Apart from standard meteorological data, the main indicators for data sharing would be *particulate concentration* data (measured by PM_{10} and LIDAR) and *visibility*. Phase 1 should also include necessary technical upgrading. A target should be set to upgrade, within the short-term, the traditional naked-eye based visibility measurement at each network monitoring station to an instrumented one (to do away with the subjectivity associated with visual estimates). Selected stations (two to five) in both the PRC and Mongolia will be equipped with LIDAR equipment to give better assessment of the vertical profile of DSS events. Initial training and capacity building for a standardized monitoring and reporting operation would be a component in this phase. It is also proposed that outcomes of the DSS simulation and forecast at the national focal agencies be shared among the partner countries in a timely way as well. It is noted that this arrangement could give special benefits to Mongolia for its participation in the network, given its relatively less developed DSS assimilation and forecast capacity. A decentralized network is preferred with data sharing for the purpose of short-term forecasting.

- **Phase 2** (medium term) The focus is on *strengthening the DSS monitoring network.* Activities could include (i) expansion of the network by including about 30 additional monitoring stations to the network, and (ii) upgrading monitoring capacity of more stations in the network. Priority for network expansion should be given to help Mongolia build up its national DSS monitoring capacity as part of the longer term development. The main focus of technical upgrading at this phase will be provided for most of the network monitoring stations. Because PM_{10} data are available in real-time, such data are more useful for forecasting and early warning than data derived from TSP sampling. Technological progress in high-speed sampling and analysis may make TSP more useful in the future for forecasting and EW. The further development of sites to include LIDAR would be a feature of this phase. Selected stations along the chain of stations (including those in the DSS source areas), would be a high priority for upgrade. Intensified efforts for capacity building on application of the more sophisticated monitoring instrument and frequent exchange of experiences among experts in DSS modeling would be the main feature of the capacity building program during this phase.

- **Phase 3** (long term) The main focus of Phase 3 is to *improve DSS forecasting methods* to provide both short-term (early warning) and long-term (seasonal) predictions. Long-term forecasting will depend heavily on data derived from ground surface monitoring and on verification of prediction model output. It would also be a time to improve the overall capacity in Mongolia in the field of DSS forecasting through software development for modeling and simulation, training of personnel for monitoring stations, data processing and interpretation, etc. The possibility of getting sufficient external funding support for this aspect should be explored. . Based on the experiences of the first phases, the partner countries may consider expanding the regional cooperation by involving other relevant countries in the region (e.g. Kazakstan). The four partner countries may explore, once again at this stage, the necessity to set up a regional databank, which might provide a platform for training and exchange of experiences and technologies on DSS monitoring and early warning with an overall objective to have the partner countries reach a similar level in terms of national capacity to monitor DSS events, forecast DSS outbreaks (onset), and predict transport routes, transit times, likely duration, and geographic distribution..

Direction of Capacity Upgrading

The findings of scientific researches have made it possible to understand the relationship between the atmospheric visibility and dust concentration. In the course of constructing the regional network for DSS monitoring and early warning in Northeast Asia, one of the priorities is to upgrade the visibility meter (Transmissometers) based observation stations from manual operation to instrumental operation as the network standard. Efforts will then go into research on identification of the quantitative relationship between visibility and dust concentration. Such identification may provide a solid basis to link up the visibility based simulation with the dust concentration based simulation of DSS events. Along with upgrading the capacity of most of the network stations during Phase 2 of network development, the above efforts will provide the possibility of combining the visibility and dust concentration into an integrated and more powerful simulation and forecast system. The DSS visibility forecasting combined with the DSS concentration forecasting may constitute the groundwork for the future DSS forecasting to not only predict dust concentration but also compare it with the observed concentration from the network monitoring stations in near real-time.

The Proposed Network Monitoring Stations in the Region

After consultation with the various stakeholders, it was agreed that the following stations are proposed to comprise the base stations for the regional network in the DSS source areas as well as in the downstream areas:

In the PRC: It is proposed that a national DSS data center (located in CMA) be established jointly by CMA, SEPA and SFA. This national focal agency could manage the input from all the PRC government agencies whose data would contribute to DSS forecasting and early warning. This national focal agency will also coordinate the network monitoring stations in the PRC for their participation in the regional network. Consistent with the phased development approach, the network development in the PRC will be done in the following phases:

- In Phase 1, the national DSS data center should be established and a network of 25 identified monitoring stations with various monitoring capability should be integrated into this system (see Table 3.1). The communication network, and hardware and software components should be upgraded at these 25 stations so as to monitor DSS-related parameters in real-time. A distribution map of the 25 stations is shown in Figure 3.4.

- In Phase 2, an additional of 18 monitoring stations should be included in the regional network (Table 3.2) in line with the envisaged expansion and upgrading of the network. A total of 43 stations, plus the national DSS data center, would comprise the system of DSS network of monitoring stations for the PRC. The national DSS data center gathers and analyzes the real-time data collected by the system and provides the real-time information to its counterparts in the other partner countries. The national DSS data center is also prepared to share the outcome of its DSS simulation and forecast with its counterparts in the partner countries, if the partner countries could reach an agreement on such information sharing and exchange.

Selected stations with LIDAR capacity/potential would be included in the DSS monitoring network, but the time of their inclusion will be decided based on resources availability and agreement between the PRC and concerned parties.

Figure 3.4 Selected Monitoring Stations in the PRC for DSS Regional Network

Source: CMA

Table 3.1 Proposed Phase 1 Monitoring Stations for DSS Network in the PRC

	Site	Visibility	TSP	PM_{10}	LIDAR	Additional Capacity
1	Jiuquan	*	//	*		
2	Minxian	*	*	*		
3	Germud	*	*	*		
4	Lanzhou	*	*	//		
5	Yinchuan	*	*	//		
6	Houma	*	*	*		
7	Datong	*	*	*	*	o
8	Zhangjiakou	*	*	//		
9	Erlianhaote	*	//	*		
10	Huhehaote	*	*	//	//	
11	Neimeng-Zhurihe	*	*	*		
12	Dianjiang	*	*	*		
13	Nanyang	*	*	*		
14	Shenyang	*	*	//		
15	Changchun	*	*	//		
16	Beijing	*	//	//	//	
17	Qingdao	*	*	//		
18	Zhengzhou	*	*	*	*	o
19	Lianyungang	*	*	*		
20	Akesu	*	*	*		
21	Bayannuoergong	*	*	*	*	o
22	Xingzi	*	*	*		
23	Baicheng	*	*	*		
24	Donggang	*	*	*		
25	Suniteyouqi	*	*	*		

Note : // means existing instrumented capacity; * means adding needed equipment; o means with a plan for adding equipment in the future.

Table 3.2 Proposed Phase 2 Additional Stations for DSS Network in the PRC

No.	Site	Visibility	TSP	PM_{10}	LIDAR	Essential Meteorology Data
1	Xinjiang-Hetian	∗	//	∗		//
2	Xinjiang-Hami	∗	//	∗		//
3	Xinjiang-Kashi	∗	//	∗		//
4	Xinjiang-Wulumuqi	∗		//	∗	//
5	Xinjiang-Ruoqiang	∗		∗		//
6	Neimeng-Ejimaqi	∗		∗	∗	//
7	Neimeng-Xilinhaote	∗		∗		//
8	Neimeng-Chifeng	∗		//		//
9	Neimeng-Wulanhaote	∗		∗		//
10	Neimeng-Hailaer	∗		∗		//
11	Qinghai-Xining	∗		//		//
12	Qinghai-Waliguan	∗		∗	∗	//
13	Gansu-Zhangye	∗	//	∗	∗	//
14	Gansu-Xifeng	∗		∗		
15	Shandong-Jinan	∗		//		//
16	Liaoning-Dandong	∗		//		//
17	Jiangsu-Nanjing	∗		//		//
18	Jilin-Tumen	//		∗		//

Note : // means existing instrumented capacity; ∗ means currently non-instrumented observation but equipment for monitoring visibility is needed or means will be adding needed equipment; “empty cell” means no plan for adding equipment in the near future.

In Mongolia: Mongolia is the home site of over 30% of the DSS events experienced by the region. It’s DSS monitoring infrastructure and capacity is relatively weak. This situation has provided a unique challenge and opportunity to improve DSS monitoring and early warning for the region as well as Mongolia---to strengthen DSS monitoring capacity in Mongolia would not only benefit Mongolia, but give considerable benefits to all the downstream partner countries through incorporating the monitoring data obtained at the origin of DSS.

On top of the list of needs is the establishment of a national network of DSS monitoring stations. Any new stations should be fully integrated into the system of the network monitoring stations. There is clear need to strengthen the monitoring data collection capacity in south Mongolia (see Box 3.1).

Over the medium term, Mongolia plans to establish a national DSS monitoring network consisting of 18 stations that are located in dry steppe, semi desert and desert areas (see Figure 3.5 and Table 3.3). The network monitoring stations are located along the dust path and windward side of the significant anthropogenic sources.

The selection of the network monitoring stations is based mainly on natural features of the area such as frequency of DSS occurrence, geographical location (intermountain corridors), and soil texture. In addition, the impact of industrial development such as mining (metal and coal) and exploration activities that can accelerate soil loosening and accumulate fine dust materials was considered. Of these 18 stations, 6 are to be designated as network monitoring stations for Phase 1 (Table 3.4) and the rest for Phase 2 (Table 3.5).

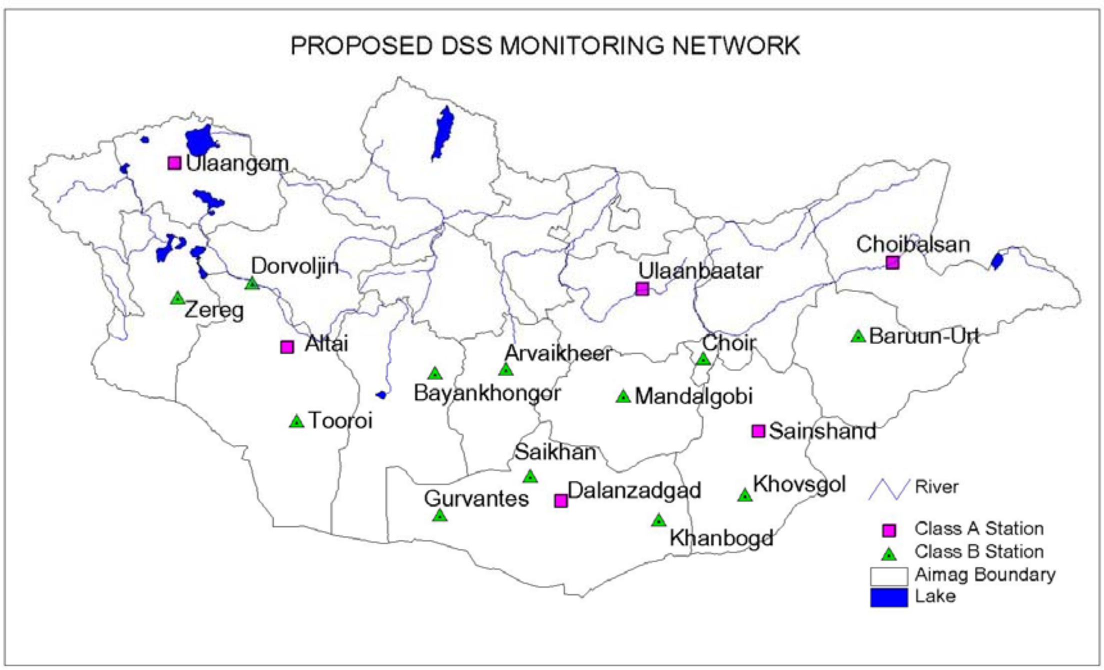
Box 3.1 Improving Present Monitoring Capacity of Mongolia

Requisites to improve current national capacity for monitoring and early warning of Mongolia are as follows:

1. Establishment of a national network for DSS monitoring and early warning involving all the major stakeholders.
2. Present monitoring and early warning system is limited to meteorological observation and weather forecasting. Improvement and upgrade of stations are warranted. Some meteorological stations located in the DSS area need to acquire new instruments for measuring DSS indicators. A minimum of three Class A DSS monitoring stations need to be established along the dust and sand sources area in the intermountain windy corridor.
3. There is an urgent need to develop the modeling and prediction system specialized for DSS forecasting with a capability to provide a 12-hour advance prediction for an early warning of a DSS event.
4. Necessary communication infrastructure in remote DSS source areas is needed to ensure real time data sharing and reporting.

4. Strengthen cooperation in the areas of data-sharing as well as in the exchange of the research results, experience, and technology with other partner countries.
5. Systematic training and development of human resources at all levels.

Figure 3.5 Location and Classification of the DSS Monitoring Sites in Mongolia



Source: Consultant Team

Table 3.3 List of Proposed DSS Monitoring Stations in Mongolia

	DSS Monitoring Stations and their Monitoring Program[1/]														
Aimag (province)	**Station Name**	**Class**	**Operator**	**Power supply**	**T,P,WS/D,Pr, Vis**	**Visibility**	**Soil moisture**	**TSP**	**PM_{10}**	**Surface condition**	**LIDAR**
Bayankhongor	Bayankhongor	B	WMO	E	+	+	+	+	+	+	
Gobi-Altai	Altai	B	WMO	E	+	+	+	+	+	+	
	Tooroi	B	NAMHEM	L	+	+	+		+	+	
Dornod	Choibalsan	B	WMO	E	+	+	+	+	+	+	
Dornogobi	Sain Shand	A	WMO	E	+	+	+	+	+	+	+
	Khuvsugul	B	NAMHEM	L	+	+	+		+	+	
Gobisumber	Choir	B	WMO	E	+	+	+	+	+	+	
Dundgobi	Mandalgobi	B	WMO	E	+	+	+	+	+	+	
Ovorhangai	Arvaikheer	B	WMO	E	+	+	+	+	+	+	
Omnogobi	Dalanzadgad	A	WMO	E	+	+	+	+	+	+	+
	Saikhan	B	NAMHEM	L	+	+	+	+	+	+	
	Gurbantes	B	NAMHEM	L	+	+	+		+	+	
	Khanbogd	B	NAMHEM	L	+	+	+	+	+	+	
Sukhbaatar	Baruun-Urt	B	WMO	E	+	+	+	+	+	+	
Uvs	Ulaangom	B	WMO	E	+	+	+	+	+	+	
Khovd	Zereg	B	NAMHEM	L	+	+	+		+	+	
Ulaanbaatar	Ulaanbaatar	A	WMO	E	+	+	+	+	+	+	+
Zavkhan	Durvuljin	B	NAMHEM	L	+	+	+		+	+	

[1/] + means programmed monitoring; L means power supply is limited while E means power supply is available.

Source: Compilation of Consultant Team

Table 3.4 Proposed Sites for DSS Monitoring in Mongolia for Phase 1

	Monitoring Site	Visibility	TSP	PM_{10}	LIDAR*	AWS
1	GobiAltai – Altai	+	+	+		o
2	Dornod – Choibalsan	+	+	+		o
3	Dornogobi – Sain Shand	+	+	+	+	o
4	Umnogobi – Dalanzadgad	+	+	+	+	o
5	Uvs – Ulaangom	+	+	+		o
6	Ulaanbaatar	+	+	+	+	o

Note : + means needed equipment; o means available equipment
* Proposed to be equipped by Japan under a cooperation agreement
Source: Consultant Team

Table 3.5 Proposed Sites for DSS Monitoring in Mongolia for Phase 2

	Monitoring Site	Visibility	TSP	PM_{10}	LIDAR	AWS
1	Bayankhongor – Bayankhongor	+	+	+		o
2	GobiAltai – Tooroi	+		+		+
3	Dornogobi – Khuvsugul	+		+		+
4	GobiSumber – Choir	+	+	+		o
5	Dundgobi – Mandalgobi	+	+	+		o
6	Uborkhangai – Arvaikheer	+	+	+		o
7	Umnogobi – Saikhan	+	+	+		+
8	Umnogobi – Gurbantes	+		+		+
9	Umnogobi – Khanbogd	+	+	+		+
10	Sukhbaatar - Baruun-Urt	+	+	+		0
11	Khovd – Zereg	+		+		+
12	Zavkhan – Durvuljin	+		+		+

Note : + needed equipment; o available equipment
Source: Consultant Team

In Japan and the Republic of Korea: As the downstream DSS countries, both Japan and the Republic of Korea have meteorological and DSS monitoring stations that are already equipped to play their part in the DSS regional network. Hence, these stations are listed to form part of the network for the first phase of network development while more stations are planned for inclusion in the future for the second phase.

Table 3.6 Proposed Sites for DSS Monitoring in Japan for Phase 1

	Monitoring Site	Class	Visibility	TSP	PM_{10}	LIDAR	AWS
1	Sapporo	A	o	o	o	o	o
2	Toyama	A	o	o	o	o	o
3	Tsukuba	A	o	o	o	o	o
4	Fukue	A	o	o	o	o	o
5	Nagasaki	A	o	o	o	o	o
6	Miyako	A	o	o	o	o	o
7	Matsue	A	o	o	o	(o)	o
8	Niigata, Maki	B	o	o	o		o
9	Tateyama (Toyama)	B	o	o	o		o
10	Inuyama	B	o	o	o		o
11	Fukuoka	B	o	o	o		o
12	Ryori	B	o			o	o

Note: o means available equipment; “empty cell” means not available.
Source: MOE of Japan

Table 3.7 Proposed Sites for DSS Monitoring in the Republic of Korea for Phase 1

	Monitoring Site	Class	Visibility	TSP	PM_{10}	LIDAR	AWS
1	Incheon – Incheon	A				o	o
2	Chungcheongnamdo – Gwangdeoksan	B		o	o		o
3	Incheon - Bakryengdo	B		o	o		o
4	Seol – Gwanaksan	B		o	o		o
5	Chungcheongnamdo – Anmyundo	A		o	o	o	o
6	Chungcheongbukdo – Chupungryeng	B		o	o		o
7	Jeollabukdo – Gunsan	B		o	o	o	o
8	Gwangjusi – Gwangju	B		o	o		o
9	Jeollanamdo – Heuksando	B		o	o		o
10	Jejudo-Gosan	B		o	o		o
11	Incheon – Gangwha	A		o	o	o	o
12	Chungcheongbukdo – Chunan	B		o	o		o

Note: o means available equipment; "empty cell" means not available.
Source: MOE and KMA

3.4 Technical Considerations

There is a need for a unified classification of DSS phenomenon for the proposed regional network. WMO has classified DSS weather into 11 categories, which could be distinguished by routine weather observation elements (wind and visibility) and they have been used in operational weather observation by its member countries. Its network covers the whole world and it is the single data source for monitoring DSS at a regional level in Northeast Asia. Therefore one of the possible way for the proposed regional network to classify DSS phenomenon is to follow the methodology based on wind and visibility data. In accordance with different characteristics of DSS and the weather observation acquired, DSS is mainly classified into the following four categories:

- Floating dust - widespread dust in suspension not raised by wind with horizontal visibility between 1 to 10 km.;
- Blowing sand - dust or sand raised by wind with horizontal visibility between 1 to 10 km.;
- Dust and Sand Storm - dust or sand raised by strong and turbulent wind with horizontal visibility less than 1 km.; and
- Severe Dust and Sand Storm - dust or sand raised by strong and turbulent wind with horizontal visibility less than 500 m.

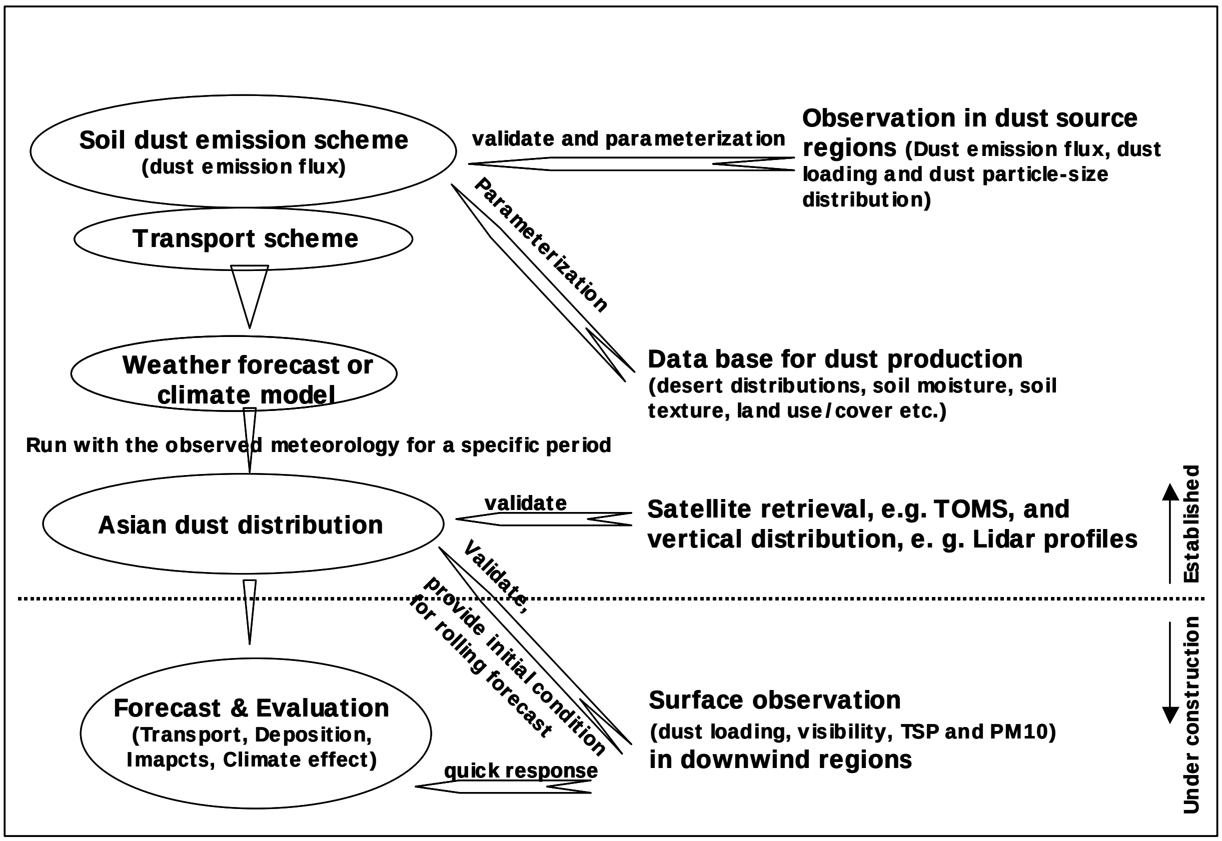
WMO criteria is proposed as a regional level classification of large scale DSS in Northeast Asia. This can be used till a new generation of dust concentration-based (e.g. PM_{10} and LIDAR) network monitoring stations has been established through technical upgrading.

There can be a local classification of DSS phenomenon based on dust or sand concentration. TSP and PM_{10} are the parameters that characterize the unique qualities and concentration of dust and sand in the air of a particular locality. It is impossible to classify the large-scale DSS phenomenon based on TSP or PM_{10} measurements without a regional monitoring network at the same instrumentation level in Northeast Asia. But dust concentration based classification can be established at local level based on TSP or PM_{10} data acquired at a specific locality. The partner countries can be encouraged to use concentration of suspended particles as a standard parameter to classify the DSS phenomenon at the local level since this will characterize the different particles suspended in the air and provide the basis to prepare local response. For this, more study is required.

3.4.1 Conceptual Framework for DSS Simulation and Forecasting

Figure 3.6 provides a conceptual framework for DSS simulation and forecasting, which forms the basis for early warning of DSS events. It is important to note that DSS simulation and forecast requires a huge amount of data obtained from different sources including remote sensing through satellites and sophisticated modeling capacity. As indicated in Figure 3.6, most of the basic infrastructures and database for DSS simulation and forecasting has already been established in the region, though at different levels in each partner country (except for Mongolia where the DSS simulation and forecasting capacity is yet to develop). As indicated in the lower part of the diagram, one important role of the proposed regional network is to establish and enhance the interaction between the forecast centers in the region and the network monitoring stations for more accurate prediction and early warning of DSS events.

Figure 3.6 A Conceptual Framework for DSS Simulation and Forecasting



This is because to accurately capture and predict the dust cycle associated with DSS events, the spatial and temporal distribution of dust loading derived from the simulation model need to be frequently validated with monitoring data gathered from ground observation through a system of the network monitoring stations scattered along the transportation routes of DSS from its origin to deposition. Continued validation of DSS movement at the ground level would allow the forecast centers in the region to have timely refinement of its forecast model through establishing a rolling simulation of a specific DSS phenomenon for more accurate prediction and early warning of the DSS event. The regional network can also enhance the development of DSS simulation and forecasting technology by promoting exchange of forecast outcomes and experiences among the forecast centers of the partner countries. This exchange will have special benefits for Mongolia where the simulation and forecasting capacity is less developed. An elaboration of DSS simulation and forecasting in the PRC is provided for reference in Box 3.2.

Box 3.2 DSS Simulation in the PRC

Scientists have conducted the model simulation of the Asian dust from 1960 to 2002. Initial parameters of the deserts in the PRC and Mongolia and other potential source areas are obtained through various sources including satellite images and WMO. Ground surface conditions in the PRC have been verified against surface observations. The combined data sets for the desert distribution/texture, land-use/roughness length, vertical flux size distribution and satellite observed soil moisture form a coherent input parameter set for the soil dust emission scheme which shows satisfactory results for simulations of the DSS events in recent years.

Comparisons between the model output and network monitoring observation under the ACE-Asia Experiment (the Asian Pacific Regional Aerosol Characterization Experiment) have shown that the model reproduces, with reasonable accuracy, the dust emission strength and hence the soil dust concentrations in the PRC and the areas downwind of the source regions. Based on all this work, a Numerical Weather Prediction (NWP) framework in the forecasting of DSS at the very-short and short ranges has already been set up at the China Meteorological Administration (CMA). The CMA has started providing early warning for DSS events through official public advisory since 2002.

3.4.2 Operational Mechanism

Operational Functions of a DSS Network

The setting up of the regional network and the associated national system for DSS monitoring and assessment will facilitate a deeper probe into causes of the DSS problem and, therefore, establish a scientifically justified perspective for policy making at the national and regional levels.

While it is a clear intention of the governments of the four partner countries to improve the level of regional cooperation on DSS, it is also clear that the mechanism and operation of data-sharing need to be worked out carefully. The main functions of a successful operational DSS network would be to:

- Clarify source areas, transport routes, and influence areas of DSS events. With access to the data accumulated for years, spatio-temporal distribution of DSS events, the physics of long distance transport of dust aerosols and the environmental impacts of each DSS will be clearly identified.

- Provide the scientific information for early forecasting and warning and for validation of models and simulations

To be effective for timely early warning, the DSS simulation and forecast models need a data collection and reporting system that can satisfy the following two key requirements:

- *Effective timeliness*: High-speed exchange of DSS monitoring data between the countries in the region and among the concerned agencies within an individual country.

The observational data should be transmitted to users within one hour, so that the data could be applied in producing DSS forecasting and early warning.

- *Maintained as an operational system:* The system should be kept running in a seamless, stable and reliable manner. Therefore, real time monitoring of its operation and emergency response capability is required. The response time should be limited to less than 30 minutes.

<u>Purpose of Data Sharing</u>

Real time data is essential for early warning services and would be used by modelers and forecasters at the forecasting center of each country (and probably by other relevant researchers as well). Timely receipt of real time data from the network monitoring stations would provide modelers and forecasters with the necessary information to make predictions about DSS paths, transit time, duration and severity as well as the geographic extent. It would also allow the rolling simulation at the capable forecast centers. By feeding back the forecast results to the network monitoring stations located at the DSS sources areas and along the transportation route, the regional network would not only allow for timely and improved model validation by ground observation, but also provide an opportunity for the forecast centers with more advanced simulation and forecasting capacity to benefit their counterparts through exchange of forecasting experiences, thus strengthening the forecasting capacity of the region as a whole.

After the DSS event has passed the archival data might be used as part of the national monitoring and evaluation effort to evaluate the accuracy of the simulation and forecasting model, and the success and effectiveness of the early warning attempt. They serve also as the database for designing more effective mitigation measures to prevent and control DSS.

<u>Mechanism for Data Sharing</u>

There exist a number of mechanisms for DSS data sharing among the partner countries (see Box 3.3 on Existing Mechanism for Data Sharing). They fall into the two types of data mechanism. Characteristics of the existing data sharing mechanisms are as follows:

(i) Data collection and transmission as part of the WMO agreement. This is a system of real time transmission of meteorological data from various monitoring stations in each member country to regional center for processing. Data provided in this system forms the basis for weather forecasts. The system has the capacity to handle large quantity of data needed for DSS simulation and has been working well at the regional level, but data transmitted in this system is generally not accessible to researchers who work outside the system.

(ii) Data collection and sharing under bilateral arrangement. Under these bilateral agreements, DSS data are collected with sophisticated instruments at several purpose-built or equipped monitoring stations. Data collected at these stations are transmitted to the host institutions, principally for research purposes. These stations have limited capacity to efficiently transfer large quantity of real-time data. Because of their recent establishment, these stations have no historical baseline data. Data from these stations may be of significant importance to scientific research on DSS phenomenon, but cannot be used as the basis for operational DSS forecasting and official early warning given the limitation noted.

Box 3.3 Existing Mechanisms for Cross Country Data Sharing

All of the partner countries are members of the World Meteorological Organization's (WMO) worldwide network. Selected monitoring stations in each country supply meteorological data at frequent intervals to the WMO centers. Data on visibility, wind direction and strength and other parameters of relevance to DSS are collected routinely as part of the WMO requirement using similar standards and indicators.This is an example of an "official" (government to government) data exchange mechanism.

The Meteorological Research Institute of Japan (JMRI) has carried out the Japan-China cooperative project ADEC in conjunction with Institutes of the Chinese Academy of Sciences. DSS monitoring stations have been set up in the DSS source areas in the western PRC and along the transport route of the dust aerosols on their way to Japan. The fully instrumented monitoring sites in the Taklamakan desert in Xinjiang provide data on the DSS outbreak and entrainment in eastward airflows. Transport and deposition are also analyzed. Numerical experiments using the Global Climate (dust forecast) Model (GCM) have also been carried out to assess the impact of dust aerosols on global climate. The monitoring is seasonal (not continuous throughout the year) and the data is not sent in real time.

The Sino-Japan Friendship Environmental Protection Center and National Institute for Environmental Studies (NIES) of the Ministry of Environment of Japan have undertaken joint research on DSS. The principal focus was on DSS transport and the environmental effect of DSS aerosols originating in the northern PRC. A DSS monitoring network was established in northeast PRC and Japan in February 2001. Six stations were established along a transect from Beijing to Erinhot - the designated source area. The sites were at Beijing, Zhangjiakou, Zhangbei, Huade, Sonid Youqi, and Erinhot over a distance of more than 1,000 km. In addition to the sites in the PRC, three sites were monitored in Japan[3]. The monitoring is continuous throughout the year and the data is sent through internet in real time basis.

The Korea-China Environmental Science and Technology Exchange Center was established in 1999 in the National Institute of Environmental Research (Seoul). The principal function is to facilitate exchange of environmental information (and personnel) and the promotion of joint research. KMA is cooperating with CMA on Asian Dust forecasting. Five DSS monitoring stations will be set up (three in eastern PRC and two in the Asian Dust path). These stations will be operated during the DSS season from February to May with the sharing of information and exchange of experts. Currently, the monitoring data is sent as an email attachment.

Note: This reiterates Section 2.5 on the existing bilateral initiatives on DSS monitoring.

To ensure effective data sharing for operational early warning of DSS in the region, two issues must be considered when designing the system: *firstly*, the collection of appropriate data from the network monitoring stations; and s*econdly,* the transmission of monitoring data among the partner countries within the region in real time.

In the immediate short term, it might be necessary to continue relying on the existing bilateral arrangements to ensure that relevant data are exchanged between the partner countries concerned. Given the limitation noted above, a more reliable data sharing mechanism for operational (rather than research oriented) DSS forecasting needs to be developed over time. First of all, each partner country should designate a national focal agency to coordinate DSS monitoring activities within the country and coordinate the country's participation in the regional network. Desirably, the regional network could establish a specialized communication system to allow for real time data sharing within the network. This does not appear to be a feasible solution. Apart from the exclusiveness of the system under MA, the communication system under WMO could be one of the solutions for real time communication.

[3] Mori, I. Nishikawa, M. Quan, H. Morita, M.(2002) Estimation of the concentration and chemical composition of kosa aerosols at their origin *Atmospheric Environment* 36: 4569-4575

Another option discussed is a kind of "passive data sharing." That is, each national focal agency collects the observation data from the network monitoring stations within the country and upload the data in real time on a specially designated section of its website for sharing with its counterparts in other partner countries through internet. This arrangement is simple, but may not be sufficient to meet the operational requirements of the forecast centers within the regional network for high speed transmission of the monitoring data needed for precise prediction of DSS events for early warning.

3.4.3 Hardware and Software Requirement

The hardware and software requirements for establishment of the proposed regional network are set out in Box 3.4, which are drawn up based on the needs of the PRC.

Box 3.4 Requirements for the DSS Forecasting and Early Warning Network: an Example from the PRC

1. Hardware:

Data Collection. For Phase 1, instruments for visibility are needed as all the nominated stations are not equipped. Also, 3 units of LIDAR and 17 units for PM_{10} monitoring are required. For Phase 2, the following are needed: 17 sets of the instrumented visibility, 12 units for PM_{10} measuring units, and 4 LIDAR.

Data Sharing and Transmission: If the data sharing and transmission is to be set up on the meteorological telecommunication system (MTS) or through internet on special pages on website of national focal agencies, it is not necessary to consider the cost for establishing a specialized communication infrastructure. But it is necessary to consider the investments for the terminal devices for data transmission and reception at each station, and for the high-speed international and/or national network telecommunication capacity in remote areas where the network monitoring stations are located, and for the network transmission devices and telecommunication consumables.

Data Processing and Storage: Mega-capacity data storage and processing system, including storage equipment, data processing computer and data dissemination server, would be needed at each national focal agency.

Simulation and Modeling: High-performance computer will be needed at the national forecast centers to handle the numerical DSS model for DSS simulation for forecasting and early warning.

2. Software

Numerical DSS Prediction Model: This should include model development, application, maintenance, refining and upgrading.

Data Processing and Assimilation: This should include the assimilation of surface and atmospheric monitoring data in different resolutions, the technique of processing DSS concentration observations and atmospheric optical observations, and the technique of assimilating and analyzing visibility and DSS concentration data.

Capacity Building: This should include the training of operational personnel at network monitoring stations and exchange of experiences between experts and technicians at the national forecast centers and academic circles involving DSS monitoring and early warning. This should also include the policy and operational coordination among the officials and policy makers responsible for regional cooperation on prevention and control of DSS in the partner countries.

3.5 Financial Implications

Establishing a regional DSS network in Northeast Asia will entail costs. Some of these costs will relate to the provision of equipment for data collection, handling, analysis and storage while others will be for data transmission/exchange. The partner countries are at different levels of socio-economic and technological development and vary in geographic and physical characteristics. Likewise, each country differs in their capacity to pay for system upgrades and network establishment and maintenance. These factors need to be considered carefully in any plan to develop a regional network for DSS monitoring and early warning. The cost implication for establishing and strengthening the regional DSS network is more focused on developing the DSS monitoring and early warning systems of the PRC and Mongolia as the DSS source areas. The DSS downstream partner countries of Japan and the Republic of Korea are already technologically more advance in their meteorological monitoring network and early warning system.

The financial implications of establishing a regional DSS network in Northeast Asia as presented in subsequent subsections are results of a preliminary estimation, which are subject to refinement and finalization as a next step of this study.

3.5.1 Development of the Regional Network for DSS in the PRC

Monitoring Station Costs in Phase 1

With improved economic conditions, issues on environment and ecology have been receiving more attention in the PRC. More money has been spent on DSS-related projects which include: (a) R&D projects, such as NWP (Numerical Weather Prediction) framework in the forecasting of DSS at the very-short and short ranges; (b) meteorological stations of CMA; and environmental stations of SEPA. As such, there are several existing independent systems relating to the DSS forecasting and early warning, which can be subject for selection and development of the regional network for DSS. However, there are two financial issues to be addressed in Phase 1. One is the fair and rational method of assessing cost recovery for the PRC contribution and the another is the estimation of incremental costs associated with equipping stations to a standard suitable for the regional network.

In Phase 1, the PRC will need some financial support from partner countries/international organizations to strengthen the existing 25 stations for the monitoring, forecasting, early warning, and data transmission in the DSS network in Northeast Asia. The incremental investment includes: (a) 25 units of visibility transmissometers; (b) 17 units for PM_{10} monitoring equipment; (c) 22 units of TSP monitoring equipment; (b) 3 units of LIDAR instruments, and (c) other investment such as human capacity building, cross-country communication for data-sharing, etc. These incremental costs are given in Table 3.8.

Monitoring Station Costs in Phase 2

In Phase 2, the number of the monitoring stations will increase to 43. This would mean an additional of 18 stations will become the part of regional network for DSS. The costs associated with this are set out in Table 3.8.

Table 3.8 Monitoring Station Costs in Phase 1 for the PRC

Cost Item	No. of Units	Unit Price ('000:US$)	Total Cost ('000: US$)
Visibility Transmissometers	25	25.0	625.0
TSP	22	17.0	374.0
PM_{10}	17	20.0	340.0
LIDAR[1]	3	176.0	528.0
Total Equipment Cost			1,867.0
Installation cost including training(10% percent of equipment cost) and construction cost for LIDAR			486.7
Transportation cost (5%of total equipment cost)			93.4
Incremental operating cost[2] of monitoring stations for DSS based on two-year activity (2004-2005)			164.8
Total Cost			**2,611.9**

[1] Includes two parts equipment: Mie-LIDAR and its computer.
[2] Due to increase in equipment, the stations will incur more staff and related operating cost. According to the PRC Yearbook 2003, the average wage of staff and workers in 2002 in the PRC is RMB12,422 (about US$1,500), the average wage of staff and workers in the Geological Prospecting and Water Conservancy which is a sector similar to DSS monitoring is RMB12,303(about US$1,500). In addition, the employer will have to pay the welfare for the staff. It is difficult to arrive at an accurate cost but on the average, the estimated welfare payment per year is nearly equal to half of the wage.

Table 3.9 Monitoring Station Costs in Phase 2 for the PRC

Cost Item	No. of Units	Unit Price ('000:US$)	Total Cost ('000: US$)
Visibility Transmissometers	17	25.0	425.0
PM_{10}	12	20.0	240.0
LIDAR	4	176.0	704.0
Total Equipment Cost			1,369.0
Transportation cost (5%of total equipment cost)			68.5
Installation cost including training(10% percent of equipment cost) and construction cost for LIDAR			536.9
Incremental operating cost of total monitoring stations for DSS based on 10-year activity			1,285.7
Total Cost			**3,260.1**

The National Data Center Development Cost

National Data Centers/Forecasting Centers should be strengthened for the operation of the network of prevention and control of DSS in Northeast Asia. The development cost for this facility consists of incremental telecommunication (operation and maintenance) cost, data storage system cost, high-quality working station cost and software cost (see Table 3.10). Any assistance in this regard will be welcome.

Table 3.10 National Data Center Development Cost for the PRC

Cost Item	Total Cost ('000: US$)
Incremental telecommunication operating and maintaining cost based on two-year activity	1,210.0
Data storage system	180.0
High-quality working station	578.0
Software cost based on two-year activity	337.0
Total	**2,305.0**

Remote Sensing Monitoring Cost Estimate

Ground surface conditions are important factors in DSS outbreaks. Hence, upgrading of the remote sensing capability of the PRC is important for monitoring the ground surface and for detecting the geographic extent and optical density of DSS events once break out occurs. The cost for such an upgrade of remote sensing capability is shown in Table 3.11.

Table 3.11 Remote Sensing Monitoring Cost for the PRC

Cost Item	Total Cost ('000: US$)
Large Capacity Computing Facilities	100.0
Depreciation of Computing Facilities	500.0
Equipment for data transfer	100.0
Total Cost of Equipment	700.0
Remote Sensing Image Processing Software	100.0
Depreciation of Image Processing Software	200.0
Other software	30.0
Model development for 10-years (@ US$100/year)	1,000.0
Remote sensing data cost for 10-years (@US$20/year)	200.0
New type Remote Sensing Image Processing Software and data cost	500.0
Total Cost of Software and Data	2,030.0
Operating cost : 10 staff for 10-years (@ US$40/year)	400.0
Total Cost	**3,130.0**

Notes: According to the PRC Yearbook 2003, the average wages of staff and workers of Meteorology, Seismology, Survey and Mapping technological supervision in 2002 are RMB16,130; RMB16,021; RMB16,868 and RMB16,478, respectively (or about US$2,000).

3.5.2 Development of the Regional Network for DSS in Mongolia

As previously indicated, there is no existing DSS monitoring network in Mongolia, therefore the following are assumed:

- all costs are preliminary estimates,
- international transportation cost (delivery) is assumed to be 5-15% of total equipment cost,
- installation cost includes training and consulting costs.

.Monitoring Station Cost for Phase 1

For three Class A stations and three Class B stations comprising the Phase 1 DSS regional network in Mongolia, total estimated cost is at US$2.9 million as shown in Table 3.12.

.Monitoring Station Cost for Phase 2

Table 3.13 presents the costs entailed for acquiring monitoring equipment in Phase 2 of developing the regional network for DSS in Mongolia. Some of the proposed sites will require continuous power supply. However, electricity supply cost is not included in the ground monitoring costing because this needs a detailed financial analysis and cost comparison.

Table 3.12 Monitoring Station Costs in Phase 1 for Mongolia

Cost Items	No. of Units	Unit Price ('000:US$)	Total Cost ('000:US$)
TSP	6	17.0	102.0
PM_{10}	6	20.0	120.0
Visibility sensors	6	16.0	96.0
Soil moisture sensors	6	5.0	30.0
LIDAR	3	176.0	528.0
		Sub-total	876.0
Installation cost including training (estimated at 20% of equipment cost)			175.2
Transportation cost - International transportation (15% of equipment cost) - Domestic transportation (by plane, car and train)			 131.4 50.0
Construction cost for LIDAR facility and ground monitoring station (3 x US$100,000) + (6 x US$30,000)			480.0
Import tax and custom clearance (20.75% of total cost of equipment)			181.8
Operating cost of six sites based on 10-year activity (including Administrative, Communication, Labor, Training, Maintenance, Spare parts etc.)			1,000.0
Total Cost			**2,894.4**

Table 3.13 Monitoring Stations Costs in Phase 2 for Mongolia

Cost Items	No. of Units	Unit Price ('000:US$)	Total Cost ('000:US$)
AWS	7	43.0	301.0
Visibility sensors	12	16.0	192.0
Soil moisture sensors	12	5.0	60.0
PM_{10}	12	20.0	240.0
TSP	7	17.0	119.0
		Sub-total	912.0
Installation cost including training (estimated at 30% of equipment cost)			273.6
Transportation cost - International transportation (15% of total cost) - Domestic transportation (by plane, car and train)			 136.8 100.0
Import tax and custom clearance (20.75% of total cost of equipment)			189.2
Total Cost			**1,611.6**

Remote Sensing Development

Like the PRC, Mongolia's remote sensing capability needs to be established and upgraded. The cost for such an upgrade is shown in Table 3.14.

Table 3.14 Cost to Establish and Upgrade Remote Sensing in Mongolia

Cost Item	Amount ('000: US$)
MODIS data receiving station	500.0
Installation cost including training (30% of station cost)	150.0
Transportation - International transportation (10% of MODIS cost) - Domestic transportation	 50.0 20.0
Import tax and custom clearance (20.75% of total cost of equipment)	103.8
MODIS data transaction cost for next 10 years	1,000.0
Sub-total	1,823.8
Operating cost based on 10-year activity (including Administrative, Communication, Labor, Training, Maintenance, Spare parts, etc.)	100.0
Total Cost	**1,923.8**

Network System Development Cost

The cost associated with developing and setting up the system for the network is shown in Table 3.15.

Table 3.15 Cost for the Development of Networking System in Mongolia

Cost Item	Amount ('000: US$)
Equipment cost - *YSAT stations at 5 remote stations (15.0 th. USD each)* - Central HUB - Message switching system - Data storage system (IBM Total Storage Enterprise Storage Server Model 800) - Internet Server (Sun Fire 4800 Server)	 75.0 1,000.0 500.0 500.0 100.0
Software cost	100.0
Sub-total	2,275.0
Installation cost including training (10% of total equipment price)	227.5
Transportation cost - International Transportation cost (5% of total equipment cost) - Domestic Transportation cost	 113.8 30.0
Data transaction cost based on 10 years (100,000 USD per year)	1,000.0
Operating cost based on 10-year activity	800.0
Grand total cost	**4,446.3**

The total project cost in the next 10 years for the improvement and operation of the regional network for DSS in Mongolia will be about US$11 million inclusive of the US$1 million telecommunications upgrade and improved computer capacity for storage and processing data**.** This cost, however, does not include the long-term operating cost, future equipment upgrading, and additional equipment purchase.

3.5.3 Funding

In order to foster regional cooperation in DSS monitoring, forecasting, and early warning on a sustainable financing mechanisms, a special fund should be raised to satisfy the operating cost of the DSS network. There are several potential sources identified for raising said funds. These are as follows:

- Contributions in cash or kind from network members and partners;
- Financial assistance from bilateral or multilateral donors such as GEF;
- Contributions from national governments;
- Contributions from regional, sub-regional and international institutions; and
- Donations from private sector.

The special fund could take the form of a Foundation or Trust Fund to which private sector, bilateral agencies, NGOs, etc. can contribute. It could be established off-shore and the funds adminstered by a Board.

Resources must be gathered at a scale to ensure an uninterrupted, smooth, and effective implementation of the various activities and program of the network. Whilst it is absolutely essential that the member countries make available funds from their own resources to the extent possible, it is also clear that external funding will have to be mobilized for various activities of the network.

Funding will be crucial at the initial network installation phase as financial support during the early stages can make an important contribution to ensuring broad initial participation and survival of the network through its difficult infancy period. Financial assistance from donor countries and international agencies can be focused on network-wide core programs or, alternatively, element-based projects. Collaboration between institutions in Asia and donor institutions should be encouraged whether in the form of formal partnership agreement or informal agreements.

Investments in appropriate technologies, particularly for electronic information exchange and electronic transfer of information will be crucial to the successful operation of the DSS network. It is estimated that the budget outlay for establishing and initially supporting the operations of the national data center and the DSS forecasting center and the cost of implementing Phases 1 and 2 of monitoring stations development will amount to US$22.2 million. It is likely that the four governments of the member countries will cover the cost for the national network coordination staff and other personnel and contribute to the operating expenses as well as shoulder a certain portion of the required equipment outlay. However, a considerable portion of the network budget will have to be sourced externally and this is where donor countries and agencies will play a key role in providing financial assistance. It should be noted that the budget estimate did not take into account the possible share of the operating cost to be met by the participating member countries either as in-kind contribution or inputted costs if the activities are spearheaded or undertaken in their respective countries.