

**GEF AGENCY of the IFAS**

**ARAL SEA BASIN PROGRAM**

**Water and Environment Management Project**

**Sub-component A1**

**National and Regional Water and Salt Management Plans**

**NATIONAL REPORT 1**

**by NWG of Tadjikistan**

**NATIONAL WATER DEMANDS AND  
OPTIONS FOR DEMAND MANAGEMENT**

**Volume II**

**DRAFT**

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## **Preface**

The National Report completes Phase 4 National Water Demands and Options for Demand Management in accordance with the Terms of Reference in which the following is said:

The aim of the report is to submit a basic information for Phase V (Basin Water-Salt Balances) and also for Phase VI (Project of Regional and National Policies, Strategies and Action Programs). This report will include the following information:

- a) future availability of water resources and regimes (quantitative and qualitative changeability). The outcomes of Tasks R2 and R3. The input for Task R8/N8;
- b) common economic future of irrigated agriculture and also different irrigation systems that are in a critical condition (see Chapter 4.3). The result of fulfillment of Tasks N5 and N7. The input for Tasks N4 and N6;
- c) further water demands in water consuming sectors, except agricultural one, based on evaluations of economic development, incentives and ways of water saving. The outcomes of Task N4. The input for Tasks R8/N8 and N9;
- d) elaborated alternative scenarios on development of irrigation sector, of the whole state and each planning zone. Every scenario includes an investment plan for rehabilitation and improvement of irrigation and drainage infrastructure as well as a plan on irrigation and drainage services management, reimbursement of production expenses and water resources conservation (see Chapter 5.6). The outcomes of Task N6. The input for Tasks N4, N5, N7, R8/N8 and N9;
- e) the results of survey of social expenses and estimate for future investments. The input for Task N6;
- f) the detailed analysis of each planning zone for elaboration of alternative scenarios of development of irrigation sector with taking into account of the necessity for: (1) forecasting of future water demands; (2) forecasting of water-salt balances; (3) definition and evaluation of measures necessary to achieve future plans on water demands and sustainable water-salt balances. The outcomes of Tasks N4, N5, N6 and N7. The input for Tasks R8/N8 and N9. The outcomes will include:
  1. biological water demands for different crops, soils and climatic conditions as well as the defined medium and long-term criteria of water use effectiveness, elaborated on the basis of reasonable and feasible norms under the aforementioned elaborated scenarios (1) of condition and functioning of irrigation and drainage infrastructure, (2)

- of system functioning, including reuse of drainage waters and joint use of surface and ground waters; (3) of irrigation methods;
2. real and feasible water demands for each planning zone in medium-term(10 years) and long-term (25 years) future; (obviously the elaboration data depend on development scenario (see point (b) above), that include an investment plan;
  3. water conservation in each planning zone in medium-term (10 years) and long-term (25 years) future in comparison with today water use;
  4. today and future water-salt balances for each planning zone, their ecological sustainability, volume of salts, discharged into transboundary rivers;
  5. defined, estimated and systematized measures on achieving the above mentioned targets on water demands, balances and ecological sustainability on the basis of results obtained as a result of carrying out the following activities;
    - assessment and drawing of maps of the following irrigated areas: (a) heavily and medium water-logged areas; (b) heavily and medium saline areas; (c) areas of salt exports from soils (areas (a), (b) and (c) may exceed each other); (d) areas with considerable natural drainage; assessment, definition of volume and cost of measures and infrastructural reforms necessary for the joint use of surface and ground waters on the areas of (d) type, additional infrastructural demands on other areas;
    - evaluation of the options of resolving the problems of salinity and ecological instability in the zones that are in a critical condition;
    - estimation of condition and functioning of irrigation and drainage infrastructure (main, inter-farm and on-farm systems) on a basis of detail field investigations in representative key regions and preliminary elaborated long-term stage by stage priority investment program;
    - assessment of current norms of operation and services as well as irrigation systems management in order to elaborate measures on reducing of operational losses, reducing of expenses and improving of rendering of services to the farms;
    - exposure of alternative options of improving the system of incentives and organizational structure;
  6. preliminary national plan on use and conservation of water resources as well as salts management by means of data collection within the frameworks of fulfillment of point (e) on national level: national water demands in medium-term (10 years) and long-term (25 years) future, irrigated areas and also future return flow and volume of salts coming into water resources of transboundary rivers, investment demands, organizational changes in time, expenses for operation and services, options of financing. The input in fulfillment of tasks R8/N8 and N9.

# 1. Introduction

## 1.1. Project Objectives and Structure.

1. The main tasks of Sub-component A1 of Water and Environment Management Project is to elaborate plans on water resources and salt management in Aral Sea Basin. One of the two main tasks is to prepare sequent politics, strategies, and programs for the Basin relating to:
  - Water resources conservation and reduction of soil salinity
  - Rehabilitation and improvement of irrigation and drainage infrastructure and also improvement of O&M of main and on-farm irrigation and drainage systems.
2. The second important task is to develop a structure that will enable interstate cooperation in the sphere of water resources and salt management, as well as will provide possibility to work out international agreements on water allocation mechanisms and river water salinity standards.
3. Team of sub-component A1 includes RWG, being the core of the team and covering basin-scale issues, and 5 NWGs - one in each of the 5 Central Asia republics, addressing the issues and problems from their national point of view.
4. Sub-component A1 includes several phases. Phase I and II have been already completed, while phase III is being carried out by the RWG simultaneously with Phase IV. This Report describes Phase IV relating to the Republic of Tadjikistan.

## 1.2. Phase IV Tasks

5. According to decisions made in previous phases of the project concerning the scope of work required in accordance with the Terms of Reference, several amendments were made relating to:
  - Power generation issues;
  - Transfer of the work on the involving of interested parties into the planning process to another component of the Project.
6. It was also agreed that the task of definition and description of transboundary water resources does not correspond to this phase of the Project and this conception had not been further developed.
7. Final options of the tasks are given in the following Table 1:

**Table 1**

<i>NN</i>	<i>Description</i>	<i>Measures</i>
N3	To assess the national water resources	To study quantity and quality characteristic of the Basin water including ground and return

		flow.
N4	Power generation issues.	To collect and submit information on power generation and power transfer systems of each country for utilization in model building and respective investigations.
N5	Assessment of national water management infrastructure.	To assess the real state and efficiency of national water economy system as well as operative management of this system for long term perspectives.
N6	Irrigation sector development scenarios.	With the assistance of respective state organizations to elaborate several possible irrigation sector development scenarios.
N7	Assessment of salinity trends and related costs and norms.	<ul style="list-style-type: none"> <li>- To assess the actual and future salinity problems and to distinguish critical zones for detail study;</li> <li>- To define economic costs depending on different levels of soil and water salinity;</li> <li>- To evaluate options for water salinity management in identified critical zones; and</li> <li>- To prepare strategy project for salinity management.</li> </ul>

### **1.3. Coordination between the Regional and National Working Groups.**

8. Coordination between NWGs and RWG endured during all phases of the project. To provide conformity of standards and work submission the NWG followed the standards developed by the RWG including procedures of preparation, consideration, and making amendments.
9. Standard forms prepared by the RWG were also used for collection and submission of data on a number of categories including water resources, water salinity regime, infrastructure evaluation and energy aspects. The RWG had prepared guidelines and instructions on some other issues as well.

### **1.4. The Objective of this Report**

10. The objective of this Report is to describe methodology and results of the work of Phase IV, and to provide basic information for the tasks that will be carried out in the next phases.

## **2. Water resources**

### **2.1. River Flows and Surface Water Resources.**

Mountain areas of Tadjikistan are main zones where water resources of the Aral sea basin are generated. These territories are characterised by arctic climate with a low average temperature (1...5<sup>0</sup>C), continuous cloudiness (230...280 days/year), and high level of fog recurrence (110...130 times a year). All these precondition low evaporation of moisture from snow cover and glacier surface, and elevated orography and its inclinations provide a rapid descending of liquid moisture to intermountain gorges, which further turns into numerous streams rushing down to the underlying territories.

Water resources of the considered zone are formed by natural renewable surface and underground waters and return waters being formed on the irrigated territories as a result of water use. The total average annual flow (data for 1960-1990 submitted by Glavtadjikgidromet of the Republic of Tadjikistan), which is formed on the territory of the republic amounts to 64 km.<sup>3</sup> The main flow (62.9km.<sup>3</sup>) goes to Amudarya basin, and about 1.1 km.<sup>3</sup> to the Syrdarya basin. In years of high water availability (5% of probability) the Amudarya river flow formed on the territory of Tadjikistan reaches up to 90km.<sup>3</sup>, and in very low water availability years (95% of probability) to 39km.<sup>3</sup>

The stocks of water in glaciers situated on the territory of Tadjikistan are estimated to be 500km.<sup>3</sup>, the melting of which forms considerable part of summer base flow. Considerable volumes of water resources of Tadjikistan are stored in mountain lakes. To their share comes around 44 km.<sup>3</sup> of water, out of which 20km.<sup>3</sup> are fresh, of drinking quality.

Water reservoirs with total volume of 1.5km<sup>3</sup> and useful volume of 7.2km.<sup>3</sup> were constructed to provide more rational use of water resources and to bring rivers flows to a hydrograph, which is suitable for water use and for flood control in the Amudarya and the Syrdarya rivers basins

The return waters constitute essentially large share of water resources (around 7% of a surface flow) of Amudarya (3.4km.<sup>3</sup> a year) and Syrdarya (1.2 km.<sup>3</sup> a year) river basins. The return waters are the total of collector-drainage flows from the irrigated territory. Out of the total annual volume of return waters 4.6 km.<sup>3</sup>, 4.05 km.<sup>3</sup> are attributed to collector-drainage waters. 0.35km.<sup>3</sup> of waters are used within the irrigation area, while the rest 4.25km.<sup>3</sup> are disposed into rivers. There are no natural depressions in the republic where collector-drainage waters can be disposed.

### **2.2. Ground Water Resources.**

The territory of the Republic of Tadjikistan is characterised by a complicated geological structures and extensive variety of physical-geographic conditions. Owing to that its hydro-geological characteristics are also very complicated and diverse. Underground waters are presented by all known types of waters, which differ by conditions and levels of their bedding, and belong to different hydro-geological structures and hydrodynamic zones. Water salinity varies within a wide

range: from ultra-fresh waters to strong and ultra-strong brines, containing several valuable microelements and gases.

At present, the underground water resources are estimated to be:

- forecasted reserves-51226 thous.m<sup>3</sup>/day;
- operational reserves-7660 thous.m<sup>3</sup>/day;
- general extraction of ground waters-6451 thous.m<sup>3</sup>/day;
- the percentage of use from forecasted reserves-12.6.

One can observe a general tendency of deterioration of underground waters quality as a result of technogenous influence, especially in Syrdarya river valley. In the Amudarya river basin, the increase of sulphates and chlorides content in ground waters is observed in the areas, where non-suitable waters are spread, namely in Vakhsh, Yavan and Dangara valleys. In intermountain and river valleys, irrigation is the main reason conditioning the increase of underground waters' level and deterioration of their quality.

### **2.3. The Regime of River Water Salinity**

Nowadays, formation of river flows and changing of their quality occurs practically along the whole length of the rivers. In upper streams of rivers and their tributaries, quality of surface flow is defined by pollution of atmosphere precipitation (acid rains and others), wind transfer of dust, polluting components and their content on ice cover. In medium and lower streams of the Amudarya and the Syrdarya river basins, quality of surface water flow mainly depends on return flow of collector-drainage waters disposed from meliorated irrigated lands, territories of cities, municipal-domestic drains, outcrop of polluted ground waters in water sources, etc.

In water resources generation zone, the surface waters (by their quality) belong to 1 and 2 classes of purity (pure waters). By coming down, the riverbed and bottom streams are saturated with mountain rocks particles, dissolving of which increases the level of mineral composition of pure natural water. Depending on chemical composition, waters of mountain rivers, lakes and ground waters are classified into hydrocarbonate (Zeravshan, Kafirnigan, Obikhingou, Varzob, Pamir and other rivers), sulphate (Muksu, Surkhob, Vakhsh and other rivers) and sodium types. In particular, owing to the fact that soils and mountain rocks are not saline, the rivers forming on south slops of Ghissar range belong to the category of rather high purity. For example, even in the periods of low water availability, salinity of Kafirnigan river waters near Ramit village does not exceed 0.25g/l. In general, it could be noted that salinity of river waters on the territory of Tadjikistan reaches up to 0.4 g/l.

### **2.4. The Changeability and Dependence of Water Use on Water Resources and Levels of Their Salinity**

The concordance of water sources regime and water use regime has an important meaning, especially for irrigation from rivers. Regulation of water sources regime is very important for a continuous water supply, irrigation, and watering, navigation needs, power generation and other purposes.

Annual river water availability is taken as a criterion for setting river water designed discharge: at designing of hydropower stations- 90%; irrigation-85%; domestic-drinking water supply-95%, etc.

When planning water resources use, it is very important to make prospect water management balances, which mean quantitative correlation of available and suitable for use water resources, proceeding from consumers' water demands within the limits of a certain territory or basin. Water resources balances are made for years of low (95%) and medium (75%) water availability years.

In all national economy development scenarios it is mentioned that water resources of Tadjikistan and levels of their salinity allows providing water consumers with water even in very low water availability years.

## **2.5. Institutional, Legal and Financial Water Resources Management**

Water resources management system at the national level of Tadjikistan is the hierarchy adopted from the previous command administrative system. But changes to market relations have been already started. New Water Code of the Republic of Tadjikistan adopted in November 2000 provides possibility to change proprietary form of water management complex according to the order set by the Government. Possibility to transfer the management of irrigation systems within limited territories to the national and foreign juridical persons was also stipulated for. At present, development of a set of respective documents is going on.

Water legislation of the Republic of Tadjikistan is based on the Constitution of Republic of Tadjikistan including Water Code, laws, normative and legislative acts recognised by the Republic of Tadjikistan.

In connection with the adoption of the new Water Code of the Republic of Tadjikistan it is supposed to make inventory of all legislative acts from top to bottom, to reveal and to remove contradictions in them, to cancel the obsolete ones and to approve new legislative acts.

The whole water management complex, especially irrigation farming and prospects of its development considerably depends on those institutions and organisations, which can influence the process of water resources management not only within the whole country, but also within its separate territories. Besides, it is also very important how these institutions execute the existing legislative acts. The main index characterising efficiency of any water management organisation's activity is the volume of their resources and investments they can input into the annual budget of the sector. In financial terms, Tadjikistan has not yet achieved the level providing complete covering of water management organisations' expenses on water supply to water users. This could be explained by inadequate charges (tariff) for  $1\text{ m}^3$  and allocations from the national and local budgets.

To optimise water resources management at the national level it is necessary to undertake the following:

- to effect gradual transfer to the systematic method of management within hydrographic units;
- to expedite countrywide creation of WUA (water user associations);

- to put into practice water demand management with differentiating charges for water and water delivery services depending on certain conditions;
- to develop various private, collective and corporate forms of water use on the base on free market water management activity.

Strategic importance and complexity of water management system presumes that the most important and unique structures should be left under the governmental ownership and funding. Ministry of Amelioration and Water Resources shall coordinate and guide water management policy in the country.

### **3. Power Engineering.**

#### **3.1. Generating Facilities**

In Tadjikistan, history of power engineering development starts from 1936. By the end of 80-s the development of power engineering reached impressive results. Power generation per capita reached almost 3000 kWh a year, which is comparable with an average European level.

Composition and structure of power engineering sector in Tadjikistan is defined by its the resource base. By absolute meanings and in comparison with other republics Tadjikistan practically does not possess real stocks of oil and gas. Out of general stocks of these energy resources in the region, which amount almost to 4.5 bill. tons of equivalent fuel, only 0.05 bill. tons of equivalent fuel fall on the share of Tadjikistan.

At the same time Tadjikistan possesses huge unique stocks of hydropower resources. If proceed from the total potential stocks of hydropower resources, Tadjikistan takes the eighth place in the world. Thus, it is clear that Tadjikistan does not have any other alternative in power engineering except hydropower resources. But their stocks are used today only on 3-5%.

The main generating capacities of Tadjikistan power generation system, as it was to be expected proceeding from its resources base, are presented by hydropower stations, taking by capacity almost 96%. The characteristics of all stations are given in a Table 3.1.

**Table 3.1****The structure of power system of Tadjikistan**

N	Name	Capacity, MW			Generated, bill.kwh
		Installed	Available	Working (average annual)	
1.	Nurek HPS	3000.0	2100.0	2035.3	11.48
2	Baipazi HPS	600.0	450.0	471.8	2.65
3	Dushanbe thermal plant	198.0	198.0	27.2	0.37
4	Yavan thermal plant	120.0	98.63	8.4	-
5	Kairakkum HPS	126.0	126.0	68.3	0.62
6	Cascade of Vakhsh HPS	285.05	162.0	160.9	0.40
	Including:				
6.1	Golovnaya HPS	240.0	140.0	140.0	0.30
6.2	Perepadnaya HPS	29.95	22.0	20.5	0.1
6.3	Central HPS	15.1	-	-	-
7	Cascade of Varzob HPS	25.43	5.1	8.4	0.05
	Including:				
7.1	HPS-1	7.15	3.5	4.783	0.03
7.2	HPS-2	14.76	1.6	3.6	0.02
7.3	HPS-3	3.52	-	0.017	-
8.	MHPS	30.62	26.825	22.33	0.089
9	DES	27.640	22.441		-
	Including:				
9.1	Mobile	9.1	7.5	-	
10	Total	4412.74	3188.996	2802.63	15.659

**3.2. Power Transmission Facilities**

Number and length of electric transmission lines and transformer substations are given in the table 3.2.

**Table 3.2.****Characteristics of electric transmission lines and transformer substations**

The length of ETL (air and cable lines) along the route, km.					Transformer substations units / thous. kva
Total					
	500kV	220kV	110kV	<35kV	
59248	226	1206	2905	54911	11213 / 13546

The electric transmission lines of 500-110kv capacity work with overload. Especially big overloads take place in distribution networks of 6-10kv. This is related to the fact that due to the absence of own mineral fuel (gas, oil, coal) the population of the Republic consumed last years up to 5 bill.kWh a year. At the beginning of 90-s this quantity amounted to 1 bill/kWh and all distribution networks are designed only for these loads.

### 3.3. Energy Control, Management and Administration.

Up to the year of 2000 the Energy Company of Tadjikistan State Joint-Stock Holding Company Barki Tojik was the organization with 100% state property and administrative management.

SJHC Barki Tojik was formed by the Decree of the Government of the Republic. The appointment and dismissal of the Chairman of the SJHC Barki Tojik and his deputies is carried out by the Government. The following structural units were included into SJHC Barki Tojik : Electric power stations: Nurek HPS; cascade of Vakhsh HPS; Dushanbe TPS; Yavan TPS

Electrical networks: Dushanbe, Leninabad, Central, South, Kulyab, Ura-Tyube, Penjikent, Gorno-Badakhshan

Enterprises: Tajikenergoremont, Energonadzor, Tajik Energy Scientific-Research Department, Management of the Rogun and Sangtuda HPS.

All of them do not have an independent balance and are on limited self-financing. Besides that in SJHC Barki Tojik there were subordination independent and self-financing enterprises:

- 1) Project-industrial constructional union on construction of electric networks, TADES.
- 2) Norak collective farm.
- 3) Project-prospecting and scientific-research institute Tajikgydroenergoproject.

There were social and dwelling objects on the balance of SJHC Barki Tojik : Nurek city, Rogun city, five kindergartens and day nurseries.

In 2000 an initial restructuring of the system was conducted:

- 1) Rogun city with all the social sphere has been transferred from the balance of power system to the balance of local management bodies.
- 2) The management of the Sangtuda HPS has formed an open joint-stock society Sangtuda and two emissions of shares have been made in the amount of 208mln.USD and shares were issued for free sale.
- 3) Incorporation of all enterprises of power system except electric power stations is being carried out.

In 2000 the Ministry of Energy has been formed.

The power system was reformed into the Holding - the shares of all enterprises were given to its management.

Unfortunately these reforms are carried out so far only de jure . They have only to be carried out now de facto .

### **3.4. Marketing and Expenses in the Sphere of Power Engineering**

The power system of Tadjikistan is under the authority of state and the entire marketing of electrical energy is controlled by the Government. The tariffs for the electrical energy are prepared by the Power Company, agreed with Antimonopoly Committee and are confirmed by a Decree of the Government.

The delivery of electrical energy to external market using fixed tariffs is carried out in accordance with simple economic agreements of power company with consumers. Export-import of electrical energy beyond the borders of the Republic is carried out on the agreements between power companies of the countries after confirmation of these agreements by the Government. In the periods of electrical energy deficits its limits of consumption are introduced. The limits are elaborated by the Power Company and confirmed by the Government.

The control on the observance of technical standards, agreement obligations and rules of electrical energy use is carried out by the State Agency Energonadzor being on a balance of the Power Company. Besides that Energonadzor is responsible for the fulfillment of the program of power saving, in particular together with enterprises it elaborates specific standards of electrical energy consumption and approves them. The costs of electrical energy at a normative operation of the system taking into account all cycles of production, transport and distribution in Tadjikistan amounts to an average 134.13mln.USD, including: salary - 13.94mln., amortization - 40.35mln., fuel- 20.93mln., purchased electrical energy- 44.65mln. In this conditions the rate for the average generation of electrical energy about 15 bill. kWh a year will be equal to 0.9cents/kWh. If we exclude not belonging in reality the price of purchased electrical energy and costs for fuel (with taking into account sharp reduction of power generation at thermal plants), then the real cost-price will be equal to 68.55mkn.USD or calculated rate costs of 0.46cents/kWh. Without taking into account depreciation costs for renovation, amounting approximately to 50% of total amortization, the rate for electrical energy in Tadjikistan will be equal to 48.38mln.USD or 0.32cents/kWh. That shows that profitability of power system is very high. For instance even at an average tariff for electrical energy in the amount of 1cent/kWh the annual income of Power Company will amount to 102mln.USD. Today an average tariff for electrical energy in Tadjikistan does not exceed 0.4cents per 1 kWh. The results of financial activity of Power Company of Tadjikistan for the last years are shown in Table 3.3

**Table 3.3**

Year	Production costs, thous. Somoni						
	Total	Including				Production of goods	Income
		salary	amortization	fuel	purchased electrical energy		
1996	10991.3	563.4	981.4	1952.2	3870.9	8385.3	-
1997	24988.1	1143.2	1044.4	6076.0	8760.1	14182.4	-
1998	27700.3	1979.6	1410.1	6896.1	4644.6	24709.4	-
1999	37657.3	3088.8	3320.2	12838.8	6349.4	31870.9	-

## **4. Development Scenarios.**

### **4.1. Economic Perspectives of Irrigated Farming.**

The agriculture of Tadjikistan at present and for the perspective will remain one of the priority branches of economy. The basis of agricultural production in the Republic of Tadjikistan is irrigated farming. Around 90% of all agricultural production of the country is produced on irrigated lands. The share of agriculture in a volume of GDP in 1996-2000 at an average amounted to 21.6%. In agriculture there is about 65% of economically active population engaged. In 1999 it accounted for 1132 thous. people.

The irrigated farming is a dominating water consumer in the country by the volumes of water consumption - around 85% and this situation will obviously remain during all the considered perspective.

Today's water resources complex of the country consists of the system of complicated and unique hydraulic structures. There are 5896km of irrigation network, including 1730km with concrete lining, 124km of canalettes, 38km of pipes, 432 of escapes, 2300km of collectors and drains, 7775 waterworks, 2133 wells, 517 pumping stations, 288km of power transmission lines, 2580 substations, 58km of telephone communication lines, 26.6km of tunnels, 3272km of road network and other funds on the balance of the Ministry of Melioration and Water Resources.

The Government of the Republic adopted Middle-Term Program of the Way Out of Agroindustrial Complex Crisis of the Republic of Tadjikistan and Priority Directions of the Strategy of Development of Its Branches for the Period of up to 2005. The aforementioned program assumes the deepening of land and water reforms; privatization and reforming of enterprises and organizations and forming of the competitive environment; development of efficient and free market infrastructure; improvement of financial-credit relations of agroindustrial complex (AIC); reorganization of the system and methods of AIC management; training of staff and scientific support.

The strategic task in the field of agriculture in a middle-term perspective is to raise the level of self-provision of the Republic in food and to increase gradually the production of raw cotton as a main strategic raw material of the Republic. It is supposed that in forthcoming period of five years the sizes of areas under crops will account for 857.9thous.ha, out of which 438.5thous.ha will be under the cereals, 270.2thous.ha - technical crops, including 250thous.ha - cotton, 59thous.ha - potato and vegetable-melon crops, 89.2thous.ha- fodder crops.

The main task for the forthcoming period is bringing the volumes of cereal production in 2005 up to 1mln.tons. That will be implemented at the expense of corresponding changes in the structure of sowings of agricultural crops, introducing into agricultural use the abandoned flood-lands, use of gardens spaces between rows, introduction of new varieties of intensive type, raising of crop capacity.

Taking into consideration special importance for the Republic of raw cotton, it is necessary to keep for the nearest 5 years the sowing areas on the level of 250-260 thous.ha at a constant increasing gross production and bringing it in 2005 up to 700thous. tons.

In 2005 it is foreseen to bring the production of vegetables up to 475thous.tons, potato-293thous. tons, fruits- 275thous. tons and grapes- 203thous. tons.

With the increase of reform process in the Republic and in particular in agroindustrial complex cooperation with international organizations becomes stronger, especially with the World Bank and its International Development Agency (IDA). In 1998 the Republican Center to support privatization of farms is created in Tadjikistan which together with the rendering of a concrete assistance in restructuring collective farms, state farms and other state and social forms of economies and turning them into dekhkan (farmer) economies and associations, implements several projects in 10 pilot regions on rehabilitation of on-farm and connected with them inter-farm irrigation collector-drainage networks with the structures on them with the objective to improve water supply and ameliorative condition of irrigated lands of chosen farms.

#### **4.2. The Basis of Assessment of Future Water Demands.**

##### Water Conservation Plans.

The irrigated farming is the main water consumer in the country and this situation will obviously remain during the whole considered perspective. The existing technology of furrow irrigation of crops as well as low level of technical condition of the majority of irrigation systems allows for non-productive losses of water. The increase of efficiency of inter-farm and on-farm irrigation systems, improvement of techniques and technology of watering, conductance of capital and current land leveling and complex reconstruction of irrigated lands need to be considered on the basis of long-term programs.

The rational use of water by means of introduction of scientifically-grounded irrigation regimes, progressive water-preserving technologies, improvement of ameliorative condition of lands has an important economic, nature protection and ecological importance.

The main directions in water conservation should be economic incentives for water conservation, comprehensive and partial reconstruction, modernization of irrigation systems, fixing of canal lining, introduction of modern techniques and technology of irrigation (drip, subsoil, sprinkle and other irrigations), organization of growing highly productive seeds with growing of low water -capacious, drought-resisting agricultural crops, introduction of strict registering of water volumes for introduction of a limited water use on farms, speeding -up the creation of associations of water users to set up an accurate economic mechanism of planned payable water use with further gradual transfer of on-farm networks into farms permanent use.

The reform in agriculture started with an adoption of the Decree of the President of the Republic of Tadjikistan from April 8, 1996 About Introduction of Payment for the Services on Water Delivery to Consumers . This is the first step on the way of introduction of free market relations into water resources sphere. It is necessary to note that the introduction of economic mechanism of water use allows to use water more efficiently.

### Water Demand for Irrigation.

The task on provision of the republican population with food and agricultural raw materials by 2010-2025 will require an involving additional lands and water resources above the maximum ones used earlier (1990) into agricultural rotation in the region. It is expected that 40-50% of the required growth of agricultural production demand will be covered at the expense of growth of crop capacity of agricultural crops, the rest part of it should be covered at the expense of development of additional land and water resources.

Ministry of Agriculture together with the Ministry of Water Resources of the Republic has approved brutto norms for irrigation of agricultural crops that are defined depending on natural-economic area, agroclimatic zone and hydromodule region. Weighted average quantities of irrigation standards by provinces are: Soghdian province- 12.2thous.m<sup>3</sup>/ha, Kurgan-Tyube zone of Khatlon province- 15.6thous.m<sup>3</sup>/ha, Kulyab zone of Khatlon province- 14.1thous.m<sup>3</sup>/ha, Ghissar zone of RRS- 15.6thous.m<sup>3</sup>/ha.

The calculations show that in order to provide the republican population with necessary quantity of food and agricultural raw material it is necessary to develop additionally by 2010 around 346.3thous.ha, and by 2025-about 470.1thous.ha of irrigated lands. For irrigation of these lands it is necessary to develop additionally about 5.02bill.m<sup>3</sup> a year by 2010 and 6.82bill.m<sup>3</sup> by 2025. Besides that out of available 718thous.ha of irrigated lands 20%- 140thous.ha of lands 55-65% suffer from the deficit of water supply. In order to increase water supply of these lands it is needed around 850mln.m<sup>3</sup> of water. The total volume of water diversion for irrigation purposes in the Republic of Tadjikistan shall amount to more than 15400mln.m<sup>3</sup> by 2010, and around 18100mln.m<sup>3</sup> by 2025.

### Generation of Electrical Energy.

The main directions and stages of development of the republican energetics proceed from the main target: improvement from the health point of view, effective functioning and then sustainable long-term development of the complex both for the provision of its own demands and for external market. They include a) a short-term program of an improvement from a health point of view and rehabilitation; b) medium-term program of stabilization and development; c) long-term program of development.

The annual generation of Nurek HPS during the forecasted period of 2001-2005 will amount to 11.3bill.kWh, and during vegetation it will fall from 7.41bill.kWh up to 5.64bill.kWh. The annual generation of Vakhsh HPS cascade during the forecasted period will be increased from 15.1 up to 28.4bill.kWh, including during vegetation from 9.96 up to 14.21bill.kWh.

The annual generation of Kairakkum HPS during the forecasted period will amount to 521.7mln.kWh, and during vegetation will reduce from 371.6mln.kWh up to 273.4mln.kWh.

The generation of electrical energy during the forecasted period of 2001-2025 will amount only to 15.0- 29.2bill.kWh, including production by hydroelectric power stations 14.7- 28.9bill.kWh, i.e. it will increase almost by two times.

### Water Demands for Municipal and Industrial Needs.

According to the legislation of the Republic of Tadjikistan municipal-domestic water-supply of the population is a priority in water resources use.

In conditions of free market economy proceeding from the possibility of share participation of population, local budgets, sponsors independently from the priority of the object it is necessary to support the initiative of construction of water-pipes for provision of the population by pure drinking water. At present in the Republic there has been elaborated a Program of Measures on Rehabilitation and Reconstruction of Water Supply Objects.

The perspective growth of unit water supply is grounded by the planned extension of housing with systems of internal water supply, sewerage and hot water supply in cities and villages. And in rural localities it is grounded by the growth of total number of cattle and poultry in personal subsidiary small holdings and farms.

The calculations show that in the Republic as a whole total water use for municipal-domestic and economic needs of population will amount to 582.8mln.m.<sup>3</sup> a year by 2010, by 2025-799.1mln.m.<sup>3</sup> a year or per capita correspondingly by 2010- 80.3m.<sup>3</sup>a year and by 2025- 89.2m.<sup>3</sup>a year.

The industry is a leading branch and a core of national economy development. It defines in many ways an industrial level and economic power of the country, pace and effectiveness of economic reforms, the possibility of successful realization of social direction of free market reforms and optimum structure of national economy.

In the conditions of free market relations development by supposed increasing of a number of small enterprises in the industry by 2010 it is necessary to consume two times more fresh water in comparison with 1990, that will amount to 1188mln.m.<sup>3</sup>, and in 2025 correspondingly three times more or 1782mln.m.<sup>3</sup>. The use of closed water use will allow reducing for a little bit the industrial demands in fresh water in future.

### The Availability of Water for Ecological Purposes.

The ecosystem of natural and artificial reservoirs during the last 30-35 years has suffered from big changes related to the construction of artificial reservoirs, storage reservoirs.

First of all Kairakkum storage reservoir and Vakhsh river valley from Nurek city up to mouth belong to the number of water objects and river valleys suffering from human influence. The solution of the problem on water prevention from pollution, protection of flora and fauna of water objects is elaboration and introduction of a complex engineering scheme of protection. After the construction of Nurek storage reservoir there has a change occurred in hydrological regime of Vakhsh river. It is supposed to elaborate a system of organizational and engineering measures providing submerging of tugai ecosystems areas in the period of spring flood. The rehabilitation of tugais along Vakhsh river in the zone of Tigrovaya balka reservation will prevent destructive processes and create a possibility to rehabilitate a number of valuable species of animals, and it will favor stabilization of temperature regime. This problem requires further investigations.

### **4.3. Future Investments.**

The total volume of investments into the national economy of the Republic by the year of 2005 will amount to 326mln.USD, construction-assembling works-227.7 mln.USD, putting into operation of capital assets-170.9mln.USD, with a growth against the last five years (1996-2000) correspondingly from 2.2 and 2.8 times.

The share of internal investments in the economy will amount to 3.9% of GDP by 2001 and 5% by 2005.

The considerable share of the central government investments will be used for the construction in the priority production sectors: fuel-energy sector, road-transport, railway and air transport, satisfying the needs of the Republic and allowing to develop other economic sectors. For those purposes there will be 186.5 mln.USD allocated or 50% out of the total volume of central government investments.

21.9mln.USD are forecasted for the construction of agroindustrial plants from the internal investment, including budget 15.5 mln.USD (9%) funds to put into operation the main funds for the amount of 15.7 mln.USD.

Out of budget funds directed towards the social sphere of the priority sectors (health care and municipal services) it is planned to invest 25.0mln.USD or 14.5% of the total central government funds and 39.3% of the expenses into non-productive sphere. 16.9mln.USD are directed to another sectors or correspondingly 9.8% and 26.6%.

Every year as a result of downpours and mud flows, other natural calamities and emergency situations an appreciable material damage is caused to the republican economy and about 2.2 mln.USD are directed every year for these purposes.

In 2001-2005 an inflow of investments and external loans is planned in the total amount of 2.7 mln.USD, including in 2001- 46.900 USD, in 2002- 50.200 USD, in 2003- 55.600 USD, in 2004- 56.500 USD, in 2005- 62.200 USD.

It is planned in 2001-2005 to direct 14.6 mln. USD or 2.5% out of the total volume of external investments for the improvement of the quality of drinking water.

A special place in the investment Program for 2001-2005 is given to the objects of state importance- Sangtuda HPS and Rogun HPS.

For the construction of Rogun HPS it is forecasted to direct 33.8 mln.USD, including budget funds - 27.0 mln.USD and 6.8 mln.USD from shares sale. Besides that it is planned to allot the sum of 12.5mln.USD of foreign investments.

For the construction of Rogun HPS it is foreseen to direct 318.200 USD from the budget and own means of Barki Tojik for the maintenance against destruction.

### **4.4. Description of Scenarios.**

In accordance with the Terms of Reference for the Subcomponent A1 NWG has elaborated three scenarios of possible future development of irrigation sector: deterioration scenario; high development scenario; stabilization and development scenario.

Deterioration scenario is based on an assumption that the trends observed in the last decade will continue in the period of forecasting as well, especially regarding strategic reforms and every year investment of the existing irrigation and drainage infrastructure. Also an assumption is made that the effectiveness of irrigation will remain on the current low level and that the level of soil and water salinity will continue to grow.

According to the deterioration scenario the forecast of losses of water supply and corresponding taking of irrigated areas out of agricultural use is made on the basis of an assumption that some of complex hydraulic constructions will be out of order. The most vulnerable are lands irrigated by pumping as well as the lands irrigated from irrigation tunnels. The losses of irrigated areas as a result of possible not operational condition of pumping stations, destruction of main water-diversion constructions, canals, aqueducts, tunnels could account for more than 420thous.ha. However the implementation of the mentioned scenario of situation development even hypothetically is unreal. The Government of the Republic of Tadjikistan till now has already undertaken serious measures on rehabilitation of existing irrigation sector and also it looks for financial and material-technical resources for elaboration and realization of the branch development program.

The scenario of stabilization and development assumes an intensification of the reform process, organizational reforming, reorganization of water resources sector, level of investment, policy of price forming and incentives to cover the expenses, water conservation, improvement of water distribution systems, etc.

Stabilization and development scenario was considered by the NWG as a basic one and it assumes: stabilization of agricultural production up to 2005 and its further development up to 2025, further privatization of lands and some advancement towards free market economy, performance of the policy, providing compensation of services and reimbursement of damages, related to flow regulation for irrigation in Central-Asian region, gradual completion of construction of the Rogun, Sangtuda N1 and Nizhne-Kafirnigan HPS with storage reservoirs.

Regarding the irrigated agriculture it is assumed to implement several important measures, among which there are the following:

- development of economic mechanism of water use in order to provide the principle of payment for the services on water delivery to consumers;
- the limitations in the growth of capital as well as getting of seeds, fertilizers, pesticides, etc. will be relaxed;
- in order to stimulate and support agriculture, including water resources the internal and external investments will be attracted and related tax, customs and excise rates will be regulated;
- the process of creation of water users associations will progress by rapid pace, that will allow to improve the management of on-farm irrigation systems;
- a gradual privatization of main funds of water resources sphere will be carried out, the actions will be undertaken on creation of water and services market, that will improve an investment climate in the branch;

- the government will give a right to specialized local and foreign juridical persons for managing state water resources objects on a tender basis within the boundaries of a limited area on a basis of agreement;
- investments into the infrastructure of water resources will raise up to the levels allowing to carry out its full rehabilitation until 2005 and carry out further development of new lands in order to provide food safety of the growing population and economy as a whole.

The high level development scenario will differ by the degree and speed of the process of reforms. The Government adopted a Concept on rational use and protection of water resources, according to which in order to provide population with food and production of raw materials it is foreseen to develop gradually all available and suitable for irrigation lands with bringing of their area up to 1.6mln.ha. This task will require an attraction of considerable financial and material-technical resources. The development of these lands will occur most probably in the latest future.

## 5. Analysis of Planning Zones.

### Waterlogging and Salinity of Irrigated Lands.

More than 310.000ha of irrigated lands that are now covered by drainage of different efficiency and types are potentially liable to salinity and waterlogging. The average republican length of horizontal collector-drainage network is evaluated as 97 running m./ha. Out of almost 200.000 ha of the lands liable to salinity and waterlogging around a half have been treated by leaching measures, and the other part remains in that condition because of the GWT rise to critical level and salinity close to its critical value.

The salinity of irrigated lands in Soghdian province takes place in West-Fergana, Dalverzine and Golodnaya Steppe massifs. The other province where salinity and waterlogging of soils takes place is Khatlon province. It is met in Beshkent, Nizhniy Kafirnigan, Vakhsh with adjoining to it Yavan-Obikiik and Kyzylsu-Yakhsu valleys.

The saline and waterlogged soils in different geographic regions differ by type of salinity. In the north of the Republic of Tadjikistan the chloride-sulfate salinity prevails, and in the south-west sulfate-chloride one. They are developed on hydromorphological elements where the natural outflow of ground waters is complicated or completely reduced. This is a periphery of debris cones, foothill proluvium plains (lower than zones of ground waters outflow), and also lower-medium river terraces. As for the center of the valley and in the depressions of river terraces (Karalang, Oikul in Vakhsh and Beshkent valleys) the degree of difficulty of ground water outflow increases, then in all regions of the Republic of Tadjikistan the soils are developing from weak to severe degree of salinity and alkali soils.

Distribution of irrigated lands of the Republic of Tadjikistan by the degree of salinity (ha) in 1996-1999 (according to the data of THME) are given in the Table 5.1.

**Table 5.1**

Provinces	Years	Not saline	Slightly saline	Medium saline	Heavily saline
Khatlon	1996-1999	274136	28777	15507	2812
Sughd	1996-1999	198007	46682	10589	4876
RRS	1996-1999	97763	130	28	25
Total for the RoT	1996-1999	589446	74558	26560	8020

### Critical zones related to salinity and ecology.

The critical zones of salinity were defined :

- by the character of soil-hydrogeological conditions, presence of salinity in the top soil, especially of a severe degree and solonchaks, shallow ground water table, their salinity and chemism;
- availability of contiguous areas of irrigation massifs, their geochemical streams towards the considered region;
- conditions and degree of natural and artificial drainability, volume and regime of the flow, salinity and chemism of flowing waters;
- specific quantities of drainage effluent of salt masses, forecast for future.

Proceeding from aforementioned criteria the following critical zones of salinity were defined: in Sughd PZ- Asht and B.Gafurov regions. In Asht region salt streams go through Kamyshkurgan and Ok-sukon depressions, i.e. there occurs an indirect export of salt masses. The second one is periodical escape of return water from Kairakkum storage reservoir. Khatlon province-Khojamaston together with Gozimalik and Yavan regions by their geochemical streams have the highest quantities of salt-return 25-27 t/ha/year. Bokhtar region belongs to that very zone where the largest in the Republic not sufficiently developed Karalang alkali soil massif of 9000ha area is located. And finally - Beshkent region where because of an unsettled problem of water allocation, the north of the valley is saline and waterlogged.

#### Condition and performance of irrigation and drainage systems.

In Soghd province the length of inter-farm canals is 1706.3km, out of them in earthen bed-741.7km. and in a concrete lining-964.6km; the length of on-farm canals is 14992.8km, out of them in earthen bed-9201.3km., in concrete lining-527.1km, in canalettes-1295.8km and in closed pipelines-3268.6km, specific length of on-farm network is 54.25km/ha. The areas provided with drainage in the province amount to 83.000ha. Collector-drainage network of 3515.4km in length functions in that area, out of that amount inter-farm network-575.8km and on-farm one-2939.6km, including an open one-1564.2km and closed one-1473.4km. The specific length of drains in the province amount to 48.0m/ha, including inter-farm network-8m/ha and on-farm network-40m/ha, out of them open one-39.6m/ha and closed-41.5m/ha. Out of the total length of inter-farm network 575.8km 209.4km or 36% are in unsatisfactory condition. Out of 2939.6km of on-farm network 780km or 26.5% are in unsatisfactory condition.

Khatlon province inter-farm canals amount to 2276.4km, out of them in earthen bed 1836.1km, in concrete lining 440.5km; on-farm canals-5096km, including in concrete lining-279km, in canalettes-1212km, in closed pipelines-2388km, specific length of on-farm network-27.85km/ha. The area provided with a drainage is 240453ha, out of them in the area of 226713ha horizontal drainage is operating and in area of 13740ha-a vertical one. Out of 1485km of inter-farm collector-drainage network 511km or 34% are in unsatisfactory condition. Out of 5885km of on-farm collector-drainage network 1858km or 31.6% are in unsatisfactory condition. Out of 404 wells of vertical drainage 81 wells operate or 20%.

Regions of republican subordination - inter-farm network- 1047km, out of them 930km are in earthen bed, 117.0km - in concrete lining; on-farm network-2362.4km, including: in earthen bed-1541km, in concrete lining - 104.4km, in canalettes - 244.4km, in closed pipelines-427.6km, specific length of on-farm network-22.9km/ha.

The area provided with drainage is 13662ha, the types of a drainage are - horizontal in the area of 13182ha and vertical - in the area of 480ha. Out of 152km of inter-farm network 54.6km or 36% are in unsatisfactory condition. Out of 453km of on-farm network 198km or 43.8% are in unsatisfactory condition. Out of 33 wells of vertical drainage only 6 wells or 18% operate.

Out of 515 pumping stations available on the balance of the Ministry of Melioration a third needs a complete rehabilitation or technical re-equipment. Out of 1600km of pressure steel pipelines 400-2400mm diameter more than half requires a complete replacement, because they are completely worn out. Out of more than 3000units of transformer substations a considerable part also requires complete replacement.

### Operation and Management of Irrigation Systems.

For the operation and maintenance in a technically good condition and irrigation systems management in the republic there are two provincial, five territorial production repair-operational state departments and unions function, and also 42 units of regional and interregional unions and regional water resources departments, presented by a big and various complex of very different on their technical level inter-farm structures and devices on water collection, its distribution and allotment of extra ground waters and protection of lands and objects from a harmful influence of flash-flood and mud flow waters.

The hierarchy of operational service is performed from the ministry through provincial and territorial water resources departments and regional water resources departments to the direct water-users: collective farms, farmers associations and other water -users.

There are special subdivisions functioning on the republican and local levels that service pumping stations, vertical drainage wells, electrical networks and substations, communication lines, and also provide a service controlling meliorative condition of irrigated lands and waterlogging of populated settlements, observation of the reliability of hydraulic constructions and storage reservoirs dams operation.

Together with rather high level of management in provincial, interregional and regional divisions and distribution of water to the points of water delivery the management of on-farm water-use is sharply behind the management on inter-farm level and as a result the efficiency of water use on that level is very low.

### Incentive and Institutional Framework.

Management system is formed on the level of the Republic and in a departmental aspect is divided into inter-farm and on-farm parts. An inter-farm irrigation system is a harmonious system, on the top level represented by the Ministry of Water Resources of the Republic of Tadjikistan which is subordinated to the Government of the Republic of Tadjikistan. Proceeding from the administrative-territorial division of the Republic there come provincial, territorial, interregional and regional waters resources management organizations, working directly with agricultural organizations, enterprises, farmers and other water-users. Besides these frameworks within the Ministry of Water Resources there are base organizations represented by construction, scientific-research, design enterprises and institutions, industrial enterprises of different branch profile. There are also specialized organizations and enterprises related to pump irrigation, energetics,

starting-adjusting, material-technical supply, informatics, management of enterprises under construction, staff training (training facility), hydrogeological-meliorative prospecting expeditions.

The institutional frameworks related to operation of on-farm irrigation systems are represented by the Ministry of Agriculture of the Republic of Tadjikistan (Department of Melioration and Ecology), agencies of local governments (Khukumats), having the institutions of agriculture in their organization which are related to agricultural enterprises, farmers. There are also collective farms, state farms, owners of personal plots, country-cottage farms, subsidiary small holdings, fisheries.

At present because of reorganization of collective farms, state farms, other state agricultural enterprises into farmers organizations, the old hierarchical system of on-farm irrigation system management has collapsed; the farmers get the land and all on-farm infrastructure is practically ownerless and without financial support. As there are numerous on-farm water-users the process of organizing them into water-users associations has started, but it will be a long process.

An economic situation in Tadjikistan and the general concept of transition to the market does not allow to cover completely a maintenance of water resources complex so far. Therefore during the transition period from planned to free market economy a great attention is paid to the incentives for market water resources activities. A payment for water delivery has been introduced to users of the state irrigation and drainage systems and tariff is fixed per m<sup>3</sup> of water with maintaining a certain degree of state support. Currently along with the occurring reforms there are some changes going on in institutional structures in order to adjust them to free market conditions in maximum with a gradual withdrawal to normative funding of irrigation systems.

## **5.2. Measures to achieve water, salt, energy and sustainability targets.**

The irrigated agricultural lands in Tadjikistan provide employment of population and play an important economic nature-forming and ecological role for 75% of the population of the country. Therefore for Tadjikistan there is a complicated, capital-intensive and long-term task of rehabilitation and improvement of technical level of irrigation and collector-drainage systems. For that purpose it is necessary to carry out a program of immediate, medium-term and long-term measures on rehabilitation and further development of land reclamation and water sector in the country.

The demographic growth and deficit of lands suitable for gravity irrigation resulted in engine irrigation, which appeared to be most vulnerable in free market conditions. In the republic up to 40% of irrigated lands are served by pumping stations, almost 30% of which are cascade ones and pump water in 5-7 stages to the height of 250-300m and more. They are complicated by design, hydromechanical and power equipment, method of work and require more qualified operations the level of which degrades due to the outflow of specialists. It is necessary to single out the most vulnerable structures from the point of view of water supply sustainability, power supply, protection of population, water-schemes and lands from floods, mud flows, underflooding. That is why it is necessary to conduct an inventory and to introduce as a separate division into a State register, water resources structures mentioning infrastructure characteristics. For the maintenance of these structures in a technically proper condition it is necessary to provide priority funding.

The increase in efficiency of inter-farm and on-farm irrigation systems, improving of a technique and technology of irrigation water application, capital and current leveling of lands, rehabilitation of irrigation infrastructure is necessary to resolve on the basis of long-term programs.

The technical re-equipment of irrigation systems will require structural reforms and creation of subdivisions on maintenance of computers, communication means, water calculation, training of highly qualified staff, creation of water-users associations.

### **5.3. Planning Zone Water Requirements.**

The forecast of water resources use in different economic sectors of the country is based on the fact that in order to provide the population of the republic by a necessary quantity of food and agricultural raw material it is necessary to develop additionally by 2010 around 364300ha and by 2025- about 470100ha of irrigated lands. The total volume of water diversion for the irrigation purposes in the Republic of Tadjikistan will account for 15428mln.m.<sup>3</sup> by 2010 and 18076mln.m.<sup>3</sup> by 2025.

When forecasting water consumption for domestic and drinking purposes of the population it is envisaged that the total number of population will grow evenly. As a whole for the Republic of Tadjikistan from 2001-2025 it will rise from 6.2 to 8.9 mln. people, including the urban population will reduce from 1.6 to 1.3 mln. people, and rural one will grow from 4.6 to 7.7 mln. people. The main efforts in that period will be aimed at the development of infrastructure of rural water supply. In the cities and regional centers rehabilitation of systems of municipal water supply will be carried out and additional water-collectors from underground deposits will be put into operation to satisfy needs of growing population.

In the conditions of development of free market relations according to supposed increase of the number of small enterprises in the industry by 2010 we have to spend two times more fresh water in comparison with 1990, that will account for 1188 mln. m<sup>3</sup>, and in 2025 respectively three times or 1782 mln. m<sup>3</sup>. The use of a closed water use will enable in the future to reduce slightly the demands of industry for fresh water.

Use of water resources for hydropower engineering is also of a great importance. During the forecast period of 2001-2025 an average long-term value of the inflow to Nurek reservoir will be 20.4 km<sup>3</sup>, including during vegetation- 16.9 km<sup>3</sup>. The discharge through a dam location will be respectively annual volume of 20.4 km<sup>3</sup>, and during vegetation it will reduce from 13.4 km<sup>3</sup> in 2001 up to 10.2 km<sup>3</sup> in 2025. The average long-term value of the inflow to Kayrakum reservoir will be 16.8 km<sup>3</sup>, including during vegetation 10.1 km<sup>3</sup>. The discharge through a dam location will be respectively the annual volume of 16.8 km<sup>3</sup> in 2001 up to 7.6 km<sup>3</sup> in 2025.

### **5.4. Planning Zone Future Energy Requirements.**

In Tadjikistan for today there are no any energy sector development plans approved by the Government. Only possible ways and strategies are being discussed. During that two development scenarios are considered as basic ones:

- inertial;

- power efficient.

The main power parameters on these two scenarios are given in Table 5.2. (Power production / Consumption in bill. kW/h).

**Table 5.2**

Scenarios	Years					
	1999	2000	2005	2010	2015	2025
Inertia	15.8/ 15.43	14.3/ 13.95	16.2/ 16.0	18.5/ 17.4	21.0/ 20.0	22.0/ 21.0
Power efficient	15.8/ 15.43	14.3/ 13.95	21.0/ 20.0	24.0/ 23.0	27.0/ 25.0	29.0/ 26.0

The general structure and its dynamic by regions are shown in table 5.3.

**Table 5.3.**

**Energy consumption in % of total.**

Region	Years				
	2000	2005	2010	2015	2025
Soghd province	21.25	18.0	17.0	17.0	16.0
Khatlon province	20.19	20.0	19.0	17.8	16.7
RRS (with Dushanbe and Tadjik aluminum plant)	57.21	60	62	63	65
GBAP	1.35	2.0	2.0	2.2	2.3

11. The structure of consumption by sectors of national economy for those regions is given in Table 5.4.

**Table 5.4**

**Soghd and Khatlon provinces in % from total.**

Sector	Years				
	2000	2005	2010	2015	2025
Municipal economy and population	42.86	40.0	35.0	34.0	33.0
Industry	9.53	10.0	12.0	14.0	15.0
Agriculture	21.90	20.0	19.0	18.0	17.0
Other	25.71	30.0	34.0	34.0	35.0

**Table 5.5.****RRS (with Dushanbe and Tadjik aluminum plant) in % from total.**

Sector	Years				
	2000	2005	2010	2015	2025
Municipal economy and population	20.55	20.0	18.0	17.0	16.0
Industry	56.63	57.0	58.0	59.0	60.0
Agriculture	10.50	10.0	9.0	8.5	8.0
Other	12.32	13.0	15.0	15.5	16.0

Inertial scenario assumes a continuation of current economy development tendencies, followed by unstable situation in dynamics of world prices for power carriers and big risks of investments in CAR.

Power efficient scenario assumes that a main attention in the course of economic development will be paid to all the aspects of increasing efficiency of power resources use. The main criteria of scenario is to reach GDP power capacity, comparable of close to current values in developed countries - 0.6 tons of conditional fuel for thousand dollars by the end of the period. That scenario presents interest from the viewpoint of possibilities of implementation of aims. Preconditions of that scenario are a sharp growth of economy with structural parallel reforms of GDP production, including based on the increase of a share of services sphere and production of non-power types of industrial production, as well as by technological re-equipment of industry, agriculture, transport and municipal and domestic economy.

It is clear that in reality some intermediate scenario will be carried out, which indices will be in a medium range between these last two, unfortunately it is impossible to make more precise evaluations at present.

The submitted in tables 5.3, 5.4 and 5.5 dynamics of change of a structure of sector consumption of electricity in regions for the period up to 2010 and 2025 was defined based on the following main targets of development:

- The republican industry envisages a moderate development of all sectors except aluminum plant. Regarding the latter one they foresee its going to the project capacity with two time increase of aluminum production against the present capacity;
- In agriculture of the country an optimization of irrigated farming with rising of water use efficiency and increase of a share of gravity irrigation is occurring. A local processing industry is developed.
- In municipal and domestic sector a program of power-conservation is actively carried out. All additionally introduced capacities are oriented to export;
- In the structure of GDP a main growth is envisaged in the field of services sphere.

## 5.5. Planning Zone Water and Salt Balances.

The problem of management of water balance of zones of separate areas takes one of the important places in the effective use of water resources. The root of the given problem is a question of a role of anthropogenic factors in a forming of water and salt balances.

The analysis of the average monthly and annual flow and salinity data during long-term period (more than 30 years) shows, that the annual flow and salinity level in any part of river does not remain constant within time, because it depends on climatic factors and first of all on the quantity of actual precipitation and on the volume of evaporation. The quality of surface waters in the catchment area is assessed as pure waters with increase of salinity level from riverhead to mouth of the river basin. The main pollutants of the river flow are escapes of collector-drainage waters with salinity of 1.2-3.0g/l and discharges of industrial enterprises.

The calculation of water diversion and use in different sectors is carried out in Water Cadastre. The data analysis was carried out on Water Cadastres for 1990-1996. The balance of intake and use of water resources in the provinces of the Republic of Tadjikistan in average during the last decade is characterized by the data of table 5.6.

The analysis carried out on flow of main rivers demonstrated that in Tadjikistan irrigation practically does not have considerable influence on the quality of natural waters. Thus in Khatlon province the water salinity in rivers Vakhsh, Kafirnigan and Pyanj in the downstream of the river in the territory of the country remains within the limits of standard- 0.25-0.8g/l. The flow of Syr Darya river the main water artery in Sughd province is characterized by the following indices. On the hydropost Akjar it is fixed that average long-term salt import to Kayrakum reservoir is in a volume of 6646 thous. tons. The salt export according to the data of the post Kyzylkishlak accounts for 12510 thous. tons. However it is known that salt coming into the river with escape waters from provincial fields does not exceed 2540 tons. A considerable discrepancy in 3300 tons is obviously related with a low quality of monitoring system for all of water schemes and irrigation systems.

The specific values of salt exports characterize Kurgan-Tyube group of regions as a zone of big quantities of salt export. In this relation Khojamaston, Gozimalik, Shaartuz, Kabodiyon and Bokhtar regions specially stand out. The regions of Sughd province (Matcha, Asht, Khojent and Isfara) turned out to be in the second place according to the values of salt export. According to reducing quantity of a specific salt export next is Kulyab group of regions. But here there are regions, where this index belongs to average ones. Those are Moscow and Vose regions. The regions of republican subordination- of Ghissar valley, where practically there are no saline soils, have The lowest indices of specific salt export.

**Intake and use of water in the provinces of the Republic of Tadjikistan.**

**Table 5.6.**

Name of the Provinces	Water diversion			Water used						Collector drainage water use	Escaped into surface water objects	Turn and repeated water supply
	Total	From surface sources	From ground sources	Total	Domestic drinking purposes	Production needs	Irrigation	Agricultural water supply	Other purposes			
Regions of Republic Subordination	2987.8	2722.8	265	2239.2	256.4	338.6	1511.8	94.8	37.8	0.108	611.4	195.92
Khatlon	6321.6	6182.4	139.4	5162.4	65.8	273	4529.8	294	0.006	78	2552.4	135.9
Leninabad	3472	1889.8	582.2	3644.8	154.2	74.8	3230.8	185	0	273.2	1275.2	306
Gorno Badakhshan Autonomous Province	335	331.8	3.44	231.4	3	0.29	227.6	0.398	0	0	37	0
Republic	13116.4	12126.8	990.0	11277.8	479.4	686.7	9500.0	574.2	37.8	351.3	4476.0	637.8

Salt balances in irrigated lands in the context of provinces are given in table 5.7.

**Table 5.7.**

Province	Water delivery, thous.m. <sup>3</sup>	Salinity, g/l	Salt import, thous. tons	Drainage flow, mln.m <sup>3</sup>	Salinity, g/l	Salt export, thous. tons
Khatlon	4529.8	0.75	3397.4	2552.4	1.58	4032.8
RRS	1511.8	0.2	302.4	611.4	0.5	305.7
Soghd	3230.8	0.93	3004.6	1275.2	1.99	2537.6
GBAP	227.6	-	-	37	-	-
Along the republic	9500.0		6704.4	4476.0		6876.1

\*-Area covered by regular observations.

## 6. Preliminary National Plans on Water Use, Power Production, Water Conservation and Salt Management.

### 6.1. Availability of Water Resources and Future Water Demands in Tadjikistan.

The Republic of Tadjikistan has the richest reserves of water resources. The river average many years flow, originating in its territory account for 64 km<sup>3</sup>. In the lakes 44km<sup>3</sup> are concentrated, of which 20 km<sup>3</sup> are fresh waters of drinking quality. A considerable quantity of water - 500 km<sup>3</sup> is in glaciers and snowdrifts. The regulation of this flow is carried out by reservoirs with useful capacity of 7.4 km<sup>3</sup>. The composition of water resources by categories of their forming is presented in Table 6.1.

**Table 6.1**

**Water resources originating in the territory of the Republic of Tadjikistan (mln. m<sup>3</sup>).**

Basin	Surface waters	Ground waters	Reservoirs	Return waters	Natural lakes	Glaciers, snow drifts
Syr Darya	1100	1464	2698	1140	0	0
Amu Darya	62900	5190	4741	2827	44000	500000
<b>Total in the Republic</b>	<b>64000</b>	<b>6654</b>	<b>7439</b>	<b>3967</b>	<b>44000</b>	<b>500000</b>

Note: 1. In Syr Darya basin 20% of ground waters are related with surface ones, in Amu Darya basin respectively - 60%.

2. Transit waters of Syr Darya are not included into the table.

In Water Code of the Republic of Tadjikistan in article 4 it is said: According to the Constitution of the Republic of Tadjikistan the internal waters of the Republic of Tadjikistan are exclusive property of the state, are common property of the people and are given only for use .

The quality of surface waters originating in the republic belongs to 1 and 2 classes of purity-pure waters. The concentration of pollutants in them does not reach the level of high pollution - 10 MPC (maximum permissible concentration).

The ground water resources are assessed in the volume of around 6.6 km<sup>3</sup>. But we have to take into account, that one can observe a tendency to deterioration of their quality, especially in Syr Darya river valley and in Ghissar zone by pollution of water-bearing horizons by irrigation waters.

Information on water diversion and use in the Republic of Tadjikistan in 1992-1996 is given below. Average annual quantities for the given periods are the followings: total water diversion 13116 mln. m<sup>3</sup>; including, from surface sources - 12127 mln. m<sup>3</sup> (92.5%); from ground sources 990 mln. m<sup>3</sup> (7.5%). Total water use 11278 mln. m<sup>3</sup>; including for domestic and drinking

purposes 479 mln. m<sup>3</sup> (4.2%); production purposes - 687 mln. m<sup>3</sup> (6.1%); irrigation 9500 mln. m<sup>3</sup> (84.2%); agricultural water supply 574 mln. m<sup>3</sup> (5.1%); other needs 38 mln. m<sup>3</sup> (0.3%); water escaped into surface water systems 4476 mln. m<sup>3</sup>; collector-drainage water used 351 mln. m<sup>3</sup> (7.9%).

The return waters are not suitable for drinking water supply, but they can be used for fishery - 20-80%, for irrigation - 40-80%. From 4476 mln. m<sup>3</sup> of the return waters of about 351 mln. m<sup>3</sup> are used.

Of 64 km<sup>3</sup> of water flow originating in the territory of Tadjikistan only about 14.1 km<sup>3</sup> are used in the republic. In spite of abundance of water resources in the area of Tajik part of Amu Darya there are regions with poor water supply such as Kzylsu-Yakhsu zone, low reaches of Kafirnigan river in Khatlon province. For Istravshan group of regions in the north of the republic the only source of improving of water provision of lands is Zeravshan river, the flow of which within the limits of Tadjikistan is used not more than 5-7%. Increase of water provision of irrigated lands in these regions as well as further extension of new irrigation areas is possible only by constructing Nizhne-Kafirnigan reservoir with useful capacity of 600 mln. m<sup>3</sup> and Zeravshan reservoir with useful capacity of 780 mln. m<sup>3</sup>

The perspective of water resources use in the Republic of Tadjikistan in the nearest 10-25 years will be mainly determined by intensive growth of the population, that according to the forecasts by the year of 2010 should account for 7.3 mln. people, and by 2025-8.9 mln. people. An increase of agricultural food production is possible only by expansion of irrigated areas as well as increase of productivity of existing arable lands. Tadjikistan possesses a considerable meliorative fund, around 1570 thous. ha net. All the lands of perspective irrigation are suitable for regular irrigation taking into consideration their development in the future the level of provision with irrigated areas per capita will be lower than a regional one.

In order to provide the population of the Republic with necessary quantity of foodstuffs and agricultural raw materials it is necessary to develop additionally around 346.3 thous. ha by 2010, and around 470.1 thous. ha of irrigated lands by 2025. By 2010 water diversion for irrigation will increase in comparison with 1990 by 31% and will account for 15428 mln. m<sup>3</sup>, and by 2025 respectively it will increase by 53.7% and will be 18076 mln. m<sup>3</sup> (table 6.4). During that specific irrigated area will increase from 0.11ha in 1990 up to 0.145 ha by 2010 and 0.133 ha by 2025 per capita, but it will not exceed average regional level of 0.21 ha/capita.

Domestic and drinking water consumption is forecasted by 2010 at a level of 0.583 km<sup>3</sup> a year, and by 2025 - 0.799 km<sup>3</sup> a year. Water diversion for the purposes of agricultural water supply is forecasted respectively by 2010 0.76 km<sup>3</sup> a year and by 2025 - 809 km<sup>3</sup> a year.

In conditions of development of free market economic relations by the assumed increase of a number of small enterprises, especially in mining industry by 2010 two times more fresh water in comparison with 1990 will be required, that will be 1.188 km<sup>3</sup>, and by 2025 respectively three times more or 1.782 km<sup>3</sup>. The use of closed water use will enable in future to reduce the needs of industry in fresh water.

The increase of water consumption for the purpose of social and economic development of Tadjikistan in all sectors, including expansion of irrigated areas, is planned only at the expense of surface water resources. Partially ground waters will be used in order to provide the population

with drinking water. Total in the Republic of Tadjikistan by 2010 18.7 km<sup>3</sup>, and by 2025- 22.4 km<sup>3</sup> of water will be required.

The decrease of water consumption in future is planned using water conserving measures, such as complex and partial rehabilitation and modernization of irrigation systems, introduction of improved techniques and technology of irrigation, economic incentives of water conservation.

Hydropower engineering will gain growing importance in water resources use. The use of hydropower resources has a strategic importance for the Republic of Tadjikistan. The annual generation of cascade of Vakhsh HPS in forecast period increased from 15.1 up to 28.4 bill. kW/h, including vegetation 9.96 up to 14.21 bill. KW/h. The annual generation of Nurek HPS in forecast period will account for 11.3 bill. KW/h, and in vegetation it will reduce from 7.41 bill. KW/h up to 5.64 bill. KW/h. During that the discharge through the dam location will be respectively annual of 20.4 km<sup>3</sup>, and in vegetation it will reduce from 13.4 km<sup>3</sup> in 2001 up to 10.2 km<sup>3</sup> in 2025. The annual generation of Kayrakum HPS in the forecast period will be 521.7 mln. KW/h, and in vegetation it will reduce from 371.6 mln. KW/h up to 273.4 mln. KW/h. The discharge through dam location will be respectively annual of 16.8 km<sup>3</sup>, and in vegetation it will reduce from 12.63 km<sup>3</sup> in 2001 up to 7.6 km<sup>3</sup> in 2025. By putting into operation Rogun and Sangtuda hydrosystems under construction of reservoirs with power generation volumes as well as regulation of Vakhsh river flow will considerably increase. Taking into account of opportune natural reservoirs for moisture accumulation Tadjikistan may become in the future an original reservoir of pure water for the whole region.

The Republic of Tadjikistan in its international policy will keep to universally recognized principles of international water law, in particular Convention on protection and use of transboundary water flows and international lakes (Helsinki, 1992), where it is said that water resources management is carried out in a way to satisfy the requirements of today generation without damage to the possibility of future generations to satisfy their own requirements, as well as the article 4 of Helsinki law of use of international rivers waters (1996), where it is said, that each and every state of the basin has a right within the limits of its territory to reasonable and equal use of international basin water. In the resolution 1803 XY11 of UN General Assembly it is said that inalienable sovereignty over natural resources declares right of nations and people to the inalienable sovereignty over their natural resources and resources should be carried out in the interests of national development and welfare of population of respective states.

## **6.2. Irrigated Areas.**

Several economic, political and natural factors, including scarcity of land resources, hardships of provision with material and technical and power resources, deficit of investments to agriculture and water sectors, the lowest index of a specific area of irrigated lands per capita (0.12 ha in 1994) in the region and a specific water use per capita (2.4 thous. m<sup>3</sup> in 1994) under intensive increase of population considerably complicate problems of provision of the population of the republic with agricultural products.

Taking into account additional development of lands irrigated areas per capita in 2010 will be 0.147 ha, and in 2025- 0.133 ha.

**Table 6.2.****Irrigated lands per capita in the Republic of Tadjikistan.**

Years	1970	1980	1991	2000	2005	2010	2025
Number of country population, thous. people	2940	3954	5515	6105	6693	7258	8955
Total lands, ha/capita	0.30	0.23	0.17	0.13	0.11		
Including irrigated ones	0.17	0.15	0.12	0.08	0.07	0.147	0.133

The future irrigated areas in the republic amount to 860000 ha, including in Khatlon province 390000 ha, in Soghd province 340000 ha, in RRS 123000 ha and in GBAP 7000 ha.

According to the development plan and distribution of melioration and water sector of the republic there is available land in the Republic. One of the first reserves is a completion of the construction of water systems included in the scheme of development for the period till 2000 and started before 1991. The names of the systems of prospective irrigation meant for the priority development in the Republic of Tadjikistan are given in table 6.3.

**Table 6.3.****Objects of prospective irrigation of the Republic of Tadjikistan.**

N	Names of the objects	Capacity, thous. ha	Planning zone
1.	Irrigation of lands of Kyzylin massif	25.0	Soghdiyan
2.	Irrigation of lands on the base of transference of part of flow of Zeravshan river into Ura-Tyube group of districts.	56.6	Soghdiyan
3.	Irrigated lands of flood-lands of Zeravshan river.	35.0	Soghdiyan
4.	Irrigation of lands of Dangara steppe.	75.0	Khatlon
5.	Irrigation of lands on the base of Bojuan reservoir.	20.0	Khatlon
6.	Irrigation of lands of Beshkent valley	12.0	Khatlon
7.	Irrigation of lands on the base of Nizhni Kafirnigan reservoir.	65.0	Khatlon
	Total	288.6	

The future crop pattern in irrigated lands of Tadjikistan is given in the Table 6.4.

As a whole in the republic by 2025 the following pattern of agricultural crops is planned: cereals 450000 ha, cotton 300000 ha, vegetables and melons 54000 ha, potato 27000 ha, fodder 125000 ha, many years plants 150000 ha and other crops 82000 ha. Total in the republic it is planned to increase irrigated area up to 1188000 ha.

**Future crop pattern in irrigated lands of Tadjikistan.**

Table 6.4.

№	Name of crops	Provinces												In the Republic		
		Sogd			Khatlon			RRS			GBAP			1990	2010	2025
		1990	2010	2025	1990	2010	2025	1990	2010	2025	1990	2010	2025			
1	Cereals	29,21	105	122	17,59	207	238	10,13	66	77	2,91	12	13	59,84	390	450
2	Cotton	93,86	75	83	197,4	171	190	22,65	24	27	0	0	0	310,91	270	300
3	Vegetables and water-melons	10,41	14,4	16,2	13,64	17,2	19,4	9,96	15,7	17,6	0	0,7	0,8	34,01	48	54
4	Potato	4,28	6,6	7,7	3,16	3,4	4,0	9,3	10,2	12,0	1,03	2,8	3,3	17,77	23	27
5	Fodder	21,53	45,6	47,5	67,65	41,2	43	28,32	25,2	26,3	12,69	8	8,2	130,19	120	125
6	Perennial	25,5	48	51,4	24,02	42,7	46,4	18,68	47,5	49,2	5,14	2,8	3	111,25	141	150
7	Others	36,85	39,6	45,1	0,38	26,6	30,3	3,72	4,3	4,9	1,23	1,5	1,7	42,18	72	82
	Total:	259,55	334,2	372,9	320,84	509,1	571,1	102,75	192,9	214,0	23,0	27,8	30,0	706,15	1064	1188

### 6.3. Future Return Flows and Salt Loads to the Main Rivers.

Return flows are an integral part of irrigation systems functioning in Tadjikistan. The retrospective analysis shows that the more water diversion into the systems is the bigger the volume of release is. Having reached maximum in the midst of 80-s, at the beginning of 90-s it started to decline. At present the flow is still characterized by a relatively big specific quantity  $6.2000 \text{ m}^3$  from ha. And total volume 4.42 bill.  $\text{m}^3/\text{year}$  at a relatively low level of salinity- 1.5-2 g/l, rarely more than 2. Big specific length of water allotting collector-drainage network-around 37 linear m./ha at a total length 11.3000km.

The data analysis of 21 big collectors shows that average monthly and annual flow levels, water salinity and salt export with them occurred to be of different character. The more typical occurred to be a picture of increase of flow and salt export with them in the middle of the year (June-September) and reduction of these indices at the end and beginning of annual cycle. During that a salinity of drainage water was changing with smallest amplitude. In another group of collectors these characteristic signs of flow volume, salinity of drainage water and salt export were leveled in annual cycle. However salinity of drainage water has big amplitude. Chemism of flowing Collector-drainage waters is chloride-sulfate. During that the chloride content of waters is from several per cents in a salt composition up to tens and several tens in the next sequence: Ghissar valley, valleys of Southwest and North of the republic.

Quantitative indices characterizing flow of waters from irrigated areas in different provinces of the republic essentially differ: thousands of  $\text{m}^3$  by flow index, tens and hundreds of tons on salt export and in grams per liter according to salinity, chemism of drainage water. The reasons for that picture of flow (water allocation) from irrigated areas of zones are:

- different volume of return waters, used for agricultural purposes: millions of  $\text{m}^3$  in Soghdian province in connection with a growing deficit of irrigation water and only first hundreds of thousands  $\text{m}^3/\text{year}$  in Khatlon province;
- in the construction of CDN of Khatlon province as collectors used natural water flows of irrigated valleys of Yavan-Obikiik, Dangara, Garauti and Tashrabad, involving in the flow their water escape basins.

In the nearest future a positively forming character of water-salt balances change did not preserve, because during that time an irrigation of new lands is planned. However in the republic there is a possibility to retain and strengthen planned positive course of ecological and land improvement processes in irrigated areas. For that in strategic actions one should orient at world biological diversification of irrigated farming in all of its spheres, including in drainage regulation as well.

In connection with specific conditions of relief of irrigated areas of the Republic of Tadjikistan reuse of collector-drainage water in the irrigation contour itself very often entails considerable costs and therefore it is inexpedient. At that return waters from irrigated massifs of Tadjikistan do not essentially influence on the quality of river flow as a whole. Nevertheless in future the use of progressive technologies of irrigation will allow reducing the volumes of collector-drainage waters, discharged to rivers. There are no natural desert depressions in the territory of Tadjikistan, where return waters would be discharged for their further evaporation. Practically all the water through the escape network or via ground streams goes back to the main river system.

In that sense the productivity of use of water resources in irrigated farming of Tadjikistan is the highest one.

#### **6.4. Interrelation between Water and Energy Sectors.**

All the interrelations between legal entities both within the states and between the states have an economic character. Flow regulation of transboundary rivers is not exclusion. Complexity here is that regarding water resources and their use any kind of simple economic scheme, for example buying-selling has not been determined yet. Of course this is related with peculiarities of the product used, i.e. water and with historical traditions and existing conditions. Existing scheme of interrelations between the entities of interstate multi-purpose water resources scheme: services on flow regulation-compensations can not be left unchanged. Really according to this scheme today Kyrgyzstan and Tadjikistan are compensated by Kazakhstan and Uzbekistan only excessive electricity of Toktogul and Kayrakum HPS, generated by them in summer during the operation of hydrosystems in irrigation regime. In fact this is just exchange of electricity. And the water delivery itself is carried out during that without any compensation, free of charge. Moreover Tadjikistan even pays extra for this: according to the signed in 1998-2001 interstate agreements between Tadjikistan and Uzbekistan for flow regulation of Kayrakum reservoir Tadjikistan receives for that in winter only 200 mln. KW/h. of electricity, giving 300 mln. kW/h.

It will be fair if in addition to that simple seasonal exchange of electricity the consumers (Kazakhstan and Uzbekistan) will directly compensate or pay a water delivery as well, that they additionally get in vegetation period .The calculation of such delivery one can do taking into account cost of a concrete hydrosystem, share of irrigation component, total operational costs and a volume of additionally received water in it.

The structure of management of multi-purpose water resources scheme in Central Asia already does not meet present conditions. ICWC and UDC Energiya are considerably limited in their possibilities and besides they function on different principles: UDC Energiya as a matter of fact is just an executive body optimizing the fulfillment of claims of national power companies , and ICWC has retained to some extent (or tries to keep) command functions. And the main thing is that they do not cooperate with each other. As a result a paradoxical situation occurs. All the operation modes of hydrosystems of the Aral sea basin are elaborated and approved by ICWC without any participation of energy sector. And these operation modes practically of all main hydrosystems are implemented by energy sector without participation of representatives water sector. One more shortcoming of these organizations is the fact that they having a status of interstate organizations in principle do not envisage either rotation of management staff or participation of specialists of other republics in the work. All of them are located in Uzbekistan, mainly in Tashkent and are formed 100% of national staff of Uzbekistan.

In some countries state managing centers are absent and water and energy sectors are not coordinated either in strategic or in operative plans. As a result the Governments of the republics often have to fulfill the functions of a simple dispatcher. Of course such organizational management system does not ensure a necessary efficient functioning of water and energy complex. This is recognized practically by everybody, and at the same time during the whole period starting from 1991 not any real steps were made towards its change.

At present it is complicated to propose some option of solution of all these problems. The reform of state management in Tadjikistan is not completed yet. Its regional aspect is still being elaborated and discussed. On the national level it is necessary to strengthen a coordination of actions of all institutions, related with water and energy complex. Also it is necessary to strengthen interrelations between water and energy bodies at regional level as well between UDC Energiya on one hand and BVO Syr Darya , BVO Amu Darya on the other. Besides these bodies themselves need serious reforms.

Obviously one of the options of solution may be creation of international water and energy consortium, but with an accent not on administrative management, but on free market schemes of interrelations.

If creation of consortium as an interstate management and coordination organization is impossible, then as an organization of commercial type ensuring fulfillment of Agreements on joint use of water and energy resources of the Aral sea basin is real. Such consortium could for instance purchase from Kyrgyzstan and Tadjikistan an extra summer power at a work of their hydrosystems in irrigation mode and its sale to them in winter. Of course in that case in order to ensure necessary profitability, summer discharge of irrigation water also should be paid by consumers - Kazakhstan and Uzbekistan - at least by agricultural products gained as a result of its use.

By present the republics of CAPS could sign only one agreement on water and energy complex. This is Bishkek agreement between the Government of the Republic of Kazakhstan, Government of Kyrgyz Republic, Government of the Republic of Tadjikistan and Government of the Republic of Uzbekistan on use of water and energy resources of Syr Darya river basin of March 17, 1998 with additions and changes according to the protocol of June 17, 1999 and annual agreements between the republics and managing subjects, setting concrete terms and operation modes.<sup>1</sup> The same Agreement on Amu Darya river basin, prepared by Tadjik side also in 1998 and repeatedly sent to other republics, was never considered.

Preparation and signing of joint agreements is a big problem at present time. Already signed agreement is not often a final solution of an issue. It may simply be not fulfilled. The 4<sup>th</sup> point of an agreement on Syr Darya river basin, that foresees, could be example:

- The Republic of Tadjikistan every year ensures operation of Kayrakum reservoir on a regime agreed by the parties, and the Republic of Kazakhstan and Republic of Uzbekistan deliver equal shares of electricity to the Republic of Tadjikistan in the period of water accumulation in reservoir with further return of agreed equivalent volume of electricity in summer period.

Unfortunately from the very beginning of its signing and till now this clause is fulfilled only by Uzbekistan with digressions. And Kazakhstan never did.

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<sup>1</sup> At the same time was signed one more common Agreement between the Government of the Republic of Kazakhstan, Government of Kyrgyz Republic, Government of the Republic of Tadjikistan and Government of the Republic of Uzbekistan on a parallel work of energy systems of Central Asian states . But this agreement regulates the relations only in energy sector and does not have any linkage with water complex. That is why it is not considered here.

A present situation can not suit the Republic of Tadjikistan and Kyrgyz Republic. As for the rest of three republics - Kazakhstan, Turkmenistan and Uzbekistan, their earlier existed and in considerable extent retained till now interrelations in water and energy resources use completely suits both on total volumes of water sharing and on operation modes of hydrosystems in cascades. To certain extent the following documents, signed in transitional period of forming of new independent states of Central Asia Agreement between the Republic of Kazakhstan, Republic of Kyrgyzstan, Republic of Uzbekistan and Turkmenistan on cooperation in the sphere of a joint management of use and protection of water resources of interstate sources signed in Alma-Ata in February 18,1992 and Nukus Declaration of Central Asian states and international organizations on problems of sustainable development of Aral sea basin, signed in Nukus city in September 20,1995, contributed to this.

Formally this as if says about a impossibility to change order of use of water and energy resources, formed in Soviet period. But today there is no need to be guided by normative-legal acts of USSR in water resources management. Signing of Alma-Ata agreement and Nukus declaration was caused in that complicated period of forming of new states by striving not to break, but smoothly reform a system, not to allow an anarchy, but provide a succession in decisions, that undoubtedly proved its value.

Thus, at present retaining of previous relations between the republics regarding water resources is not undoubtedly obligatory. They could be changed. It is necessary only to warn in advance about it other parties. The possibility and necessity of such changes was set up in the Agreement on joint actions on solution of the problems of the Aral sea and Priaralye, ecological recovery and ensuring social and economic development of the Aral sea, signed in Kyzylorda in March 26,1993.

The analysis of all available international agreements shows that the republic has a full right to use of their hydrosystems with reservoirs, because this is necessary in the interests of the country itself. A total principle of that behavior could be formulated in the following way:

- 1.Sovereign state possesses all the rights to set absolutely river flow regulation modes on belonging to it and located on its territory reservoirs of any corresponding to its national interests.
2. In case if those modes touch the interests of other states of the basin, the state-owner must on agreement change the operation modes in favor of other interested states with giving to it from their side respective compensations.

In international practice there are real precedents of such a rule use.

## **6.5. Financial Alternatives for Agricultural Infrastructure.**

### **6.5.1 Necessary Capital Investments.**

In the course of tasks fulfillment during Phase 4 there was carried out an elaboration of methods of calculation of the costs during investment of rehabilitation of irrigation and drainage infrastructure. As a whole a balance cost of meliorative fund in the Republic of Tadjikistan was defined in an amount of 1.517bill. USD.

The according cost of rehabilitation has been defined in an amount of 746.412mln.USD. It is necessary to note that the mentioned quantity has been obtained by calculation, because after 1990 an inventory of main funds was not carried out. In principle this order of figures corresponds to the degree of wear and tear of main meliorative funds, adopted in Medium-Term Program of the Way Out of the Crisis of Agroindustrial Complex (50%), adopted by the Government of Tadjikistan in September 2000.

The annual cost for rehabilitation of irrigation and drainage sector in the prices of 2000 amounts to 64.8mln.somoni (29.45mln.USD), and actually the costs of different sources amounted to 12.708mln.somoni (5.774mln.USD), this points to low investment in operation of irrigation and drainage systems.

As a forecast, with taking into account operation tariffs for the services on water delivery and under the condition of 100% payment by consumers, and also invariable state support annual internal investments in the volume of 10mln.USD may be expected.

#### 6.5.2 Operation and Maintenance Costs.

Operation and rehabilitation works on melioration systems bear seasonal character, stipulated by natural conditions and demands of agricultural production. Thus all the works on preparation of irrigation systems are conducted every year in non-growing season, i.e. from October up to April, and the works on operation of irrigation and collector-drainage networks take place in growing season, i.e. from April to October.

Therefore all the estimations for the cost-price of works on melioration systems are to be conducted in an annual context, i.e. to estimate production costs of the system per year (annual costs), the cost-price of operations and service per ha of irrigated (dry) area, cost-price per m.<sup>3</sup> of water delivered per year, etc.

For the operation of melioration systems the most important element of the cost-price (expenses) is amortization of main funds. The rest of expenditures consist of costs on salary, current repair, cleaning of canals and collectors, for the payment of consumed electricity in the zones of pumping water supply, salary for administrative-managerial staff and other expenses.

On the meliorative systems, that are on budget funding, amortization is accounted for because these systems do not have their own income and can cover amortization only allocating of assigned budget to them for such purposes.

According to the Regulations on Conductance of Planned-Preventing Repair of Hydromeliorative Systems and Constructions , a complex of technical measures is fulfilled every year, directed at the maintenance or rehabilitation of both the systems and structures as a whole and of their separate constructive elements and parts.

The current repair of systems and structures is made with the objective to prevent meliorative funds from untimely wear and tear by means of prevention measures and removal of small damages and disrepairs, the estimated cost of which does not exceed 20% of the initial cost of the repaired object.

The special place in operation of meliorative systems take costs of maintaining irrigation and collector-drainage network - 1/3 of all the expenditures. The capital repair of structures on inter-

farm network is carried out, when the current balance cost amounts to 20-50% of its initial cost. For the on-farm network this cost is 20-85%. The capital repair is made with the purpose of full and partial rehabilitation of networks, structures or their separate elements. The cost of full rehabilitation of some structures, included in the repaired object, exceeds their initial cost.

## **6.6. Institutional Framework.**

As the ecological reforms progress in the country, there will be institutional changes occur in agrocomplex and water resources sphere. In particular according to the new Water Code of the Republic of Tadjikistan the possibilities are foreseen for a change in the forms of ownership of water resources system, transfer the rights of management to special local and foreign juridical persons on a limited area. The institutional changes in water resources sphere will occur in connection with a planned and prepared management reform of the Republic of Tadjikistan, declared in a Statement of the President of the Republic of Tadjikistan E.Sh.Rakhmonov to Majlisi Oli (Parliament) of the Republic of Tadjikistan on April 27,2000. It is necessary to note that with the development of free market relations during the last 10 years some movement is made towards water resources management within the limits of administrative units, that caused corresponding institutional changes.

All the water resources complex and especially irrigated farming and its future development depend to a considerable extent on all these institutions, which influence water resources management both as a whole in the country and in some areas, and also on the fulfillment by these institutes of existing legislation. Of course in the process of future institutional changes an evaluation will be made of the work of each organization and effectiveness of services rendered by them. Therefore for the optimization of water resources management system on the national level it will be necessary to carry out a gradual transfer to a management system within the limits of basins, to speed up the creation of water-users associations and to develop forms of private, collective and joint-stock water-use. All of this must correspond to institutional changes, changes of the functions of the Ministry of Water Resources and Ministry of Agriculture, in particular in the transition to contractual relations with subordinate organizations and enterprises.

In connection with putting into operation a new amendment to the Water Code it is necessary to analyze the existing hierarchy structure of water resources complex with the purpose of further reforming. The reform must cover the following directions in the water resources sector:

- improving of economic basis of functioning of water resources subdivisions;
- specification of structural functions of the sector on each hierarchic level: republic-province-region (basin);
- improvement of the principles of water resources complex management, taking into account the large changes occurred in economic relations between the subjects during the last 10 years;
- deep study of the existing schemes of complex use and protection of water resources, their adaptation, in case of necessity their change with taking into consideration local and national economic interests;

- development of national water policy and strategy taking into account current and future interests of the republic.

But the fulfilling of these tasks will be closely related to the general economic development of the Republic, pace and effectiveness of land reform, establishment of favorable conditions for attraction of local and foreign investments into water resources.

## **6.7. Political Environment and State Regulation.**

During the period of independence of the Republic of Tadjikistan several basic legislative acts have been adopted, which make the process of reforms, including agricultural sector, irreversible. This is a Law on Property, Law on Dekhkan Farms, Water Code, which is the core of economic mechanism of water-use, and others. In September 2000 the Government of the Republic of Tadjikistan has adopted a Medium-Term Program of the Way out of the Crisis of Agroindustrial Complex and Priority Development Directions of Its Sectors for the Period of up to 2005 . This document defines the ways of deepening of economic reforms in agroindustrial complex and in agricultural sector in particular. The deepening of land and water reforms is foreseen. In these issues a great attention is paid to the problems in reforming management structure.

The privatization and reforming of enterprises and organizations, forming of competitive environment should play their positive role in establishing and developing free market relations in a village. An investment policy and strengthening of material-technical base favors this. This is an attraction of new investment sources (long-term credits, receipts from the equity issue of joint-stock enterprises, insurance and other non-government foundations, funds from private persons ,etc., personal assets, means of non-budget funds, foreign investments and others.

Improvement of financial-credit mechanism goes in the way of:

- provision of development of cost and conjuncture free market information with its submitting to all the subjects of free market;
- development of the system of state purchases taking into account the needs of the state and possibilities of the budget;
- improvement of the system of short-term and long-term crediting of producers of goods.

In the field of price-forming and price policy Tadjikistan follows a combination of free price-forming, because the system of state orders is annulled, conductance of flexible antimonopoly policy, creation of equal economic conditions to all producers, irrespective of ownership and management forms.

In the field of tax policy a course is taken towards the stimulation of production of agricultural products. It is assumed to introduce a single fixed land tax, not depending on the results of economic activities, with simultaneous liberation of all other taxes. The system of tax and custom privileges exists and is being improved. During stabilization of an income part of the budget a creation of special state funds of agrarian sector financial support and the whole agroindustrial complex (AIC) is assumed. The means of those foundations could be directed at financing of state target programs of AIC, means of protection of plants and animals from vermin and illnesses,

compensation of losses as a result of death of sowings of agricultural crops, financing of measures on development of pedigree stock-breeding and elite seed-farming, state support of farms.

One of the directions of state regulation are special measures of state support to the farms located in extreme and unfavorable for farming regions. At present a reduced tariff on electricity for the zone of pumping irrigation of lands is fixed and operates. The tariff on water delivery from state irrigation and watering systems is also reduced. It covers not more than 30% of costs of water resources organizations and the delivered water is not fully paid. By the Decision of the Government of the Republic of Tadjikistan an annual 10% increase of collection of payments for the services on water delivery is foreseen. According to the forecast the full payment of the fixed privileged tariffs is expected not earlier than 2006.

The farms in the first three years of their existence are exempt from the payment of the land tax. Seed-growing areas, experimental plots, variety-testing, pedigree farms, lands of water fund are exempt from the land tax.

Foreign economic activity of the agroindustrial complex foresees an extension of export potential, international division of labor, taking into account an effective use of favorable natural and economic conditions of each country, improvement of management mechanism of foreign economic cooperation, reduction of import of AIC production up to minimum, which could be produced in Tadjikistan up to volumes, satisfying the needs of population, extension of import of non-traditional goods which could be produced only under the unique conditions of the country (geranium, citrus plants, nuts, etc.). Tadjikistan needs a definite period to adapt agrarian sector to the world free market on the conditions of World Trade Organization, but with a condition of protection of interests of producers of the Republic of Tadjikistan.

## **6.8. Water Quality Standards.**

Water quality is characterized by the structure and properties of water defined by its fitness for concrete type of water utilization and water consumption. Water quality criteria are the characteristics by which an assessment is made of water quality in accordance with types of water-use and water-consumption. Maximum permissible concentration (MPC) of harmful substances in water, elaborated by the Ministry of Health Protection of the former Soviet Union are still used in our Republic. MPC is the main hygienic standard put into the basis of modern water-sanitary legislation. The standards of MPC (mg/l) are elaborated for all possible substances coming into reservoirs. The drainage waters are forbidden to discharge into reservoirs according to the degree of pollution exceeding the MPC. Pollution of drainage waters is measured at a control node.

The biochemical demand in oxygen (BDO) points to the content of oxygen in water (mg/l) needed for the oxidation mainly of organic substances which cause water pollution. For the domestic waste waters the demand for oxygen is rather stable and depends on the standards of water consumption per capita. In the industrial wastewaters BDO fluctuates in very wide range.

The hydrogen index (pH) defines the concentration in water of hydrogen ions and shows its acidity or alkalinity. The points of the pH index for domestic water-use must not exceed 6.5- 8.5.

The organoleptical features of water characterize the smell, taste and swimming admixtures, unfavorably influencing people. These features are estimated in points.

In sanitary-hygienic standards for quality assessment of domestic-drinking and municipal purposes the following indices are used: suspended substances, swimming admixture, smell and taste color, temperature, hydrogen index (pH), salinity of water, dissolved oxygen, biochemical oxygen composition, disease stimulus and poisonous substances.

Common demands to the composition and features of water used for domestic-drinking water supply are given in Table 6.5.

Common demands to the composition and features of water used for domestic-drinking water supply.

**Table 6.5**

Indices	Demands and indices of water quality of water objects
Suspended particles	Content of suspended particles must not increase during the escape of water flow more than 0.25mg/l.
Swimming admixture	There must not be pellicles of oil products and other compounds.
Smell and taste	Intensity more than 2 scoring points is not allowed. The water must not have any illegitimate smells and fish meat smacks.
Color	It must not be observed in a column of water of 20cm.
Temperature	It must not exceed more than 3 degrees in comparison with an average monthly quantity during last 10 years.
Hydrogen index (pH)	Within the limits of 6.5- 8.5
Salinity of water	On a dry residue not more than 1000mg/l, including chlorides 350mg/l and sulfates 500mg/l
Dissolved oxygen	Not less than 4mg/l in any period of the year in a sample taken until 12 a.m.
Biochemical demand in oxygen	With a temperature of 20°C must not exceed 3mg/l.
Disease pathogens	On content of bacteria of intestinal bacillus group. Number of microorganisms in one mm. <sup>3</sup> : without water preparation not more than 100, with water preparation not more than 10000.
Poisonous substances	Not exceeding MPC.

The characteristic feature of surface river water quality is an increased turbidity, especially in spring and autumn period, that is related to floods and rainy floods. The data on turbidity and as a whole on hydrochemical regime of rivers are issued by Gydrometsluzhba of the Republic of Tadjikistan in a separate series Annual Data on Dry Land Surface Water Quality that are the part of state water Cadastre.

The salinity by a composition of dissolved salts is the main index of suitability of water for drinking. Operated standards consider the following gradations of suitability of surface waters for drinking:

- 0-600mg/l- good drinking water;

- 600-1000mg/l- satisfactory drinking water;
- 1- 1.5g/l- water permissible for drinking;
- 1.5- 2.5g/l- water permissible for drinking if necessary;
- 2.5- 4.0g/l- water permissible for drinking at a last resort;
- more than 4g/l- water not suitable for drinking.

Quality standards of water used for centralized water supply are regulated by State Standard (GOST 2874-83- Drinking water) and Regulations on Surface Water Protection from Pollution. Conformably to the aforementioned conditions water in the majority of the territory of Tadjikistan rivers have good drinking quality during the whole year. In a low water period the drinking water quality in some rivers deteriorate because of the increase of salinity.