



# **MANAGEMENT OF WATER RESOURCES IN UZBEKISTAN AND WAYS OF RAISING ITS EFFICIENCY**

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September 1998

Prepared for

Central Asia Mission  
U. S. Agency for International Development

Environmental Policy and Institutional Strengthening Indefinite Quantity Contract (EPIQ)

*Partners:* International Resources Group, Winrock International, and Harvard Institute for International Development

*Subcontractors:* PADCO; Management Systems International; and Development Alternatives, Inc.

*Collaborating Institutions:* Center for Naval Analysis Corporation; Conservation International;  
KBN Engineering and Applied Sciences, Inc.; Keller-Bliesner Engineering; Resource Management International, Inc.;  
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## **Executive Summary**

The report has been elaborated by the group of scholars in the Institute of Strategic and Interregional Studies at the President's Office of the Republic of Uzbekistan within and supported by the EPIC Program.

Its preparation was caused by the necessity of objective and critical assessment of water consumption experience accumulated in the Republic of Uzbekistan in order to obtain the increased effectiveness of water use under the situation of forecasted water deficit. The other need was to work out recommendations for the optimized participation of the Republic of Uzbekistan in the regional cooperation related to the problems of water use.

For these purposes the report contains:

- Main provisions of the existing normative and legislative base on the issues of water use, and formulated recommendations concerning the improvement of this base;
- Problems of water use in Uzbekistan by regions and sectors of economy;
- Recommendations made on the basis of the critical water quality assessment to improve water quality including the use of foreign experience (primarily, the U.S. experience);
- General proposals on the implementation of water saving technologies as a way to the rationalized use of water resources; and
- Some approaches to the problem of power generation and use, as one of the key factors for regional cooperation in water use.

The authors of the report believe that the optimization of water use at the national level and the unification of approaches to fulfill of this task in the neighboring countries of the region will allow to create favorable preconditions to strengthen and develop regional cooperation in the issues of mutual use of water and energy resources and overpower the existing concomitant differences.

In the process of the report elaboration, the opinions and estimations of the chief specialists from some local and foreign institutions and organizations on the issue were examined. Then, the authors made an attempt to formulate the experts' recommendations concerning the problems of the water use on rationalization at the national level.

The Improvement of the Legal Base.

1. Under the transition to the market, it is necessary to create equal economic conditions, including full water supply, for all managing subjects involved in growing crops and other agricultural activities.
2. In order to improve rational use and protection of irrigated lands in agriculture, the agricultural law should be developed as an independent branch with due regard for ecological and geographical peculiarities of a specified locality.

3. Proceeding from the foreign experience, it is proposed to adopt the “Law on Land Utilization in Agriculture”, because of improper attention in the “Land Law” paid to the ecological and legal issues of rational use and protection of irrigated lands in agriculture.
4. The Ministry of Agriculture and Water Management, the Uzbek Concern on Water Construction should turn to the construction of collector-drainage and other reclamation network at the more upgraded, technologically higher level. At the same time a passport system needs to be introduced (ecological and economic passport of irrigated land) in each region of reclaimed and irrigated lands to determine quantity and quality characteristics of land areas.
5. Considering the ecological and legal aspect of the problem of ownership regarding irrigated lands and other natural resources, it ought to be emphasized that the right of private ownership should not be extended for application to the irrigated lands, for their entering into market turnover can result in very grave and irreversible consequences.
6. For rational use and protection of irrigated lands it is necessary to promote active participation of central and local authorities in the ecological management, i.e. to include in the process the mahalla<sup>1</sup> committees, small and private enterprises, joint ventures, lease farms, dehkane<sup>2</sup> farms, and businessmen.
7. Ecological control groups should be created within the mahalla committees. These groups would be involved in the issues of rational use of irrigated lands, water and forest resources, and atmospheric air.
8. Water resources should be regarded as a special natural resource, which is to be evaluated differentially emanating from its use in agriculture (agriculture or animal husbandry). With the aim of preventing from wasteful water use it is necessary to establish charges for water for all legal entities and individuals exercising the right of agricultural water use. Therewith, a farm or person that violated the contract provisions, should bear the legal responsibility in the event of losses resulted from insufficient water supply.
9. Law enforcement bodies should be administratively independent from each other in rational use and protection of irrigated lands. This will allow to set close contacts between land surveyors and hydraulic engineers of farms. The Office of the Public Prosecutor, Republic of Uzbekistan, should tighten supervision over environmental violations, over irrational use and in the area of protection of irrigated lands, in particular.
10. Environmental offenses in the area of rational use and protection of irrigated lands are characterized by:
  - Guilt of offender (land or water user);
  - Illegal ecological behavior;
  - Causal relationship between the violation of environmental law and resulting ecological consequences;

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<sup>1</sup> Mahalla is a town block in Uzbekistan.

<sup>2</sup> Dehkane are farmers in Uzbekistan.

- Ecological damage to water and irrigated lands; and
  - Real threat to the ecological condition of irrigated lands, crops and other natural resources.
11. In the event of violating the requirements of ecological and legal protection and rational use of irrigated lands, the offenders should be brought to the strict ecological and legal responsibility.
  12. The Code “On Administrative Responsibility” is expedient to be amended with such Articles as “Responsibility for Violation of Economic Requirements on Protection and Use of Irrigated Lands”, “Responsibility for the Use of Irrigated Lands for Improper Purposes”.
  13. It is judicious to amend the Criminal Code of the Republic of Uzbekistan with such Articles as “Unauthorized Construction on Irrigated Lands”, “Illegal Sale and Squandering of Irrigated Lands”, “Destructive Use of Irrigated Lands”, “Illegal Improper Use of Irrigated Lands”, “Illegal Managing of Irrigated and Agricultural Lands”.

Unfortunately, the existing legislation doesn’t allow to cover new verges in relationships connected with the arising of private water users in Uzbekistan. Providing the same status for the rights of farmers as for the rights of other water users, it is necessary to perform more detailed assessment of relationships taking into account the peculiarities of farms. Economic mechanism of interaction between a farm and water delivery organizations needs legal support.

Article 49 of the Law “On Water and Water Use” provides limited water consumption for agricultural purposes on the basis of contract. Hence, relationships between water management and water users are based on the acknowledgement of their equality. Thus, the contract should be developed in conformity with the Civil Code, and therefore the responsibility between them is a prerogative of the Civil Law.

The establishment of the limited water use corresponds to the norms of civil legislation (Article 1, Civil Code). So, the restrictions for transfer of goods (for example, water is an object of the Republic property, Article 214, Civil Code) can be introduced in conformity with the legislation, if it is necessary for the safety and protection of people’s life and health, preservation of natural and cultural treasures. Therefore, the execution of obligations undertaken by the state water management organization and water users, as it is stipulated in the contract (previous version), is ensured by the legal forfeit (fine, penalty). Law, but not the code of administrative responsibility should set this forfeit.

In prospect, the Cabinet of Ministers should adopt a new Resolution “On Limited Water Use” or amendments to the previous resolution, in accordance with the Law “On Water and Water Use”, taking into consideration the requirements of Civil and Tax Codes. The resolution should have an enclosed standard contract. A mechanism of measures, applied in case of default or improper performance of obligations by parties, should be also defined.

For instance, a water user pays a fine (forfeit) for an untimely payment of tax for water use, penalty for improper use, i.e. for excessive water use. The state water management organizations are responsible for the failure to supply water under the set terms and amounts, and etc.

The rights of water users depend upon the status of a farm: if the farm functions as a legal person, has a settlement account and seal, it possesses the right of free access to water resources; and if the farm functions as a member of an Association or cooperative, or collective farm, i.e. is not independent, the access to water resources is implemented through the irrigator's service or irrigation cooperative.

In the majority of cases water diversions in all branches of industry, municipal management, and agriculture are licensed considering specific average annual amount, and the Government reserves the right on water. Water users in the face of a farmer can unlikely argue with the Government upholding his right on water. Moreover, state water management authorities set annual water amounts for each irrigated area or system following their own canons and do not coordinate the matter with water users.

The right of water user on his border should be guaranteed and licensed for certain amount of water dependent on the irrigated area and normative load, at least considering the biological requirements of plants and the highest effectiveness obtained by water users on their territory.

Water consumers using water bodies for industry and thermal energy should observe the set normal amounts, technological norms and rules of water use, and also should undertake measures to reduce water consumption and terminate the discharge of sewage water via the improved production technology.

For the more effective use of water resources, the necessity to use the world experience of water consumption under the conditions of water deficit is ripe.

Basing upon the analysis of the above experience it is possible to propose the following steps for improving economic mechanisms of water conservation in the countries of Central Asia, and Uzbekistan in particular.

1. The expansion of water users' rights through the transfer thereof for certain payment with the reserved possibility to return these rights after a specific period. Both users and their associations can represent the interests of water users. Water management at the local level will be characterized by two structures: water service, having the right to regulate, store and deliver water with recouping its own costs; and associations, or groups of users having the right for water use and transfer of a certain amount of water. This legal basis will create the necessary precondition for the increased interest of water users in water conservation.
2. The foundation of a Water Bank within a country, basin or oblast. If a certain probation period should precede the charged water use (it is connected with the pricing for all natural resources), then the Water Bank can be established much earlier since:
  - a) All hydrotechnical facilities are under the centralized management, consequently it is easier to conserve, deliver, and transfer water from the rights seller for water use to the purchaser;
  - b) Economic condition of the right holders is of little importance; and
  - c) If water organizations set up a target to find additional water resources, they will pay for this water to the holders of rights and use it for the conservation of environment and storage of water reserves for the dry period.



With the establishment of the Water Bank, water use comes up at the new level, where the main water use remains temporarily free-of-charge (for the major part of water). Water is mainly used based on a special permission for water consumption and normal amounts set for specific year. Water use will be also based on water pricing into which water consumers enter pursuing their own interests.

The implementation of the charged water use inside the country will promote to a sharp increase of the efficiency of water use and therewith to reduce to minimum all types of losses. This, in its turn, will allow to answer the question how urgent is the issue of water deficit.

For example, as of now, the republic average water used on 1 hectare of irrigated land amounts to 10,000-12,000 m<sup>3</sup> (compare with Israel, where water per 1 ha totals 5,500 m<sup>3</sup>). The amount of water per capita is 2,500 m<sup>3</sup>, whereas in conformity with the world standards the normal level of such volume is 1,700 m<sup>3</sup>. The data are evidence of wasteful, squandering use of water resources, while they are limited. Along with it, the data concerning the approaching crisis of water use in the region are evidence of the exaggerated estimations.

The problems of water use in agriculture for clear reasons are of particular interest. Statistics testifies that the cost of the crop production output from irrigated lands totals over 60% of the gross agricultural output. Irrigated agriculture (crop production) creates 19.8% of the republic's national income. Main funds of irrigated agriculture account for 20.8% of all production funds of the economy, 17.5% of the consumed power and 30.9% of the population able to work.

Water supply deficiency of irrigated agriculture in the republic will become a serious constraint for the development of economy in the nearest future. It is caused by:

- The growing water deficit due to the interstate allocation of water resources;
- The reduced irrigation capacity of rivers in the Aral Basin in the nearest future resulted from the global changes of climate;
- The increasing antropogenic man-made impact on environment;
- Quality of water resources; and
- Salinization of irrigated lands and ineffective use of land and water resources.

Water consumption on 1 hectare during the period of 1980-1995, especially after 1985, had a stable trend to reduction, and the effectiveness of irrigation water use tended to the increase. Water use on 1 hectare showed considerable differences between oblasts. The highest specific water consumption is in the farms of the Republic of Karakalpakstan, Khorezm, Surkhan Darya and Bukhara oblasts. This results from the soil and reclamation condition of irrigated lands and produced crops.

Low specific water consumption is observed in the Samarkand, Dzhizak and Syr Darya oblasts. This fact may be explained by the disposition of irrigated areas at the ends of irrigation systems and the availability of up-to-date hydroreclamation systems having high level of efficiency. The productivity of irrigation water, expressed in m<sup>3</sup>/sum, considerably varies by the

oblasts of the republic. The data regarding the discharge of water per 1 sum of output shows, that the highest level of efficiency is in the Navoi ( $3.3 \text{ m}^3/\text{sum}$ ) and Samarkand ( $2.9 \text{ m}^3/\text{sum}$ ) oblasts (average prices of 1991/1995).

The situation is explained, besides the above reasons, by the production of highly profitable crops. The lowest output is in the lower reaches of the Amu Darya.

Nowadays, little attention is paid to technical improvement of the irrigation systems existing in the republic. Measures thereof were uncoordinated and implemented on small areas, therefore, without the required effect. The tensivity of water management situation is connected with the present, but yet technically imperfect, condition of the hydroreclamation system, the low level thereof became one of the reasons that caused the exhausting of water supply assigned amount set for the perspective.

$27 \text{ km}^3$  (43%) of  $63 \text{ km}^3$  the total consumed water are productive and consumptive flows, i.e. directly participating in the national production. Correspondingly,  $36 \text{ km}^3$  include return flow losses from different sections of irrigation network, and also drainage waters. Only part of this water is used again ( $8.4 \text{ km}^3$  or 23%), consecutively and inside the contour. In the Syr Darya basin return flow amounts to  $4.7 \text{ km}^3$ , and to  $3.7 \text{ km}^3$  in the Amu Darya basin. The rest of water comes back to the sources or to the irrigation and discharge lakes and lowlands, and also disperses for transit water.

Now, about 20% of water used for irrigation are being lost in the interfarm network. Network inside the farm is characterized by more serious water losses. As experts estimate, from 50 to 60% of water entering the internal network is being lost. Besides, about 10% of water are also being lost in the temporary irrigation network.

Measures of maintaining internal systems in operating condition are carried out by the farms themselves. Farms make manual cleaning of the irrigational and open collectors. In the event of more serious repairs, requiring the use of equipment, specialists and resources, the contracts between producers and contractors are prepared. Today, under the grave economic situation, independent farms cannot pay for the services of construction organizations. In this situation and because of the failure of internal hydroreclamation systems, the Government plans to finance purposeful programs on the reconstruction of the systems.

Under the growing water deficit, in addition to the technical capital-intensive measures, organizational measures, which do not require considerable investments, are of great importance. Possible organizational measures include the implementation of the charged water use system and the organization of water management under the market conditions. Along with the charged water use, there are other ways to increase the interest of farmers in the economical water consumption. The right of a farm to use the saved amount of water for production or sale to other farms may be one of such ways.

It should be taken into account therewith, that even the implemented charging for water doesn't guarantee that farms mobilize all their reserves on water saving, if such saving will lead to the reduction of established water supply amounts to these farms, i.e. incentives to save water are insufficient. Therefore, it is expedient to assign a certain amount of water to farms, which use irrigation. In this case farms would receive rights on water by virtue of implemented

irrigation projects, approved acts of land management or other grounds. Water amount can be differentiated, taking into account the weather conditions of different years.

The implementation of the charged water use requires the detailed analysis of proposed concepts on the charge for water.

In Uzbekistan different methods have been developed for calculating water charges, which calculate mainly average costs for delivering 1 water unit. These methods define final costs as expenses on the formation of flow, including the cost of water regulation, transportation, and delivery. Water assessment is defined as the total costs, calculated for one year.

Water is the state property in the Republic of Uzbekistan and is used only for exact purposes. Now, water itself doesn't go from one owner to another, thus, it is not for sale. Therefore, the essence of water charge is the charge for the use of water. The Institute of Macroeconomics and Social Studies synthesized useful elements of the above concepts and developed methods to charge water use in irrigated agriculture. These methods include three groups of charges, which differ by the ways of calculation, activities and uses. These are payment for the right to use water resources in the farm, payment for water service and payment for the quality of delivered water.

Payment for the right to use water resources proposes introduction of licensing. License for water use is an official permission issued by local authorities to agricultural water consumers for using water resources during a certain period of time. Without such license a water user has no right to use water, and should not be served by the state hydroreclamation systems. The license agreement can contain a set of conditions determining the procedure of using the license and the course of using water by consumers.

Payment for water services includes services related to the formation of water in the source, and services of water delivery and diversion to the interfarm network. The aim of water delivery charge, based upon the direct covering of water management outlay for water supply in irrigated agriculture, is to create conditions, in first place, for stimulating reduced water consumption, and secondly for transferring water management organization to self-financing.

Water diversion charge is the charge for services of diverting waters of the collector-drainage network from irrigated lands to create a favorable reclamation situation, and to stimulate farms to reduce the diverted amount.

Rent charges for the quality of delivered water take into account the quality of water from irrigation source. These methods are aimed at the establishment of higher charge for water of better quality through withdrawal of a part of water consumers' income in the form of a differentiated water rent.

A. Karimov (Institute of Water Problems) recommends to set a partial charge for irrigation water for the latest 10-15% of the delivered amount. If consumption keeps going at the level of 85-90% of the set limit, farms are supplied with free-of-charge water. The paid water can be sold or purchased. The world experience proves that the size of water charge should not exceed 10% of the gross income of water consumers. In this case the charge is a means stimulating water conservation.

The following among the proposals on rational use of water resources in agriculture attract attention:

To improve farm water use under the conditions of land reform and the farm reorganizations, it is recommended to establish a new institutional structure at the farm level of the Water Users Association, which will be a self-financed organization and perform functions of management and allocation of water resources for farm.

The maintenance of hydroreclamation and irrigation systems in the operating condition will require certain investments. The existing irrigation systems inside farms have not been repaired for the recent 5-7 years, since they had been transferred to the balance of farms. This, in its turn, results in the immense technical and organizational losses of water resources on the republic scale. The list of measures and the sources of financing thereof should be precisely defined.

In order to carry out effective water policy in Uzbekistan under the market conditions, it is necessary to create relevant economic market environment. The right of agricultural producer to own the produced output needs to be developed.

For the Water Users Association to be established, organizers, who are trustworthy and have institutional background. A Water Users Association (WUA) is quite acceptable for Uzbekistan as an organizational structure. With any form of the Association the farmers' benefits should exceed the costs of their participation.

The legal basis, which facilitates the solution of problems, is an extremely important circumstance for providing WUA an opportunity to develop productive relations with other organizations, keep bank accounts and undertake other activities. Clear definition of the proprietary rights of WUA on water and irrigation infrastructure will serve a powerful means in the transfer of management and related costs from the Government to WUAs. The support policies of the Government and legal base are very important for the long-term sustainability of WUA.

The role of the Government will change, as WUAs will assume additional obligations. The support of WUAs by the Government should be continued. The budget of WUA should be the basis for calculating water charge at the farm level. These costs will be covered by fees, paid by the members of WUA.

Calculation of big marginal difference for separate types of output helps to focus attention on the state of affairs in the production of each crop in a WUA so, that it is possible to calculate their input into the common profit. Calculations made by specialists show that this profit is, on average, 1.5-2 times higher with WUA, than without it.

The existing regulation of prices for main crops, and as a consequence, low level of profitability of agricultural production makes the charged water use impossible. Thus, establishment of WUAs and water charges require fundamental changes of the state policy in the direction of market reforms.

As a whole, recommendations targeted at the increased effectiveness of water use in Uzbekistan can be formulated as follows:

- Carry out institutional reforming of water management system at the farm level with establishing sustainable Water Users Associations;
- Create economic conditions for profitable agricultural production;
- Secure the right of ownership on the produced output;
- Liberalize the sale of output and pricing system; and
- In the first years of WUA coming-to-be, render the state support in the form of privileged loaning and taxing for the members of WUA.

The charged water use should be implemented to reduce financial burden of the country and increase the interest of farmers in economical consumption of water resources. Water tariffs should be based upon the budget of WUA. This will require creating a legal base for water use, taking into consideration new business forms and new institutional forms of WUA management. The following should be done:

- Define the legal status of private water users;
- Elaborate the appropriated legislation stimulating the development of WUA; and
- Encourage the experimental approbation of WUA at the farm level in different natural and economic zones. Various types of farms can become bases for the established WUAs.

The general idea of many recommendations is the necessity to realize high technologies in water use. Among them are:

- Measures of low capital intensity and competitive reclamation measures;
- Flow system of drip and flush irrigation on cotton;
- Weakly flush and long-line furrow irrigation of cotton;
- Sip irrigation; and
- Pulsed irrigation.

Problems of ineffective use and ecological safety of water resources are caused mainly by the imperfect mechanism of water management in the republic, apart activities of water management structural divisions, lack of full and timely information in some parts of water management. (For example, the State Committee on Nature in the Republic of Uzbekistan has not lately had data on use, condition and environmental impact of the Chadaksai mine, the specialized place for industrial wastes. The Committee argues that territorial inspectors thereof have no access to this object.)

The insufficient understanding of relation between development, management, use and processing of water resources and water ecosystems can lead to situations fully complicated and serious from the point of view of ecological, economic and social safety. According to the findings of experts, in connection with financial difficulties Ministry of Agriculture and Water Management has ceased to keep the state statistical records 2 TP (water management) on the use of water resources.

Besides, lately, the Kyrgyz Republic hasn't been providing data on annul precipitation and snow storage. This impedes to forecast the Syr Darya water level, and, consequently, the

water allocation in the Republic. It means, that in the course of three years the republic hasn't had thorough analysis and monitoring of condition and perspectives regarding the use of water resources. Such situation is fraught with not only ecological, but also economic and social consequences.

For more active participation of people, local private and public organizational structures, the role of Government should be changed. Here, the fundamental principle is that in any given situation management at the very lowest acceptable levels is effective. However, at the same time, this principle supposedly means decentralized approach to water management, including such institutes of authority, which would deal with water problems and be able to determine priorities, policy directions, targets, and, where acceptable, to prescribe standards.

The concrete proposals on overcoming consequences of the Aral catastrophe and rationalizing water use, which require appropriate orientation of investment policy and financial inputs are:

- Start forest reclamation works on the dried bottom of the Aral Sea to create protective, reclamative feeding and soil-protective plantings. Restore reed thickets in the delta for the animal world by feeding them with ground waters of close bedding; and
- The irrigated area of Uzbekistan amounts to 4 million ha; over 2 million hectares of which need reclamative improvement. Under the situation occurred in the region it is necessary to cease the development of new lands for irrigated agriculture completely.

By virtue of objective reasons, problems of water use in the Central Asian region are directly connected with the issues of producing and allocating power generated on hydropower plants. Taking it into consideration the most rational proposals are proposals on the parallel operation of the Uzbekistani energy system with other energy systems of CIS.

With the transition of the Central Asian countries to market relations, the question of operating the United Energy System of the Central Asia in parallel with energy systems of the North Kazakhstan and United Energy System of Russia is becoming urgent again, because it will allow to expand the market of power and capacity owing to consumers of Russia and other countries of CIS.

Operation of the United Energy System of the Central Asia in parallel with the United Energy System of Russia can be provided under the observation of a series of conditions:

- In the UES CA and Kazakhstan the main transmission network with voltage of 220-500 kV should be included in transit. Furthermore, in order to ensure the effective parallel operation of United Energy Systems in Central Asia, Kazakhstan and Russia it is necessary to reconstruct the automatic emergency systems and devices for regulating frequency and power transfers; and
- The first stage of project works, determined the structure of emergency management for the future United Energy System, was finished in 1997.

Preliminary cost of reconstruction for the automatic emergency systems is estimated to be \$5,177,000, including \$54,000 for the Uzbekistani objects, \$4,256,000 for the Kazakhstani objects, \$518,000 for the Kyrgyzstani objects, and \$349,000 for Russian objects. The

implementation of the project will allow to exchange power in the amount of about 600 MW between UES CA and energy systems of the North Kazakhstan.

Further increase of power transfers suggests the construction of the new power network objects in Kazakhstan, and that will require considerable investments.

Parallel operation of the Uzbekistani energy system being a part of UES CA will allow to improve the reliability of power supply owing to the common reserving with other systems, and reduce necessary power reserves in the energy system.

Besides, this would be a serious factor for the rationalized allocation of water resources with taking into account real needs of water and energy consumers in the region.

# **1. Introduction**

The report has been elaborated by a group of research associates at the Institute of Strategic and Interregional Research under the President of the Republic of Uzbekistan, supported by the programme “Environmental Protection Policy and Improvement of Organisational Structure of Resources Management in Central Asia” (EPIC).

Preparation of the report was made necessary for an objective and critical evaluation of the gained-experience of water utilization in the Republic of Uzbekistan with a view of increasing the efficiency of water resources utilization and working out recommendations for optimization of Uzbekistan’s cooperation in work on water utilization problems.

With this aim in view the report gives the major terms of the existing normative-and-legal basis on problems of water utilization and formulated recommendations for its improvement; sets down the problems of water utilization in Uzbekistan by regions and sectors of the economy. The state of water quality being critical, the report gives some recommendations aimed to improve it, involving the use of foreign experience (that of NS in the first place); sums up the proposals in introduction of water saving technologies as one of the trends of rationalising water resources utilization. The report as well mentions some approaches to the problem of generating and using hydroelectric energy as one of the key factors regarding problems of regional cooperation in the sphere of water utilization.

Composers of the report believe that optimization of water use at national level and unification of approaches to having this problem solved in the neighbouring states of the region will make it possible to create favourable prerequisites for consolidation and promotion of regional cooperation on problems of joint utilization of water and energy resources and for overcoming the now existing differences with regard to this.



## **2. Water Resources of Uzbekistan (General Description)**

Uzbekistan is one of the biggest areas of irrigation farming in Central Asia. The main sources of irrigation area the rivers Amu Daria, Syr Daria, Zaravshan, Kashka Daria, Syrkhan Daria, Chirchik and Akhangaran. Total water consumption in the republic is now stable on the level of 62-65 cu.km. of the total volume of water 85% is used in agriculture, 12% in industry, 3% for municipal needs.

The quantity of annual flow within the republic makes up about 9% of all resources, used by the country. The Syr Daria, with its water collecting area of 150 thou.sq.km. is second to the Amu Daria which contains twice as much water (36 cu.km.), but the former is considerably longer (2140 km). The Syr Daria flow is formed from the rivers Naryn, Kashka Daria, Chirchik, Angren, Keles, Arys and the rivers of Fergona valley.

Most of the lakes in the territory of Uzbekistan are in the middle stream of the river Syr Daria basin and in the middle and lower stream of the Amu Daria. Anaksai is the biggest lake system. It comprises lakes Vostochnyi (eastern) Arnasai, Tuzkan and Ardar. Their origin is ascribed to the beginning of intensive development of the new irrigation zone Hungry Steppe and construction of main collectors. The major changes in the lakes conditions took place when about 21 cu.km of the Syr Daria water was discharged from the Char Daria reservoir into the Arnasai system.

There are two groups of lakes in the Syr Daria basin. One of them stretches along the periphery of the irrigable land tract of Hungry and Dzhizak steppes and is composed of three lakes: Vostochnyi Arnasai, Aidar and Tuzkan; the other, in the area of the Dolvarza tract, consists of two lakes: Kalgansyr and Yangikul.

### **3. Legal Basis of Water Use and Recommendations on How to Improve it**

Regulation of the use of interstate water sources situated in the territory of the republic and other states, in the Aral Sea basin is being effected in conformity with interstate treaties and agreements. But in some cases when utilization of some border waters of Uzbekistan is not regulated by the international treaty, it is exercised in conformity with Uzbekistan's legislation. Disputes about water use are settled by the Cabinet of Ministers of the RU, local organs of power and management, as well as by organs of water management, environment protection, geology and mineral resources and other authorized organs. Disputes on water use between Uzbekistan and other states are considered in the order, established by interstate treaties.

All waters are to be protected from littering, pollution and exhaustion which may be harmful to people and cause lessening of fish reserves, worsening of water supply conditions and other unfavourable phenomena due to the change of physical, chemical and biological properties of waters, decrease of their ability of natural purification, violation of hydrological and hydrogeological condition of waters.

State record of waters is aimed at establishing their quantity and quality and data on consumption of water for drinking and domestic needs of the population and for different sectors of the economy. Planning of water utilization should ensure scientifically substantiated distribution of water between water users, taking into account, first and foremost, satisfaction of people's needs in water for drinking and domestic use, protection and prevention of its harmful effect. At planning of water utilization they take into consideration the data of the state water cadaster, water management balances, diagrams of complex use and protection of waters.

The state water cadaster contains data on water records in qualitative and quantitative indices, registration of water users and data of water use records.

1993 saw adoption of the law "On Water and Water Use" which contains provisions regarding regulations of water relations, rational utilization of water for people's needs and the economy, protection of water from pollution, littering and exhausted, prevention and liquidation of water harmful effect, betterment of the state of water facilities, as well as protection of the rights of enterprises, institutions and organizations of dekhkan (peasant) farms and citizens in the sphere of water relations.

Water is the state-owned property, national wealth of RU. It is to be rationally used and protected by the state. State management in the field of water use is exercised by the Cabinet of Ministers of RU, local organs of power and management, as well as by specially authorised state organs such as the Ministry of Agriculture and Water Management (surface waters), the State Committee of RU for geology and mineral resources (subterranean waters) and the State Committee of RU for control over safe conduct of operations in industry and mine supervision (thermal and mineral waters).

**Table 1**  
**Functions of Ministries and departments for water resources at regional and national level in the Aral Sea basin**

Ministry, department	water management function	activity in development of water resources
Regional level: uzgidromet	collection, analysis generalization of hydrological data	Information provision with operational and periodical data
National centre of space nature use	collection generalization of hydrological data	Periodical for information at request
International Committee for control of water resources	Agreement on international distribution of basic rivers outflow coordination	Distribution of water resources limit depending on water plentiful year and establishment of water supply to Aral area and Aral sea
BVO of Amu Daria	Control of water intake from Amu Daria in accordance with limits of republics	Water supply by main systems of Amu Daria outflow
BVO of Syr Daria	Same as from Syr Daria	Same, river Syr Daria
National level Ministries and Committees of rural water management	Organization of Water supply and draining off of water to irrigation systems of oblasts and rations	Control of water resources use, exploitation of main water systems and river structures
	Irrigation, land drainage, protection of river waters elaboration of agromeliorative and agrotechnical measures	Breakdowns, catastrophes productivity  water use protection of soil and water
Ministries and departments of hydrology	Prospective of subterranean waters, determination of reserves, etc.	Control over utilization of subterranean waters partial exploitation of water supply systems
Departments and organizations of municipal economy	Development of sewer system and drinking water supply of towns and populated localities	Exploitation of republican systems of water supply, urban systems of water supply and sewer

Departments and organizations of fishing establishment	Lake, river, pond fishery	Development and utilization of water resources
Ministry of Health	Development of hydropower engineering	Development of standard quality acts of water resources for draining needs and rest
Forest management	Methods of forestry running	Protection of soil and water
State Committees for Environment	Monetary of environment quality	Requirement for regulation of water quality

The task of Control by the State over utilization and protection of waters includes provision of observance by all Ministries, State Committees and Departments of the established order of water use fulfilment of duties regarding protection of waters, prevention and liquidation of harmful effect, rules of making water records. Public association, collectives and citizens are urged to help state organs to materialize the measures on rational utilization and protection of water. At placing, designing, building and commissioning new and reconstructed enterprises and various facilities, at introducing new processes it is necessary to ensure rational water use and to observe the requirements of health protection and first and foremost satisfaction of people's drinking and domestic needs. They take measures to ensure records of water taken from water facilities and returned to them, protection of water from pollution, littering and exhaustion, prevention of water harmful effect, restriction of land flooding to the minimum, protection of lands from salinization, drying up, as well as preservation of favourable natural conditions and landscape.

The Law provides for conditions of placing, designing, building and commissioning enterprises, structures and other installations on fish breeding reservoirs; determination of places for construction of enterprises, structures and other installations influencing the condition of waters.

The Law prohibits designing and construction of direct-flow systems of water supply to industrial enterprises, which for their conditions of production can not be transferred to circulating water supply and waste-free technology. It also prohibits to commission enterprises, structures and other installations affecting water conditions. Projects of building bridges, passages and other transport communications through water facilities are to be concerted with organs of water management and power engineering.

Water use for agriculture is exercised with the object of creating favourable water conditions on irrigation lands of all forms of farming. Water use on irrigation systems, main canals, reservoirs and other water facilities is practised on the basis of internal economic and general plans of water use with actual yearly provision taken into consideration.

Lands of water reserve, irrespective of the form of land use property, are exploited as single water system; they are the state-owned property and are not subject to privatization. Water installations are used for irrigation of agricultural lands, with established order of water use limitation observed.

Agricultural water users must: observe the established limits, plans, rules, norms and

procedure of water use; keep records of water intake, keep the internal economic irrigation; flooding and collector-and-drainage network in working order; perform a complex reconstruction of melioration lands and maintain favourable conditions for agricultural crops irrigation and flooding of pasture lands; improve ways and methods of irrigation by introducing a resource saving technology and up-to-date irrigation machinery; remove causes and consequences of negative processes by monitoring waters used for the needs of agriculture; raise the efficiency of water used for special purpose.

At present stage of society evolution the law-making practice and agrarian-legal science face some complicated and responsible tasks, solution to which is of great ecologo-legal importance for rational utilization and protection of irrigation lands and other natural resources.

The most topical of them are:

- 1) Under the conditions of transition to a market economy it is essential that equal economic conditions be created for all economic entities growing agricultural crops and other agricultural activities.
- 2) With the object of bettering rational utilization and protecting irrigation lands in agriculture there is a needs to develop agricultural law as an independent sector taking into account the ecological and geographical peculiarities of this or that locality.
- 3) Proceeding from the experience of foreign countries proposals are made to adopt a Law regarding land use in agriculture for the Law “On Land of the Republic of Uzbekistan” does not devote enough attention to problems of rational utilization and protection of irrigation lands in agriculture.
- 4) Minselvodkhoz. Glavsredazsovhovzstroy should pass on to the construction of a collector-drainage and other meliorative network on a completely new highly technological level. AT the same time each region of cultivated and irrigation land should introduce a passport system to establish qualitative and quantitative character of land areas.
- 5) Considering ecologo-legal aspect of the problem of property on irrigated lands and other natural resources we should accentuate the point that the irrigation lands used in agriculture must not be given the right of private property, because their further market circulation may lend to rather grave, irreversible consequences.
- 6) With the aim of rational use and protection of irrigation lands it is necessary to ensure active participation of central and local government bodies in the ecological management, makhala committees, small, private and joint enterprises, rental and dekhkan farms and also employers.
- 7) Special ecological control groups should be at makhala committees. They will go in for the problems of rational use of irrigation lands, water, forests and atmosphere.
- 8) Water resources should be regarded as special natural resources and depending on the use in agriculture (farming, cattle breeding) they should be differentially evaluated. To prevent wastefulness of water resources it is necessary to institute control and pay for water all those who enjoy the right of agricultural water use. The responsibility of a person or organization

for the losses in case of insufficient supply, breach of the terms of the agreement should be stipulated.

- 9) The administrative independence of law enforcement bodies from each other for the benefit of rational use and protection of irrigation and other natural resources is necessary. This will ensure closer contacts in the work of land surveyors, hydraulic engineers in farmers' and dekhkans' economies. Office of Public Prosecutor should keep under special supervision all the cases of ecological breaking the law and unrational use and protection of irrigation lands.
- 10) Ecological wrong-doings in the field of rational use and protection of irrigation lands are as follows: fault of a wrong-doer (land tenure or water user) unlawful ecological behaviour causation between violation of the law and the following ecological after effects; ecological harm caused to irrigation lands and waters; a real threat to the ecological conditions of irrigation lands, agriculture vegetation and other natural resources.
- 11) In case of the breach of the requirements of ecologo-legal protection and rational use of irrigation lands, wrong-doers should bear ecologo-legal responsibility.
- 12) The currently operative code of the Republic of Uzbekistan "On the administrative responsibility" is advisable to be supplemented with such articles as "Responsibility for infringement of economic demands on protection and use of irrigation lands". "Responsibility for the use of irrigation lands by land tenurers for wrong purposes.
- 13) It is advisable to supplement the Uzbekistan Code with such articles as "Unauthorised disposal of irrigation lands", "Illegal sale and squandering of irrigation lands", "Wasteful use of agricultural lands", "Violation of ecological requirements of irrigation lands", "Illegal use of irrigation lands for other purposes". "Illegal disposal of irrigation lands or agricultural arable lands".

The Republic of Uzbekistan adopted a Land Code which came into force as from July 1, 1998 by the decision of Liy Madglis of the Republic of Uzbekistan of April 30, 1998. One of the fundamental principles of the Land Law is guaranteeing special protection, widening and use for strictly special purposes of all agricultural lands, and first of all irrigation lands. One of the categories into which the Republican land reserve is subdivided are lands of the water reserve, i.e. lands occupied by water establishments, water economy constructions and strips of land on the banks of water units.

Scientific prognostication includes working out the scheme of use and protection of land and water resources of the Republic and its regions.

Internal economic organization of land use includes internal economic organization of the territory of agricultural enterprises, offices and organizations, which introduce scientifically grounded rotation of crops, putting in order all agricultural arable lands, work out measures against soil erosion and also a complex reconstruction of irrigation lands.

Irrigation lands are the lands suitable for agricultural use and watering which have permanent or temporary irrigation system, connected with the sources of irrigation, which supply these lands with water.

Organs of agricultural and water organizations are obliged to supply landowners and farms who irrigate lands with irrigation water in accordance with the established limits taking into consideration the amount of water in those water sources and according to the order of water law.

Irrigated lands need special protection. Transference of these lands into nonirrigation lands is exceptionally rare and is done only in exceptional cases with due regard for soil-meliorative and economic conditions, water supply, availability of water sources and the limits on them by the regional khokim in accordance with the cabinet of ministers of the Republic of Kazakhstan.

Especially valuable productive irrigation lands are arable lands with a cadastral mark exceeding 20% above the average regional bonitos marks. Exclusively valuable productive irrigated lands need special protection and transference into non-irrigation lands is prohibited.

Allotment of exceptionally valuable productive irrigation lands for construction of enterprises, buildings is permitted only by the decision of the Cabinet of Ministers of the Republic.

Article 74 “Violation of Water Use Rules” in the Code of the Republic of Uzbekistan endorsed by the RU Law of the 22d of September, 1994 was worded up as follows: Violation of rules and limits of water intake from natural water sources (rivers, sai, lakes, springs, underground water and also water taken from natural water, resources without fish protecting constructions provided for by the project - gives the right to the authorities to impose a fine on a person to the amount of 1/2 or one minimum pay and for officials from 1 to 3 minimum salaries. Violation of rules of water intake from irrigation systems, uncontrolled use of water, unauthorised hydrotechnical operations, violation of established limits and plans of water use - is fraught with a fine to the amount of 1/3 to 1/2 for a citizen and to the amount of 1/2 to 2 minimum pays for officials.

Part one and part two of the article a fine from to 3 for citizens and from 3 to 7 minimum salaries for officials in case of a repeated violation of the rules during the year.

According to the law “Dekhkan Farm” (1992) limits of water use for dekhkan farms, state cooperatives, enterprises, organizations and individuals are by the bodies authorised by khokim of the region. The order of control and calculation of water consumption for a dekhkan farm is defined by the Law of the Republic of Uzbekistan. Work on planning and construction of roads to dekhkan farms are carried out at the expense of the local budget, but melioration and land improvement of huge tracts of land are carried out at the expense of the republican budget. Repairing and maintenance of all hydrostructures on the dekhkan territory are carried out at his own expense. Water management installations are turned over to farms without time limit. Conflicts concerning interrelations between the organs of water management and dekhkan farms are being settled by court and court of arbitration on the established order.

The dekhkan farm is an independent production unit equal in rights with the enterprises and organizations of other forms of property. Hence limited water use specified in article 30 “Water and Water Use” is applied to dekhkan farms as well. These farms according to article 40 of the Civil Code are commercial bodies, consequently their constitutive documents are to

be registered in the prescribed order (art. 3 doesn't speak of regulations). It's necessary to learn the methods of solving conflicts between the organ of water management and dekhkan farm (if there are any).

On the whole, the Law is to be brought in accord with the Civil Code of RU. It is based on art. 2 of the Civil Code of RU which envisages application Civil Code to other transgressors in the following cases: family, labour relations and relations concerning the use of natural resources and environmental protection. At elaboration of legislative acts it is necessary to keep to the principle (art. 3, Civil Code of the RU part 2) which reads: "Standards of Civil Law in other acts must be in accord with this Code".

Resolution of the Cabinet No 385 "Of a Limited Water Use in RU" of the 3 of August, 1993 develops Articles 30 and 39 of the Law "On Water and Water Use". Item 3 of the Resolution provides for water use and quantity control on the agreement with the regional organ of water management. But, item 4 of the Resolution, where all the obligatory conditions of the agreement are envisaged, doesn't meet the requirements of art. 364 of Civil Code of RU. If we take into consideration that regional water management organizations render services of supplying farms with water, it's clear that relations are of the Civil Law character and therefore they must be brought to conformity with art. 358 of Civil Code. Besides, this resolution must be accompanied with a standard agreement, the draft of which should undergo an obligatory examination at the Ministry of Justice and only then the Cabinet will recommend it to be used by those who supply and those who use water. The resolution must correspond to new conditions, that is to the Civil Code and the taxation Code.

Unfortunately the existing legislative basis doesn't embrace all the new sides of interrelations connected with the appearance of private water users in Uzbekistan. It is necessary to give a more detailed evaluation to these relations taking into consideration all the peculiarities of dekhkan farms. Legislative support to the economic machinery as regards the interaction of farms and water management organizations.

Article 49 of the Law "On Water and Water Use" envisages limited water use for agricultural purposes according to the agreement. Consequently the relations of water organizations and water users are based on the recognition of their equal rights. So the agreement must be worked out in accordance with the Civil Code, that's why the responsibility between them is of a Civil-legislative character.

Establishment of limited water use corresponds to the standards of the Civil Law (art. I C.C.). So limitation goods replacement (for example, water is an object of republican property, art.214 can be introduced in accordance with the Law, if it is necessary to secure safety, for health and life protection of people, nature preservation and cultural values.

That is why fulfilment of obligations by the state water organization and water users as it is envisaged by the agreement is fraught with a fine which is to be set by the Law, but not by the coat of administrative responsibility.

In future according to the Law "On Water and Water Use" a new Resolution must be adopted by the Cabinet. "On limited Water Use" or a supplement to the old one with the requirements of Civil and Taxation Code taken into account. A model agreement ought to be appended and a mechanism of measures in case of non-compliance with the regulations by the



sides concerned be determined. For instance: water user, is fined for being late in paying taxes, state water organizations are also fined in case of inaccurate water supply.

Water users' rights depend on the status of the economy. If it is functioning as a juridical person, it has an account in the bank, a seal, then it has the right to have a free access to water resources; but if the organization is functioning as a members of an association or cooperative then his access to water resources is possible through irrigators or irrigation cooperatives.

In most cases water use in all branches of industry, municipal economy and agriculture licenced according to average year volume and the right to water is the state prerogative. A farmer can hardly have a chance to argue. More than that the volume of yearly limit for every irrigation territory or system is defined by the state water management organs according to their own canons, often without consent of the water consumers. The right of a water user on his border should be guaranteed and lisensed for some definite quantity of water in accordance with the area of irrigation and a standard load, perhaps on biological need for plants on his territory.

Water users who make use of water installations for indusrtial purposes and power engineering are obliged to keep to the established limits, technological standards and rules of water use and also take measures to reduce water expenditures, to stop discharging sewage by perfecting technological processes.

Inflow systems for newly projected and introduced industrial units are prohibited with the exemption for the enterprises and other establishments which can not be transferred to circulating water supply. "Usufruct" exploiting water units for the needs of hydraulic engineering is carried out in conformity with the requirements of complex use of hydroengineering units can be used not only for hydraulic engineering but also for some other needs, depending on natural conditions.

Hydropower establishments are obliged: to keep strictly to the established order, the conditions of filling and wear, spillway and variation of the level; guarantee sanitary and nature protection.

Enterprises, organizations and offices exploiting all kinds of water construction are obliged to follow the conditions of filling and spillway. The order was established in the interests of water users, land owners, farmers - for those who live in the zones of water reservoirs which are being constructed to satisfy their water needs.

Water power developments and other hydrotechnical constructions on rivers, sais, water main and serving several canals and collectors are the state water establishments and are exploited by the units of water management in accordance with the rules worked out by the projects.

The necessity to improve and perfect the use of water resources became ripe and the idea to introduce water users to the world knowledge with water being in short supply.

#### **4. World Experience of Water Uses (Legislative Basis, Problems of Water Saving) Composed with the Water Management of Uzbekistan**

The experience of the USA Western States was thoroughly studied with the aim of perfection of economic mechanisms of water saving. Acquaintance and study of the work of water management of these states compared with the water management of Uzbekistan shows the following difference in the functioning of these organizations.

Special attention is given to the problem of preservation of environment and integrated development of water management. They do not grow the prevailing crop there with the exception of lucerne in southern states, which is exported.

The conditions for the economic development in Uzbekistan are quite different. Its main aim is to supply markets with goods and agricultural products mainly. And this makes the difference between the compared structures of water users. In Uzbekistan and in the above mentioned states water users have the right to the efficient use of water. In California this right can be made over only on permission of water institutes as sale or lease. The normative documents determine the borders within which water use can be effected. Exceeding these borders entails additional payments. Water users are not interested in water saving on their territory because it is not profitable and involves only additional expenditures.

That's why the establishment of legal basis, stimulating water saving measures is of great importance.

RU Laws establish maximum taxation reduction and beneficial credit rates for enterprises for development and introduction of little waste and resource saving technologies. An effective system of water saving is functioning in Texas. Water users can get a low interest loan for water saving projects and buy costly water husbanding equipment. Participation of American authorities of all levels in financing of projects is very important. We can practise it under our conditions with the keep of khakimats' funds for solution of water supply problems.

Having analysed the above experience we can propose the following stages to perfect economic water saving problems in Central Asian countries and Uzbekistan in particular.

1. To expand the water users rights by handing them over for some payment and retaining the opportunity to return them in some time. Water users' interests can be represented by them or by their associates. Water management at the local level will have two structures: water service that has the right to regulate, collect and supply water with full compensation for expenditures and associations or users groups having rights to use and transfer water. This legal basis will create the necessary prerequisites for growing water users interest in water economy.
2. Creation of a water bank within the country, basin or region. If transition to a payable water use must be preceded by some preparatory period (connected with price formation) then the water bank (or Drought Water Bank) can be set up much earlier because:
  - a) all hydrotechnical constructions are under centralized control (management) and it is easier

to save, deliver and transfer water from the water use rights, seller to the buyer.

- b) owners' economic conditions are of no significance.
- c) water organizations, if they are aimed to find some additional water resources, will pay for this water to the water owners and use it for environmental protection, creation of reserves for a drought - afflicted period.

Creation of a Water Bank will mean a new stage and the water use on the whole is to be temporarily free (for greater part of water) and is carried out on the basis of a special permission for water use and limits determined for a concrete year and paid water use which water users accept, proceeding from their own interests.

Introduction of paid water use within the country is sure to increase the effectiveness of water use and reduce to minimum all kinds of losses.

So the experience of USA Water Banks in some states is of great interest.

#### **4.1 Water Bank, State California**

The first drought Water Bank was created by the Bureau at the drought period in 1997. This experience has become the basis for creation of the drought Water Bank by the state agencies in 1991.

It is part of the Water Resources Department (WRD) functions. A committee of buyers was formed to coordinate conditions and time of future contracts for buying water for the Water Bank. Special changes in the Law were made to retain sellers' water rights and support their participation in the Water Bank. Water agencies were given permission for a contract with WRD and other agencies for water transfer outside their territory. It was ascertained that the temporary water transfer of 1991-1992 will not exert influence upon the existing water rights. Also some water rights were inserted to insure the buyers. For example, in case of transferring rights, water was recognised to be officially used on the lands it had been transported from, besides it was not the reason for any losses or confiscation of rights.

The water seller searched for water reserves:

- a) on the basis of water saving measures and the transfer of the saved water to the Bank;
- b) leaving land lying fallow, the seller transferred the surface water to the Bank;
- c) using subsoil waters, he transferred unused water to the Bank;
- d) transferring it from local reservoirs on farmers' lands.

Taking into account the fact that farmers will get some additional profit from the Water Bank, the price was set to be 125\$ for acre/foot (1230 cu.m).

Water distribution from the Bank was done so that all critical, urgent needs were satisfied first. The following priorities were taken into consideration:

- needs for the areas of critical needs, urban territories with less than 75% supply, agricultural water users whose need is to save permanent and highly productive crops during some critical

period, for fish and wild nature;

- water for nature needs when preventing the economic deficit;
- filling in the Water project reservoirs of the state;

California experience showed that the Centralized Water Bank has some advantages: provides an opportunity to transfer water from the buyer to the seller; sponsored by the State it can reduce the cost of water transfer; the State fund provided the bank programme with the initial working capital; the State water Department took recorded water transfer at water distribution and exploitation of hydrotechnical constructions.

## **4.2 Texas State Water Bank**

It is in 1993 the Water Bank for sale and transfer of water rights within the state was established by the state of Texas Department of Water resources development. The main bank task was to promote water saving through the preserved water deposits, purchasing and transfer of water and water rights. Now according to the Law the owners of rights for water use could deposit about 50% of water rights.

The water rights owners deposit their rights with the Bank or transfer them directly to the buyer on permission of the Texas nature resource protection commission.

A Water Bank can be established in all the countries of the Aral sea region. The comparative analysis showed that the following measures can be taken.

The water use legal basis should include some provisions promoting introduction of market mechanisms in the water management capable of exciting water users' interest in water saving. The following addenda are possible. The water use right can be supplemented with the right of its transfer for pay or lease. The law must guarantee that the transfer of water use rights is not the basis to losing these rights or their reduction.

Water used for transference and received as a result of some measures on water saving must be considered used within the territory of the first water user.

It is possible to give rights for a short-time water use but only in exceptional cases and only as a temporary measure.

To establish a drought water bank

The aim of it is to organize an alternative water use which is to be a supplement to the existing which is free for agriculture and it will rise water users interest in the water resources economy. It is necessary to find a one time only loan for the establishment of the bank to be under the relevant ministry;

To further direct agreements between different water users on water transfer. According to such agreements the funds of the users themselves will be directed to water saving in their regions and further transfer of the saved water to others whose funds were in use.

To introduce paid water use

It will increase effective utilization of all natural resources, water resources too, besides it will minimise all kinds of unproductive water losses.

The USA work on bettering water quality is of great interest for Uzbekistan. Water is a serious problem for RU and we shall speak about this water problem below. Just for a comparison we shall how the US Law “On Pure Water” works.

The US Law “On Pure Water” was 25 years old in 1997. Rivers, lakes and springs had been polluted so that they could become a source of inflammation, now they are the centres of a healthy way of life thanks to “On Pure Water” Law.

But the population is still threatened with numerous microbes from waters in USA as outflows were not controlled because of some uncoordinated acts. The population doesn't want partial and non-concerted actions, but a solid federal support to water quality protection in all river basins.

Federal departments are obliged to work so that the “On Pure Water” Law could win full recognition and support. That's the minister of agriculture and water management, director of the Agency on environmental protection together with all departments concerned are ordered to work out a general plan of actions, based on achievements made in the first 5 years. These are three main tasks: to intensify measures on people health protection against substances polluting water resources; an effective control of outflows; better quality of water in river basins.

The plan must be worked out on the basis of the following principles:

- to work out coordinated mutual approach to the problem
- to try and avoid duplication if possible in the actions of federal, state and local departments;
- to involve the population in work;
- to work out a rational approach to the problem of pollution control, including market mechanisms, stimulation, cooperation with land owners.

The plan must include corresponding administrative, legislative, law enforcement and financial measures and be composed of the following components: people's health protection, prevention of polluting outflows, management of river basins.

## **5. Water Management Problems in Uzbekistan**

### **5.1 Quality of Water**

The rivers of the region from their upper reaches and along all their flow are subject to pollution by livestock farming, municipal, industrial waste flows collection and drainage waters discharged into them. In the territory of the republic the polluted sewage from more than 5.000 units of water consumers with their overall volume of water disposal amounting to 20% of the overall water disposal into open water units is discharged into the surface water, while the volume of polluted industrial sewage in 1994 totalled 215.1 million cubic meters. The Surkhondarya River: the mineralization of the river water in the Surkhondarya upper reaches does not exceed 0.42 gram per litre, in the lower flow it rises to 1.23 gram per litre. For the most part of the year the water contains hydrocarbonate, sulphate, sodium, magnesium and calcium.

The basin of the Kashkandarya River: the mineralization of the river water in the basin's upper reaches does not exceed 0.26 gram per liter, while in the lower flow at Karatikon it increases up to 3.4 gram per liter. At the river outlet from the mountains the water contains sulphate, hydrocarbonat, magnesium and calcium. It mainly in the Kashkandarya's tributaries that the water of a satisfactory quality can be observed, while the quality of the water at the river outlet from the mountains varies from bad to extremely dangerous.

The basin of the Zaravshan River: the average annual mineralization of the water up to the city of Samarkand does not exceed 0.3 gram per liter and after the discharge into the river of more mineralized drainage waters increases up to 0.5 gram per liter. The water of the Zaravshan River has been found to have a high content of antimony which is very dangerous for human health.

The Fergana Valley: the amount of mineralization of the water in the rivers flowing down the mountains to the Syrdarya River (which are Isfairamsai, Margilansai, Koksui, Kasanai, Gavasai, Sokh, Chadak) ranges from 0.17 to 0.60 gram per liter. Because all the collector and drainage water within the limits of the valley are discharged into the Syrdarya, the mineralization of the water in it varies from 0.67 to 1.34 gram per liter.

While analyzing the extent of pollution of the rivers' water the following facts can be noted: the most polluted are the rivers' water of the Fergana Valley, and it is too dangerous for human health to be used for drinking; the surface water of the Zarafshan and Kashkandarya rivers are of a bad quality as well. It is only in the basin of the Surkhondarya River that the river water is of a satisfactory quality. Pesticide pollution of the surface waters is characteristic of all the regions.

The water resources of the rivers of the Aral Sea basin could secure the irrigation of 4.8 million hectares of land provided that large-scale water protection and water preservation measures were taken, but there came a complete exhaustion of the water resources with 4.2 million hectares being under cultivation.

In the respect of ecology, the surface streams and basins of the republic are subdivided into six types depending on character of anthropogenic load:

- clear water streams and basins, mainly those in them mountains, with a low mineralization of the water and a small content of biogenic, elements and organic compounds. A harmful substance, such as heavy metals, pesticides, etc, which can be often found in water basins, does not exceed the permissible levels. These water streams and basins are Pskem, Akbulak, Kuylsai, Tashkesken, Terekly, Aksu, Geledarya;
- little polluted water streams and basins of the foothills zone which are subject to pollution by recreation writs and small settlements (the rivers of Aktashsai, Ugam, Akhangaran, Gavasai, Kashkandarya, Amankutan, Saragan and the water reservoirs of Charvak and Gissar). A higher concentration of organic and mineral biogenic substances is characteristic of this type, as well as a small increase pollutants is not very significant;
- mildly polluted water streams and basins which are located in the densely populated foothills and flat country zones. There a two or three times increase (compared to the background) in the content of biogenic mineral and organic components and in the overall mineralization can be observed, as well as an increase in the amount of pesticides (which is sometimes two or three times as much as that of the permissible level). These are the rivers of Chirchik, Akhangaryan, Koksandai, Naryn, Karadarya, Isfai, Ramsai, Margilansai, Zaravshan, Tusunai. The water reservoirs of Tynyabuguz, South, Surkhandarya, Chimkurgan, Kayrakum, Tuyamun, the upper portions of the Salar River and the Karasu Canal;
- moderately polluted water streams and basins which are the mouth portion of rivers, lakes, collectors and the portions of rivers located in the zone of arable lands of the old irrigation zone. These are the water streams into which industrial waste flows with a high concentration of mineral nitrogen and organic substances are discharged: the rivers of Chirchik and Koksandai, the North - Bagdad collector and the Siab collector. In these water units an excessive concentration of pesticides (rising up to the amounts that are 3-5 times as much as the permissible level), oil products and heavy metals are constantly observed. The water mineralization increases 4-5 times compared to the background;
- polluted water streams and basins which are those of the collector and drainage system in the arable lands zone with a high salt content of the soils and a high mineralization of the water (3-5 times as much as the permissible level), and also those water units is that are subject to pollution by compound industrial and municipal sewage at the portion located below large populated areas;
- dirty and highly polluted water streams and basins are characteristic of populated industrial city zones. Discharged into these water are organic substances and compound multicomponent waste flows which may contain toxic compounds. The heavy metals concentration in such water units may exceed the permissible levels by 40-50 times. Belongings to this category are the rivers of Kalgan, Chirchik and Salar.

In the water bodies polluted by the industrial and domestic effluents there is observed the increased content of the biogenic mineral organic substances, oil products and heavy metals in average up to 3-5 maximum permissible concentration (MPC) and above. Against the background of the raised level of pollution, the tendency is recorded as to the growth of ions of heavy metals, copper, chrome and other metals. To this category of the water bodies there should

be referred the following: the Karasu Canal - lower Tashkent City, the Akhangaran and Chirchik Rivers - in the places of discharge of the wastes from the bast-fiber mills, diverse small water flows and the irrigating network within the limits of the town and downwards the populated areas.

The decrease of the volumes in applying the mineral fertilizers and pesticides in agriculture, approach of the water content in the rivers to their standard level, drastic decrease in 1994 of discharges of the polluted waste waters into the open water bodies have favorable effect upon the water pollution condition of the major water flows in the Republic. In 1993-1994 the water quality was significantly improved in the main water flows of the Fergana Valley where the water pollution became corresponding to the background values.

On the territory of the Republic there are in operation over 600 diverse facilities for treatment of the polluted waste waters, but only a half of them satisfy the requirements imposed on the treatment technology.

The most adverse impacts are observed in the Southern Aral Sea coastal region. The reduction in the outlet and lowering of the Aral Sea level caused the drying out of more than 50 lakes with the area of 50-60 thous. ha. The boundaries of the deserts have expanded through drying out of the sea bottom and seaside delta covered with the melkozem (fine earth) and salt particles. For the first time the dust storms associated with the sea drying out were recorded in 1975. Since 1981 similar storms take place 90 days during the year. In consequence of the salt settlement, the cotton crop loss amounts to as much as 5-15%, and in regard to the rice: 3-6%. The half of the population lacks the qualitative drinking water.

Subsequent to the carrying out of water protection actions, the water quality in the Isfairsai, Margilansai and Kokandcay Rivers and in the Southern Fergana Canal has improved, and since 1993 their water quality is kept on the level of the moderately polluted waters. In the Republic the content of the HCCH isomers in the surface water bodies has a tendency to its reduction except the Aral Sea coastal region where the concentration of pesticides is kept on the level exceeding the normative rate by 5 times.

Every year there is observed the tendency in degradation of the surface waters quality of the water-bearing horizons formed in the valleys of the Rivers Chirchik (salinity 3-9 MPC), Akhangaran (salinity 1.2-1.7 MPC, total water hardness 1.2-1.7 MPC, sodium 1.5-2.5 MPC, sulfates -2.0 MPC, salts -5.0 MPC, Cadmium -2 MPC), Zarafshan (DDE - 4 MPC, DDT - 10 MPC). The alarm is caused by the state of the ground waters in the industrial zones of Kokand - Kakir, Fergana -Margilan where the content of the oil products and phenols over 100 MPC was revealed, as well as nitrogen compounds, diverse salts and other hazardous for the organism elements exceeding 10 MPC. The primary polluters are the Rustam PA, the Kokand Superphosphate Plant, the Azot Fergana PA, the Fergana Chemical Plant of Furan Compounds.

The local pollution of the ground waters by the filtering effluents of the common tailings dump of the Copper and Lead Concentrating Mills as well as of the phosphogypsum tailings from the Chemical Plant has occurred in Pskent Rayon of Tashkent Oblast which caused the failure of the drinking water intakes.

To prevent the degradation of the soils, the irrigation water should not be worse than the



surface-water resources. The intensity of the washing regime should be reduced to the minimum so as to weaken the adverse impact of the irrigation waters on the soil and removal of humus out of it, as well as on the water exchange with the ground waters, volume of the drainage flow resulting in improvement of the irrigation water influence on the soil-and-ecological conditions.

The recommendations of the Center for Scientific and Technical Information of the Ministry of Agriculture of the Russian Federation have aroused a certain interest: low-saline irrigation waters with the salts content less than 0.3 g/l cause the processes of eluviation in the irrigated soils which lead to the decrease in the water permeability.

The waters are aggressive with the salinity less than 0.12 g/l so there is no reason to use the waters with low salinity. In case the salinity of the irrigation waters is more than 2 g/l and the intensity of the washing regime is up to 105, it is possible to cultivate salt-tolerant crops while other crops will be depressed because of the soil salinization. The alkaline, chloride and sulfate waters of the sodium composition influence adverse impact on the soil.

Under the influence of the discharged collector and drainage waters, salinity and chemical composition of the river waters will change considerably. Since the beginning of the 70-th the water salinity in the Syr Darya River at its outlet from the Fergana Valley (the Bekabad section) exceeded 1.0 g/l, up to 1985-1990 in the downstream (the Kazalinsk section) it got as far as 2.0 g/l reaching 2.6-3.0 g/l during certain months. The return of the collector and drainage waters to the river sections contributes to drastic degradation of the river water quality. The induced irrigation with the water of raised salinity in case of the deficit balance leads to salinization of the soil and water sources and to degradation of their meliorative state.

The analysis of the water-and-meliorative and water-and-economic indicators of the irrigated cropping in the relationship with the water and salt regime of the river and the irrigated area shows that there exists the close dependence caused by the major destabilizing factor - the discharge to the river channels of the waste high-saline collector-and-drainage waters, and consequently, the problem of removal of the return drainage effluent beyond the boundaries of the river and its reuse outside the irrigated area is one of the primary challenges.

On the whole, development of the regional economy is governed by the ecological conditions of the water resources. The data on the use of these resources over 1993-1996 depict that more than 30% of the polluted water are discharged without treatment, and the share of the industry in it accounts for 90%.

The ecological requirements for the water use optimization aggravate in the area of the irrigated cropping in connection with diversity of the natural conditions and, in particular, with the properties of soils, crops and technologies of their cultivation, with alterations of the requirements regarding the water resources with the increase of their pollutants and differentiation of the water quality assessments considering the economic, social, ecological, technical, agronomic, international and legal aspects.

## **5.2 Water Supply of the Population**

In the Republic they embarked on the implementation of the program «Pure Water, Sanitation and Health» that specifies the radical improvement of the drinking water supply and

sanitary-and-hygienic conditions of the people's life. To achieve these targets there are allotted USD 117 million including the contribution of the Government of Uzbekistan in the amount of 13 million dollars.

Regarding development of the municipal and drinking water supply and the sewer systems in the cities, urban-type communities and district centers, the Republic would fall far short of the pace of construction of the housing and cultural-and-community facilities as compared with the more developed regions. Every year the length of the worn-out water-supply lines in the Republic tends to increase by 300 km, and their annual replacement at the expense of the operating costs accounts only for 120-150 km. The issues of rational use of the drinking water begin to acquire the greatest urgency since the water losses amount up to 25-35%.

To implement the actions for increasing the efficiency, it is required to alter radically the water use structure of the branches of the economy. The assessment of the water resources potential and rigid water saving demonstrates that there is a possibility to save 10-15 km<sup>3</sup> of water per year. At present the water consumption per 1 ha of the irrigated lands makes up 14 thous. m<sup>3</sup>, and the optimal rate per 1 ha may be in the range of 11.5-12 thous. m<sup>3</sup>.

The analysis of the annual water consumption shows that the major volume of the low-efficient losses of municipal and drinking water (14-18%) falls on the irrigation of the trees and shrubs of the public green zone and the household land plots in the summer period because of lack of the city irrigation network, on the discharge of the water out of the intrahouse heating system and through unwinterized water posts during the winter period. Considerable volume of water (3-5%) is being lost at the emergency sections of the worn-out water supply pipe-lines and because of lack of the water consumption metering devices.

In 1993 the drinking water quality was not in conformity with the sanitary and chemical standards as to the chemical indices by 28%, the biological values - by 13%. The highest bacterial pollution of the water bodies surfaces in Tashkent is 55.6%. Tashkent Oblast - 46%, in Karakalpakstan - 48% while the average republican level of pollution is 14.8%.

Taking this fact into consideration, since 1990 in the Republic there is realized **«The State Program for Improvement of Supplying the Rural Population with the Drinking Water»**.

During 1990-1005 in the Republic there are put into operation about 13.5 km of water supply pipelines which enabled to tackle the problem partially (Table 2). As a result of it, provision of the rural population with the centralized water supply over the last 5 years increased in the Republic by 8% whereas in Karakalpakstan by 11% and in Khoresm Oblast - by 32%. In 1997 there were put into operation 1799.4 km of the water supply pipelines, that is more than in the previous year by 14%.

**Table 2****Centralized Water Supply to the Population (in %)**

	City 1990	Village 1990	City 1994	Village 1994
Uzbekistan	81.0	52.0	84.0	58.9
Karakalpakstan	66	21.4	82.9	32.4
Khoresm Oblast	80	23.2	80.2	55.2

Since 1991 the State Geological Committee started their work by the program «**Geoecology of Uzbekistan**» targeted at the assessment of the ecological state of all natural media with the determining of the wide complex of the elements-pollutants and the developing of actions on the nature protection. In the course of implementation of this Program there are completed the geoecological investigations and mapping of the Aral Region. The poor qualitative composition of the surface and ground waters should be considered the most unfavorable factor causing the emergency ecological situation. The water arteries and ground waters are polluted by oil products, heavy metals, pesticides and phenols. The Khoresm Oblast and Karakalpakstan are completely become depleted of the water supply sources at the expense of the fresh ground waters.

The performed mapping has revealed considerable salinization of the soil horizon on the irrigated areas caused by the dust and salt blow-outs from the dried part of the Aral Sea, intensive underflooding and evaporation. In consequence of the unregulated irrigation regime, about 50% of the lands in Khoresm Oblast and in Karakalpakstan have occurred to be underflooded. The level of the subsoil water has raised by 2-3 m and more. About 40% of the irrigated lands in Khoresm Oblast are covered with areas of low and medium degrees of pollution by herbicides.

### **5.3. Review of the Water Use Problems by Regions**

#### **5.3.1 Water Supply in Fergana Valley**

The social and demographic challenges of Fergana Valley development anticipate the necessity in the specific review of the water use state in this densely populated area.

The theoretical reserve of the irrigation water-supplying capacity of the Syr Darya River is equal only to 0.1 mln. ha, and with the maximum complete use (without regard for ecological aftereffects) of the water resources in this basin (the aggregate water intake is 50.8 km<sup>3</sup>), the irrigated area may be brought up to 3.2 mln. ha including those in the Fergana Valley - up to 1.44 mln. ha (the available land reserve suitable for irrigation of this basin's territory comprises about 10-11 mln. ha). The data indicate that the native natural potential of the water resources in the Syr Darya Basin is almost depleted, and for the long-term perspective in the countries of this region (particularly in the Fergana economic district of Uzbekistan) there may arise the challenge of the water shortage which is specified primarily by the high level of the population growth in the region.

The agricultural sector of economy should not only enlarge steadily production of the food products, but as one of the major consumers of the water resources it would be forced to release the fresh water resources for satisfying the water demand for municipal and industrial purposes and for regulating the ecosystem.

In the Fergana Valley, as in the Republic on the whole, they are being confronted with an acute problem concerning the water use rationalization. At present the volume of the water consumed per 1 hectare of the irrigated land in the Republic makes up in average 10-12 thous.  $\text{m}^3$  (for reference, in Israel 5.5 thous.  $\text{m}^3$  is consumed per 1 hectare of the land), and the volume of water per one person is 2.5 thous.  $\text{m}^3$  whereas according to the world standards the normal level of the water volume per one person amounts to 1.7 thous.  $\text{m}^3$ . The data indicate the uneconomic and wasteful consumption of the water resources when they are dramatically insufficient.

Some pollution of the ground waters by the oil products take place at the Altyaryk-Beshalysh deposit in Fergana Oblast that caused grave ecological situation.

### **5.3.2. State of the Water Resources in the Angren-Almalyk Agricultural District**

The Angren-Almalyk agricultural area is situated in the intermontane valley of the Akhangaran River. The Akhangaran River is the right-bank tributary of the Syr Darya River with the catchment area of 7710  $\text{km}^2$  and the length of 236 km. The household, drinking and industrial water supply for the Angren industrial center is ensured by 92.2% through the subsoil waters and by 7.8 % - through the surface waters.

The Akhangaran deposit of subsoil waters coincides with the alluvial shingle beds of the Syrdarya and Golodnaya Steppe complexes of the deposits. The water permeability is up to 300 m/day. The thickness and efficiency of the productive water-bearing horizon increase from 10 m and 0.01-0.16  $\text{m}^3/\text{day}$  near the Turk village to 40 m and 0.5-0.6  $\text{m}^3/\text{day}$  near the Ablyk village; 80-90 m and 3.5  $\text{m}^3/\text{day}$  near the Sartamgaly village; 120 m and 8.3  $\text{m}^3/\text{day}$  at the Saganak section.

The principal role in formation of the subsoil water deposit under the natural conditions is due to the infiltration of the surface waters: the channel flow of the Akhangaran River, flows from the irrigation canals and irrigation network. The river waters are fresh with the content of the dry residue of 290-400 mg/l, water hardness up to 5 mg-equiv./l and with a minor content of fluorine, lead and other components.

The Akhangaran deposit of the subsoil waters (ADSW) was explored in 1949-1974 regarding its central part by the Uzbekgidrogeologia PA. The productive water-bearing horizon of the ADSW on the territory of the industrial area operates 18 large group water intakes and 200 separate well-drilling water intakes united territorially into 3 water-intake complexes: the Almalyk, Akhangaran and Saganak ones.

The aggregate average annual water-intakes discharge in the agricultural and industrial region in 1995 amounted to 11.34  $\text{m}^3/\text{sec}$ . The consumers of the subsoil waters deposit are the Almalyk Mining and Smelting Complex, Ammofos PA, Akhangarantsoimaterialy PA,

Akhangarancement PA, Novoangren HPP, Suvokova PD, agricultural complex, the cities of Almalyk, Akhangaran, Nurabad and rural settlements.

The favorable features of the water resources of the Akhangaran intermontane valley are as follows:

- existence of the common subsoil waters deposit along the whole length of the valley being unique as to its dimensions, water quantity and water quality suitable for the household and drinking water demands;
- continuous re-establishment of the subsoil water reserves through the surface flow, high dynamics of the water exchange process;
- the intermontane valley of the Akhangaran River is the natural collector which is characterized by multiple qualitative increase of the water resources downstream the valley;
- natural protectability of the Akhangaran subsoil waters deposit against the antropogenic impacts due to the slightly penetrable ancient terraces in the boundary parts of the region where the major industrial facilities, cities and rural populated localities have been concentrated.

The detrimental peculiarity is the natural deficit of the water resources due to lack of the glacier recharge of these water resources. During the low-water years the water supply to the agricultural and industrial region amounts to 60-70%; the natural process of degradation of the water resources quality downstream the valley increases under the influence of the raised antropogenic impacts. As a consequence, in the lower part of the valley there are formed the zones with water quality unsuitable for the household and drinking purposes; concentration in the valley of the industrial centers, cities and agricultural complex would lead to intensification of the ecological load on the water resources of the agricultural and industrial region.

The antropogenic impact on the water resources occurs in the result of:

- regulating the flow of the Akhangaran River by the Akhangaran water reservoir as well as regulating the flow of its lateral tributaries and redistributing the flow on the area (withdrawal of the flow from the river channel and its transportation by the concrete interregional canals of the irrigation and intra-farm network);
- diverting the ground waters by heavy-duty water-intake complexes occupying a considerable area (tens square kilometers) and located at a great distance from the water consumers;
- water draining from the city areas and industrial sites which is consistent with the intensive water consumption both of the ground and surface waters (industrial, municipal, domestic and waste effluents);

The aggregate antropogenic impact would tell differently on the quantity and quality of the water resources raising in various parts of the agricultural and industrial region the accumulation or depletion, pollution or dilution of the water resource.

For the normal functioning of the Angren-Almalyk-Akhangaran agricultural and industrial region, there is necessity in the adequate management of the whole water resources complex. Therewith, it is required to solve the principal challenges: rational and efficient consumption of the water resources including the optimal operation of the water intakes, and stabilization and improvement of the ecological state of the water resources.

In the valley of the Akhangaran River on the territory of the Angren-Almalyk-Akhangaran agricultural and industrial region there is functioning the Water Resources Monitoring System of the Intersectoral Laboratory for the Water Resources (ILWR) at the Tashkent State University realizing the following logical scheme: monitoring - information - forecast - recommendations - management.

The special features of the Water Resources Monitoring System (WRM) are as follows:

- the structure of the WRM consists of 1120 water facilities including 560 operating wells, 350 observation posts, 85 piezometers and 120 hydrometric stations; the hydrochemical network involves 470 water servicing stations;
- complexity of investigations: hydrogeological, hydrometric and hydrochemical observations;
- immense database of the full-scale field investigations: by the streamflow - 70 years, by the climate - 60 years, operation of the water intakes - 45 years, the level and hydrochemical regime of the ground waters - up to 50 years, etc.;
- systematic bank of the synthesized information (hydrogeological, hydrological, hydrochemical and meteorological) for tackling the scientific and applied problems and tasks.

The established ILWR Monitoring System is the unique one not only in the Central Asian region, but in all CIS countries as well.

The monitoring enables to solve two main tasks: effective co-existence on the common territory of the region of the urban and rural population with the industrial complexes, and supply of the qualitative drinking water to the population of the cities and settlements under conditions of the technogenic impact on the ground waters reserves.

***The Gissarak Water Reservoir*** in the Shakhrisabz Rayon owes its existence to the urgent necessity in expanding the irrigated areas for the agricultural crops. Its construction was commenced at the beginning of 1976. By virtue of the Gissarak Reservoir 48.5 thous. hectares of the upper zone have received the water, and more than 12 thous. hectares of the new lands have been developed.

To deliver the water from the Aksu River to the Shakhrisabz, Kitab, Yakkabag and Kamashin Rayons, the hydrosystem and canals Aksu-Yakkabag and Yakkabag-Beshkutan have been constructed. In parallel with the dam construction at the place of junction of the Aksu and Karasu Rivers, the settlement for the builders of the hydraulic facilities has been developed.

In 1996 in the Kitab Rayon the builders of the hydraulic system completed development of the 150 hectares for the drip irrigation and turned them over to the farm «Varganza», the project was prepared for the farm «Kishlyk» where 300 hectares would be irrigated by applying

similar irrigation method. The farms «Khisor» and «Okdare» received 250 hectares of the developed lands.

In 1996 the construction of the water reservoir in Yakkabag Rayon was also commenced.

***The Tupolang Water Reservoir.*** In 1982 the construction of the reservoir was commenced which was destined to be completed in the course of 10 years. The complexity of this construction was in the fact that it was required to raise the dam with the height up to 190 meters. It was decided to build the HPP on the base of the reservoir. It was estimated that the HPP will generate inexpensive power. The HPP construction was commenced in 1995.

In 1996 the dam reached the elevation of 100 meters. In August of 1995 when the water level in the rivers dropped to the minimum, the Tupolang water reservoir made it possible to give the pre-September irrigation for the cotton on the considerable area. The waters of the Tupolang reservoir irrigate several thousands of the lands in the Republic.

The water reservoir was estimated to contain eventually 500 million cubic metres of water. The completion of its construction will make it possible to solve the problem of irrigation of agricultural crops in the Sherabad Steppe in August and cultivation of 30 thousand or more hectares of virgin and disused lands.

The water power station will serve as an additional facility for water discharge which, on the one hand, will make it possible to provide cheap energy and, on the other hand, to increase the safety of the water reservoir, which makes it essential to complete the construction of all facilities of the Tupolang water reservoir in the soonest possible time.

### **Mistakes Made in the Process of the Golodnaya and Karshin Steppes Cultivation**

In the process of the cultivation of both the Hungry and Karshin Steppes the same negative phenomena took place: the rise in the ground waters level, secondary salinization of the irrigated lands, low crop capacity, large volume of the drainage flow, strong influence of the ameliorative systems on the quality of the surface waters, etc.

The area of the irrigated lands in the Hungry and Karshin Steppes amounts to 90 and 30 percent of their total area respectively. Irrigation many times boosts biological, geological water and chemical elements rotation. It involves the emergence of steady positive feedback the essence of which is in striving for getting higher crops through the application of high irrigation standards with the low level of the irrigation technology, which leads to deterioration of the soil-amelioration, hydrogeological, geochemical and ecological conditions. To improve these conditions it will be necessary to increase the anthropogenic influence which will involve intensification of the washing regime, construction of the drainage facilities which activates negative processes.

The emergence of these relations is the major reason for the similar negative processes that go on on the irrigated lands of the Karshin and Hungry Steppes. It makes it inevitable to introduce hydromorphic regime on the irrigated lands, to carry out intensive drainage and leads to instability of the ecological and amelioration situation and impossibility of effective management of the natural resources.

Under natural conditions the input parts of the water balance in the Hungry and Karshin Steppes were formed in different ways. The amounts of precipitations and underground water inflow are approximately equal while in the Karshin Steppe due to its large area and the peculiarities of the hydrogeological conditions precipitations that amount to 82% in the input part of the balance prevail. In the consumption part of the balance the elements proportion is also different. Evaporation in the Hungry Steppe including the evaporation from the ground water surface in decreases and depressions and the underground flow and withdrawal are approximately equal. In the Karshin Steppe with the ground waters deposited at a 5-metres depth and a high heat supply the amount of the evaporation corresponds to that of the precipitations and totals 82%.

With the irrigation of lands without constructing drainage facilities irrigation water prevails in the input part of the Hungry Steppe balance totalling 71%. In the Karshin Steppe (due to the fact that the irrigated lands amount only to 30% of the total area of the given zone) irrigation water totals 59% of the input part of the balance. In the consumption part of the balance it is the evaporation that plays the main part in it totalling to 72-82%. Under such conditions the rise in the level of the underground waters on the irrigated lands due to the irrigation technology that is in use is inevitable. Lack of the drainage under such conditions could have led to a complete degradation of lands as a result of their excessive humidification and salinization.

Water balance in irrigation and construction of systematic drainage facilities is as follows. In the consumption part the drainage flow totals 24-39%. Accordingly, the amount of the evaporation in the consumption part drops to 44-68%. The role of the drainage in the consumption part of the Karshin Steppe balance is quite small and the evaporation prevails. This fact can be explained by a small area of the drainage lands. The relation of the evaporation to the drainage flow differs: in the Hungry Steppe it is 1.13 while in the Karshin Steppe it is 1.82 which shows that the water resources in the Karshin Steppe are more effectively used. The volume of the drainage flow which is 50% is too big and cannot be justified from the point of view of a rational nature management. Drainage on the irrigated lands is intended as a measure to combat the results rather than the reasons of salinization such as a low efficiency, much losses of water and hydromorphic regime. From the point of view of a geosystematic approach the expanded use of drainage will increase the geological rotation, boost geochemical flows and make the ecological and amelioration situation worse.

The results of the investigation show that the ways should be explored to improve the ecological situation of the irrigated lands, to increase their productivity and to lessen the negative effect on the natural environment through the lowering of the irrigation standards values, liquidation of the soils salinization and reduction of the drainage flow volume. It is essential that the efficiency of water management be increased and that the level of the ground waters be lowered. In some instances in the Hungry and Karshin Steppes collector and drainage waters are used for watering due to which the soil salinization of vast areas takes place as well as a high variation of crops for areas and years.

The analysis of the situation shows why the results of the anthropogenic activities (the ecological and amelioration situation) turned out to be similar in spite of the differences in the natural and farming conditions and the amelioration systems constructions. It is apparent that the maintenance of the hydromorphic regime on the irrigated lands is inexpedient as, due to steady positive feedback, it will contribute to deterioration of the ecological and amelioration situation and lowering of the irrigated lands productivity. It is also inexpedient from the point of view of the amount of water resources consumed to produce a single unit of agricultural products.



## 5.4 Water Management in Agriculture

The cost of the plant growing produce received from the irrigated lands amounts to more than 60% of all the gross agricultural output. 19.8% of the republic's national income is generated in the irrigation farming (plant growing). The major funds of the irrigation farming total 20.8% of all the industrial funds of the republic's economy, 17.5% of the electric power consumed. 30.9% of all the population capable of working are engaged in the irrigation farming.

Along with favourable climatic and natural factors, considerable labour resources with a low rate of migration of rural population and its traditional skills and experience gained over centuries of growing agricultural crops using irrigation should be mentioned among other positive factors.

Problems of water supply of the irrigation farming in the republic is going to become in the near future a serious limiting factor in the development of the republic's economy. The problems are caused by the increasing deficit of water resources connected with the inter-state distribution of water resources; reduction of the irrigation capability of the Aral Sea basin's rivers in the near future in connection with the global climate changes; the increasing anthropogenic impact on the environment, the quality of the water resources, salinization of the irrigated lands and inefficient use of the land and water resources.

Over the period from 1980 to 1995, especially since 1985, water consumption for 1 hectare tended steadily to decrease while the efficiency of the irrigation water use tended to grow. The amounts of water used for 1 hectare differ greatly in different regions. The largest amount of specific water consumption is observed in the farming enterprises of Karakalpakstan, Khorezm, Surkhandarya and Bukhara Regions which is connected with the soil-amelioration condition of the irrigated lands and the agricultural crops that are grown.

A low amount of specific water consumption is observed in Samarkand, Jizak and Syrdarya Regions. This fact can be explained by the location of the irrigated areas at the final portions of the irrigation systems and the presence of high-engineering hydroameliorative highly efficient systems. The irrigation water productivity expressed in cubic metres per sum varies considerably throughout the republic's regions. The amount of water consumed for 1-sum amount of the produce shows that the irrigation water is most productively used in Navoi (3.3m<sup>3</sup>/sum) and Samarkand (2.9 m<sup>3</sup>/sum) Regions (in accordance with the average prices in 1991-1995). This fact can be explained, besides the above-mentioned reasons, by the production of highly profitable crops. The lowest amounts of the produce output fall on the lower reaches of the Amudarya River.

The irrigation systems within and between farms are braided with concrete facing or other antifiltration materials, the irrigated areas are enlarged. Horizontal, vertical and combined drainage facilities are constructed on the lands that are subject to salinization. All the necessary conditions for putting into practice water protection irrigation technologies are created, the efficiency of high-engineering irrigation systems is raised to 0.8-0.85.

At present the issue of technical upgrading of the existing irrigation systems does not get enough attention in the republic. Measures on improving technical condition of the irrigation

systems were not taken systematically and the desired effect was not achieved. The tensivity of the situation with water management is connected with the technical condition of the hydroameliorative system which is not perfect though quite modern. The system's low level has become one of the reasons for the exhaustion of the water resources' limit determined for the perspective.

Out of 63 km<sup>3</sup> of water used by the consumers, 27 km<sup>3</sup> (43%) represent productive non-returnable losses of the flow being directly used in the production of the national economic produce. Accordingly, 36 km<sup>3</sup> include the return flow as the losses from different segments of the irrigation system as well as the drainage waters. Only part of these waters can be re-used (8.4 km<sup>3</sup> or 23%) inside the circuit and successively. In the Syrdarya River basin it amounts to 4.7 km<sup>3</sup> and in the Amudarya River basin – to 3.7 km<sup>3</sup>. The rest of the water gets back to the sources or to the irrigation discharge lakes and is also dispersed for the transits.

In the inter-farm system at present about 20% of water used for irrigation is lost. The inside-farm system is characterized with more considerable water losses. According to experts' estimation, 50 or 60 % of water that gets into the inside-farm system is lost. Besides, about 10% of water is lost in the temporary irrigation system.

The measures on the maintenance of the inter-farm systems in working conditions are carried out by the farms themselves. At the farms the cleaning of the irrigation and open collectors is carried out by hand. When more serious repairs have to be conducted which involves use of technical equipment, participation of experts and drawing resources, agreements are concluded between producers and contract organizations. At present single farms cannot pay for the services rendered by construction organizations because of the hard economic situation in the republic. Under such conditions, due to the breakdown of inside-farm hydroameliorative systems, the state is planning to fund special programmes for the reconstruction of the systems.

Surface furrow watering at present still remains the main way of irrigation in Uzbekistan. It is based on the use of a low-productive manual labour. The watering efficiency is extremely low, on the average it does not exceed 0.48-0.55. The generally used at present furrow watering involves the discharge of water at the end of a furrow the amount of which is 25-30% of the watering standard thus reducing the efficiency of the water use and lowering the quality of the river flow. Uneven humidification of a field leads to decrease in crop yields (excessive humidity at the beginning and lack of humidity at the end of a furrow) and makes the watering very time-consuming (32-40 hours and more).

At present the inside-farm irrigation system of four types is mainly used in the irrigation farming: on the ground bed, in concrete facing, through ferroconcrete channels and underground pipe-lines. The analysis of the technical and economic indices of different types of irrigation systems showed that the irrigation system with various types of antifiltration coating considerably reduces water losses. It helps to save water resources and, consequently, money and to lower the exploitation expenditures on construction and exploitation of the main and inter-farm irrigation systems. Calculations made specifically for the conditions characteristic of Uzbekistan show that in case investment into water management projects for different types of inside-farm irrigation systems is considered, the most profitable is the variant with the use of ferroconcrete channels.

For the economic indices of power and capital intensiveness, the horizontal drainage surpasses all other types of drainage. The generated over the past 50 years experience of using

various types of drainage in different natural conditions of the old and new irrigation zones makes it possible to arrive at the following conclusion: any type of drainage in itself creates only the background against which the complex of organizational, management and agroamelioration measures leads to an optimum ameliorative effect. That is why, along with its construction and rational exploitation, it is necessary to regulate water management, to carry out grading and capital washing of lands subject to salinization and to use an optimum irrigation regime.

In the conditions of an increasing deficit of water resources carrying out organizational measures that do not require large investments is very important. The possible organizational measures include introduction of water pricing, organization of water resources management in the market economy conditions. Besides paid water consumption, there are other ways to make agricultural producers more interested in economical use of water resources. Such methods may include fixing of a farm's right to use the saved volume of water for production purposes or selling water to other farms.

Besides, it should be taken into consideration that even in case payment for water use is introduced it cannot be guaranteed that farms will mobilize all their resources in order to save water if such saving will lead to reduction in the amount of water allotted to them, i.e. the incentives for water saving are insufficient. That is why it is expedient to fix a certain amount of water for farms that use irrigation. Farms would be given the right for water supply in accordance with the performed projects of irrigation, the confirmed land-tenure acts or on other grounds. The volume of water may be differentiated taking into account natural conditions for different years.

#### **5.4.1 Demand for Water at the Farms Level**

The need of water is determined in accordance with the structure of the sowing areas. The sowing areas on the irrigated lands are determined by local authorities proceeding from the distribution of the state order. The irrigation standards for crops are determined proceeding from their belonging to a hydromodule area depending upon the soils, relief and climatic conditions characteristics. Water consumption plan for the vegetation and non-vegetation periods has been worked out, water supply division for ten-day periods has been made.

But in practice watering terms and standards are not followed strictly. Demand for water varies depending upon the season. Factors that influence the demand are determined by biological needs of the grown crops, natural and climatic conditions, plants feeding. The greatest need of water is observed for winter wheat in October (3 waterings, 800 m<sup>3</sup>/hectare), for cotton - in June and July (4 waterings, 1000 m<sup>3</sup>/hectare), for maize - in May and June (4 waterings, 900 m<sup>3</sup>/hectare), for fodder crops - in April and May (4 waterings, 1000 m<sup>3</sup>/hectare), for vegetables - in May.

#### **5.4.2 Irrigation and Amelioration Service's Activities**

The Irrigation and Amelioration Service is responsible for a timely water supply, distribution and withdrawal of water within the boundaries of a collective farm, maintenance of hydroameliorative system in working condition. The head of the Service is the chief irrigator who is equated in status with the farm's chief specialists, participates in the farm's council and is

responsible for making decisions on water management at the farm. The chief irrigator is appointed by the head of the farm in accordance with the regional organization's recommendation and is approved for the position at a meeting of all the collective farm's members.

The Irrigation Service does not have an account of its own and is not a legal entity, all financial operations are conducted through the farm's accounting. The major functions of the Irrigation and Amelioration Service are as follows: an all-round-year study and analysis of the ameliorative condition and hydrogeology of the irrigated lands; study of the inside-farm hydroameliorative system's condition, determination of a place for technical service and carrying-out of cleaning and repairs of the irrigation and collector and drainage systems; attracting on a contractual basis of contract organizations to conduct large-scale work on the systems.

At present the Irrigation and Amelioration Service meets with certain difficulties: the number of people working at the Service tends to decrease because of the untimely payment of salary while the number of private water consumers increases; amelioration facilities and means of transportation are worn and need repairing. Because of the high prices on spare parts and technical facilities and the lack of financial means on their accounts farms cannot purchase them: during the vegetation period farms face the problem of untimely and insufficient water supply while the water management organizations bear neither administrative nor material responsibility; the Irrigation and Amelioration Service depends upon the head of a farm to give it directions, but it should have an opportunity to make decisions independently when, for example, it is expedient to carry out an unplanned watering in order to compensate the insufficient water supply.

### **5.4.3 Cooperative Societies on Irrigation and Amelioration**

In 1994 in order to improve water supply of the agricultural products producers the Department on improving ameliorative condition of the irrigated lands at the Ministry of Agriculture worked out the regulations of a new structure – a co-operative society on irrigation and amelioration. The major function of these societies is providing water supply for farms with different forms of property on a contractual basis.

The major facilities operated by a society were supposed to be inside-farm irrigation and drainage systems, hydrotechnical constructions, pump stations, transportation facilities, building where technical facilities are kept. The above-mentioned facilities are turned over to the co-operative societies on a contractual basis for the period of 10 years or more. The number of the attending personnel depends upon the irrigated lands area and technical equipment of the hydroameliorative systems.

Mutual payments for the amount of the work that is done are made by the co-operative society on irrigation inside the collective farm with cheques, by transfers and with population – in cash. To carry out complicated work the co-operative society can attract other organizations on a contractual basis. In order to make an efficient use of technical facilities they can be rented out on a contractual basis. The co-operative society performs the same functions as the irrigation and amelioration service but it enjoys wider powers to ensure that the water consumers bear administrative and material responsibility for violations of the rules on rational and economical use of water resources.

#### **5.4.4 The Influence of the Land Reform Policies and Farming Reorganization Water Resources Distribution**

In course of the research conducted in different regions of the republic the following range of problems connected with water use facing the agricultural producers in Uzbekistan has been determined. Equalizing the rights of peasants' farms with those of other water consumers it is necessary to give a more detailed assessment of relations taking into account peculiarities of the farms. It is essential to introduce the legal basis for the economic mechanism of relations between farms and water supplying organizations.

Another problem is the inefficient use of water resources because of the lack of incentives for farmers and other water consumers to use water resources economically. To maintain the inside-farm hydroameliorative systems in working condition capital investments are needed. But the private water consumers are unlikely to make the necessary investments into the lands amelioration and improvement of the water management infrastructure without being given further guarantees for the land ownership and wider powers to use their production output than they have now.

#### **5.4.5 Concepts on Determining the Amount of Payment for Water Use Worked Out in Uzbekistan**

Different concepts of determining the amount of payment for water use have been worked out in Uzbekistan. They are based on the whole on assessing average expenditures on delivering of a single unit of water resources. These methods determine the final expenditures as the expenditures on the flow formation which include the cost of the water resources regulation, water transportation and supply, and the cost of water as the total amount of expenditures given for one year.

It has been determined that water is the state property of the Republic of Uzbekistan and should be used only for its direct purposes. At present water itself cannot be turned over from one owner to another, that is it cannot be purchased. That is why the essence of the payment for water is the payment for the use of it. The Institute of Macroeconomy and Social Studies (Trushin E.F.) has synthesized the useful elements of the above-mentioned concepts and worked out the method of determining of payment for water use in the irrigation farming. It includes three groups of payments which differ in the ways of calculation, direction of activity and realization of use: this is the payment for the right to use water resources at one's farm, the payment for water management service and the payment for the quality of the water delivered.

The payment for the right to use water resources envisages the introduction of licencing. The licence for the use of water resources is an official permission granted by local authorities to agricultural water consumers to use water resources for a certain period of time. Without such licence a consumer should not have the right to use water resources and to be served by the state hydroameliorative systems. A licence agreement may contain a number of terms stipulating the order of the use of the licence itself and the direction of the water use by consumers.

The payment for the water management services includes the services on water formation in the source, water delivery and removal into inter-farm systems.

The payment for water delivery is intended to create conditions, first, for stimulating farms to reduce the volumes of water consumption and, second, for the conversion of water management organizations into self-funding which is going to be done on the basis of direct justification of water management organizations expenditures on rendering services on water supply of the irrigation farming.

The payment for water removal is the payment for the services on removal of collector and drainage system waters from the irrigated lands in order to create favourable amelioration conditions, to stimulate farms to reduce the volumes of water removal.

The rent payments for the quality of the water delivered are based on quality of water from the source of irrigation. This method is aimed at fixing a higher payment for water of a better quality through deducting part of the income of farms-consumers of water as a differential water rent. A.Karimov of the Institute for Water Issues recommend that a partial payment for the irrigation water for the last 10-15% be fixed. If the volume of consumption remains at a level of 85-90% of the fixed amount water is delivered to farms free of charge. The water that has been paid for can be sold and purchased. As the analysis of the world experience shows, the amount of the payment for water should not exceed 10% of the gross income of water consumers. In such case it will serve as an incentive for economical and rational use of water.

#### **5.4.6 Proposals for Rational Utilization of Water Resources in Agriculture**

Water resources are used very inefficiently in irrigation farming. To use them rationally in market conditions it is necessary to work out a system of measures of organizational and technical character. Organizational measures include introduction of a system of paid water use, organization of water resources management under market conditions. Technological measures are drainage, antifiltration measures and water saving technologies of irrigation. The present legislative basis does not make it possible to embrace new aspects related to appearance of private water users in Uzbekistan. To determine the rights for distribution of water at an economic level national traditions should be taken into consideration. To equalize the rights of farmer economies and private water users the legislation must precisely determine their relationships with peculiarities of farmer economies taken into account.

The following recommendation could be given to improve water utilization at the level of farms under the conditions of land reforms and reorganization of farmer economies: establishment of a new institutional structure at the level of economies of water users' association which is a self financing organization dealing with the functions of management and distribution of water resources at the level of economies. Keeping hydromeliorative and irrigation systems in working order needs investments. The present internal economic irrigation systems have not been repaired in the last 5-7 years since they were handed over to the balance of economies. This, in its turn, results in huge organizational and technological losses of water resources of the republic. It is absolutely essential to determine the list of measures and sources of their financing.

To make the water policy in Uzbekistan effective in conditions of market relations it is necessary to create relevant economic market environment. It is also necessary to secure the right of property to agricultural producers to their products, the right to dispose of products at market prices.

The Association of Water Users should involve organizers who enjoy authority with the population and are trained in the field of institutional development. An association of water users as an organizational structure at the level of farms is quite acceptable for Uzbekistan's conditions. Associations of water users (AWU) are beneficial in any form.

The legal basis which promotes solutions to the tasks is a circumstance of great importance for giving AWU a possibility to efficiently build up relations with other organizations, have bank accounts and undertake other forms of activity. Precise definition of AWU property rights to water and irrigation structure will be a powerful means in the process of turning over the rights of management from the state to AWU. For long term and state operation AWU need support of the state and a legal basis.

Role of the state will be changing as the AWUs take upon themselves additional obligations. The budget of the association of water users will be the basis for calculation of payment for water at the level of farms. The expenses will be covered owing to the dues of the association members.

Computation of big marginal difference for individual kinds of products helps to focus attention to the state of things in output of each agricultural crop in AWU. So it becomes possible to calculate their contribution to the common profit. Computations show that at the establishment of AWU this profit on an average will be 1.5-2 times higher than without AWU.

The present price regulation for main kinds of cereals, which results in a low level of profitability of agricultural production, makes paid water use possible. Thus, introduction of AWU and payment of water requires fundamental changes of the state policy towards market reforms.

As a whole recommendations aimed to raise the efficiency of water use in Uzbekistan may be formulated as follows:

- to have institutional reformation of the system of water use management made at the level of farms and to create stable water users associations;
- to provide economic conditions for profitable agricultural production;
- to secure the right of ownership to agricultural output and the right to free disposal of it;
- to liberalize the sale of products and the system of price formation;
- in the first years of AWU's coming into being the state must give support to it in the form of privilege crediting and taxation of AWU members.

To cut down the financial burden of the state and to make the farmers interested in economical utilization of water resources it is necessary to introduce paid water use. Water payment tariff at the level of farms ought to be based on the budget of AWU/This will involve establishment of water use legal basis to take into account the new forms of managing, new institutional forms of AWU management. It is advisable to institute the legal status of private water users, to give a juridical grounding of the right to water; to elaborate a relevant legislation stimulating the development of AWU; to encourage experimental approbation of AWU at the

level of farms in different natural and economic zones. Creation of AWO may be based on different forms of farms.



## **6. Water Conservation Measures under the Conditions of Environmental Crisis in the Pre Aral Zone**

Since the early sixties of this century water inflows to the Aral Sea have been dramatically reduced in amount due to the reasons: irrigated lands have been expanded and more water has been diverted for irrigation. (In 1986 irrigated areas covered 6.8 million hectares and water diversions were in the range of 115 cu.km.) By 1975 about 35.2 cu.km of water flowed down to the Aral Sea, by 1980 water inflows amounted to 10 cu.km, and in 1986 the Syr Darya and the Amu Darya waters did not reach the sea.

One of the urgent problem to be solved to restore the Aral Sea water inflows is to increase the Syr Darya throughout capacity to 1,800-2,000 cu.m/s and to raise the capacity downstream from the Chardara hydro system. These measures will reduce the amount of water flowing to the Arnasai depression (most water is evaporated there) where over 28 billion cu.m of water has been stored in recent years. (In the late 1980 about 16 billion cu.m of water was stored in the depression.) The Chardara hydro system with its 100,000 kW hydropower plant discharges 1,850 cu.m/s, and the Arnasai hydro system lets through 2,100 cu.m/s of the Syr Darya flood water. The hydro system at the Chardara Reservoir was laid out so 30 years ago on account of high cost of flood protection measures taken for the Central Asian railway stretches (at Karauzyak and Chiili locations) during the flood and ice-blocking periods.

Downstream from the Kzyl Orda dam, the discharge capacity of which is 1,700 cu.m/s, the river, because of the channel silting, was not able to pass more than 1,500 cu.m/s of total water released from the reservoir prior to the flood time. Water-meadows of the river in the Kzyl Orda neighbourhood are personal plots of town dwellers with all sorts of buildings erected. As a result this makes the estimated water flow down the river impossible. To renew the river channel capacity means to breathe in new life into the Lower Syr Darya and the delta, and to stabilize the Arnasai water storage.

The Syr Darya channel downstream from the Chardara hydro system within 40-45 km (this is the total area of degradation of the stream channel) can pass through floods of 0.1-1.0 probability, but the reservoir can release only 18,000 cu.m/s of water.

Uzbekistan has necessary material and technical potential to improve water supply and water conservation measures. The potential may be effectively developed for 4,212 thousand hectares of irrigated lands. More than 50% of them are under lift irrigation. There are 247 irrigation systems and 61 reservoirs operating in Uzbekistan. The interfarm irrigation network extended through 27,712 km, the farm irrigation system reached out to 165.5 thousand km. The efficiency of allocated farm water resources is still low.

In 1992, water diverted for farm irrigation amounted to 46.2 km, but only 37.6 km of water for irrigation was provided. Water losses amounted to 20%, and in Karakalpakstan and Khorezm they came to 34%.

With the aggregate of quantity, time period and rates of crops rotation optimized, it is necessary to take into account the environmental requirements for protection of natural resources and life medium security. However, these requirements are not yet being materialized, the only aim pursued is to get the highest possible crop yield. Differentiation of the irrigation regimen is

based on hydromodule division of the territory into districts. The data obtained are used to calculate the discharge capacity of irrigation canals, to make plans of water utilization and operation of hydraulic systems of land-reclamation. Uzbekistan's lands to be prospectively irrigated are divided into 8 soil and climate districts (Lower Amu Darya, Chirchic-Angren, Samarkand, Bukhara, Kashkadarya, Surkhandarya). There are 10 hydromodular districts defined on the basis of mechanical composition of soils in the aeration layer and the depth of subsoil water assurance. Provisions are made for plants to use subsoil waters depending on the depth of occurrence and dampness of the plant-rooted ground.

The present-day meliorative state of irrigable lands in the Pre Aral Zone is disappointing. The subsoil waters level of irrigated lands is above critical. The drainage-and-collector network is not long enough and imperfect as regards the design. The present situation concerned with utilization of Central Asian water resources for irrigation and hydropower generation was brought about by construction of installations related to development of virgin lands along the Karakum canal in Turkmenistan, in Golodny (Hungry), Surkhan-Sherbad, Karsha and Dzhizak Steppes of Uzbekistan and the failure to build power projects with water flow regulating capacities some 15-20 years prior to it.

The present water consumption and permanent losses come to about 110 cu.km, the residual flow to the delta top being 7-8 cu.km. With water mineralization increased the agricultural crop yields decrease. Some fertilizers applied are carried deep into the earth owing to increased quotas of irrigation. This results in impoverishment of the soil structure.

### **Basic causes of the current situation:**

- due to a low technical level of the old irrigation systems in the Aral Sea basin water utilization is not economical enough. Absence of a stimulating and managerial mechanism aimed to ensure economical utilization of water from regulating reservoirs is one of the faults as regards operation of the irrigation system;
- when implementing the projects they somewhat distorted "The General Diagram of Complex Utilization of Water Resources of the Syr Darya and Amu Darya";
- excessive water inlet results in accumulation of considerable quantities of collector-and-drainage water which is diverted to special irrigation water reservoirs outside the irrigation lands;
- river water quality deteriorates because of discharge into rivers of collector-and-drainage waters which carry a great amount of fertilizers and chemical weed-killers (Uzbekistan applies over 30 kg/hectare of them) penetrating into soil;
- owing to irrational use of water resources in the Pre Aral Zone and high mineralization of water, water consumption exceeds the designed rates which bring about secondary salinization of lands.

In the final analyses the complicated situation regarding water supply in the Aral Sea area, dominance of extensive forms of economy, failure to observe crop rotations and agrotechnical methods ended, of late, in slowing down of the growth rates of labour productivity and falling of the region behind in socio-economic development. Leaving the current situation regarding irrational use of water resources as it is entails sinking of the Aral Sea level, aggravation of the socio-economic situation in the region.

## **7. Rational Water Use Problems and Some Recommendations**

### **7.1 Petty Capital Intensive and Competitive Land-Reclamation Measures**

Increase of water supply in agriculture will entail a great amount of capital investment in the intrafarm network. At the same time an increase of water supply by improving the irrigation techniques alone and laying out the irrigable sectors is unprofitable, whereas reconstruction of the intrafarm irrigation network alone does not give the desired results.

Biological drainage of the dekhkan-owned lands through introduction of intensive crop rotations, application of biofertilizers and the proposed forest-plantations efficiently protecting irrigated plots from inside do not need any extra expenses on improvement of the irrigation techniques and lay-out, on reconstruction of the irrigation and collector-and-drainage network. Also, protective plant belts, like alfalfa crop rotations, are an effective means against wind and water erosion.

The costs of crop rotations and biological drainage are not more than 5,000 sum/hectare, but they raise the crop yield by 5 to 10 per cent with the net gain being 100-150 sum/hectare. Imposition of water charges entails the necessity of installing water meters with remote control in all points from which water is diverted for irrigation. This will cost around 2,000 sum/hectare, and economize 10-12 per cent of irrigation water. As a result extra net profit will come to over 400-500 sum/hectare with the payback period covering 4-5 years.

It is advisable to make real investments in biodrainage, crop rotations and provision of the intrafarm irrigation net with equipment of automated remote water costing systems, control of water division and mutual settlements without delay.

### **7.2 Gravity Flow Irrigation System: Drip and Flush Irrigation of Cotton Fields**

1993 saw the invention of a dropping appliance "Hamrani" operating on the basis of the hydrodynamic principle. It did not require high water heads, fine water purification or costly pilot plants. The gravity flow system of drip and flush irrigation runs at low water heads (0.8-1.8 m.w. col) without any power pumping facilities wanted. The gravity flow system consisted of a water diversion unit with a coarse filter, a sectoral pipeline of polyethylene with "Hamrani" droppers installed at a two-metre distance from one another. Application of drip and flush irrigation favours economical and productive water use, optimum water and air regime of soils, excludes irrigational erosion of them, furthers rich stable crops of raw cotton.

Application of drip irrigation saves water and simultaneously increases the yield of agricultural crops of better quality. With the feed of required quantity of water directly to every plant, the soil does not get humidified below the rooting layer, there appears no formation of free water surface which promotes intensive evaporation; with the surface discharge of water being averted the humidity regime is maintained at the level promoting better conditions of plant growth and evolution.

### **7.3 Weakly Flush and Long-Line Furrow Irrigation**

The weakly flush and long-line furrow irrigation methods developed in 1994 meet the present-day requirements to save water resources and to raise the productivity of lands. The results of the research are as follows: more economical and productive water discharge; no irrigational erosion of soils when this system is used on lands of big declivities (up to 0.02); exclusion of irrigation water discharge at furrow ends and depth percolation; plants develop more evenly; raw cotton yield increases.

#### **7.3.1 Sip Irrigation**

Sip irrigation consists in changing the run discharge of water and its full discharge at the stage of irrigation. Discharge into furrow is assumed to be continuous as it is extremely difficult to ensure its discreteness under production conditions. Water can considerably be saved (up to 20-40%) when applying sip irrigation. This method of irrigation helps make the labour productivity 2-3 times as high. The technology of this method includes quite a lot of different combinations of pulses and activities, water feed and intervals between them.

Results of the experiments showed that the extension of irrigation jets run largely depended on the duration and frequency of cycles: as soon as the water supply cycle became shorter and less frequent, the length of the run also grew shorter approximating to the solid jet run. However, discontinuous water delivery needs application of irrigation facilities, in particular TKP-90 sprinkling machines which could rapidly change the water supply regime. The period of water feed with discontinuous irrigation does not last as long as with continuous. So, furrow irrigation with a discontinuous jet makes it possible to lengthen the furrow by 20-40%, to water the field more uniformly ( $df=0.9$ ); with discontinuous jet irrigation potato crops rise by 4-6 t/hectare with irrigation rates lessened by 15-20%; introduction of sip irrigation method entails provision of dekhkan farms with irrigation equipment.

#### **7.3.2 Pulsed Irrigation**

Pulsed irrigation is a variety of the furrow irrigation method. It is implemented by setting pulse-pauses for water discharge within optimal time transferring them now to one furrow strip, now to another. Irrigation pauses make it possible to reinforce furrows, diminish the wash-out of soil, absorb water at the furrow heads, accelerate the jet run to the furrow end. The pulse pause as well makes it possible to reinforce furrows for a subsequent discharge, which may gradually increase from pulse to pulse. Uniformity of irrigation and soil moistening improve the quality. The pause- beat lasts 20 minutes.

There are various irrigation techniques that reduce wasteful irrigation by 10-30%. There are portable polymerous or aluminum pipes, siphon units, sprinklers, soil cultivation with polycomplexes, which is especially effective on soils of high water permeability and on subsiding grounds with an unfavourable sloping relief.

### 7.3.3 Water Conservation Irrigation Technology

Development of rational elements of discrete furrow irrigation is a prospective trend of economical use of irrigation water. In 1994-1996 the Akhunbabayev cotton-growing farm was the place to investigate the elements of furrow irrigation technology on the methods of the SANIIRI institute, and elements of the irrigation regime on the methods of the UzNIIH institute. Mathematical treatment relating to the yield data was done on V. Peregudov's method of dispersion analysis. Methods of absolute economic efficiency were used to select the optimum irrigation technology.

With a view to desalinize the soil and to create water reserves for simultaneous germination of cotton plant annually in early spring they irrigate cotton fields (1.5-2 thousand cu.m/hectare) to keep the soil moist. To maintain the optimum regime of humidity in the rooting layer under the conditions of hydromorphic ameliorative regime they provided 4-5 irrigations during the vegetation period. According to the results of the 1996 research water conservation with furrow irrigation applied was 30%, with application of discrete technology of every furrow irrigation – 20-25%, at discrete irrigation of inter-row spacing – 41-42%. The minimum irrigation rate of cotton-plant 3,000 cu.m/hectare corresponds to row-width discrete irrigation along the shortest possible furrows (100m). At discrete irrigation of 200 metre-long furrows water consumption is 160 cu.m/hectare more (5.3%), of 300 metre-long furrows – 275 cu.m/hectare (9.2%). It is necessary to cut down the volume of water discharge between the steps and correspondingly to lessen the operating pause when irrigating heavy loamy “takyr” meadow lands of low permeability. As is seen from the experiments the uniformity indicator for soil moistening at discrete irrigation is 15-18 points as high. Maximum cotton yield in each version group of the same size furrows is equivalent to the version of discrete low-width irrigation. Practically an equally rich crop of raw cotton was gathered in at discrete irrigation of 100 and 200 metre-long furrows. Judging from the fibre output the versions of irrigation are not much different. However, judging from the mass of 1,000 seeds, preference is to be given to the most high yielding version of discrete low-width irrigation of 200-metre furrows. More equal crop distribution was achieved with the version of discrete irrigation (0.01-0.02) which provided uniform moistening of soil rooting layer along the whole length of furrows.

Cotton plants cultivated on meadow soils of the Surkhan-Sherabad steppes are irrigated with subsoil waters. Proceeding from the fact that cotton plants receive water of the same quality for all the versions of irrigation, the structure of the latter has been calculated by the balance method. The share of subsoil water evaporation is the biggest for versions having the least consumption of irrigation water. With experimental versions of water conservation irrigation technology water consumption per 1 centner of raw cotton is twice as little against the scheduled versions. The same versions are known to consume the maximum amount of the soil water reserves which are to be replenished by spring moisture filling irrigation.

Based on the analysis of water conservation technology of irrigating fine-fibre quality “Termez-24”, cultivated by ridge sowing on “takyr” meadow soils, they made the following conclusions:

- with discrete irrigation of 100, 200 and 300 metre-long furrows water consumption is 0.3-0.4, 0.6-0.7 and 0.8-0.9 l/s respectively;
- there is no surface discharge or deep filtration. As a result when irrigating the cotton plant

on 100, 200 and 300 metre-long furrows, they save 30.3-56%, 44.5-65% and 52-55.2% of water respectively;

- application of discrete irrigation technology provides for uniform moistening of the soil rooting layer along the furrows. This increases productivity of both the irrigation water and applied fertilizers and creates a favourable water-feeding regime of the soil for growth, development, maturation and raising of high cotton yields. With discrete irrigation of 100 and 300 metre-long furrows the increase in the cotton harvest was 3.3-4 c/hectare and 2.6-2.9 c/hectare respectively;
- on hydromorphic soils of the Surkhum-Sherabad Valley irrigation of every other furrow makes it possible to conserve 40-50% of water as against irrigation of each furrow. Owing to small rates of irrigation the soil does not thicken much, improves its water and physical properties, water from dry row width gets less evaporated, evaporation of subsoil waters and salt accumulation in the rooting layer of soil get reduced;
- maintenance of considerable water-feeding/ thermal and air regimes of cotton plant with discrete inter-width irrigation promoted rich raw-cotton crop: with furrows being 100, 200 and 300-metre long it was 36.3, 34.9 and 36.5 c/hectare respectively. Uniform soil moistening by the length of furrows provided for good quality of cotton fibre (1<sup>st</sup> industrial grade);
- under conditions of a hot climate of the Surkhan-Sherabad Valley and close range bedding of subsoil waters, cotton plant water consumption includes: 33-63% of irrigation water, 30-48% of replenishment with ground waters, 8-13% of utilization of moisture reserves in the soil, 7% of precipitation.

The least possible irrigation water use of 116.4-92.5 cu.m and 113.1-93.9 cu.m per 1 centner of raw cotton was for discrete irrigation of 100 and 200 metre-long furrows, the largest possible – for scheduled versions (156.9-117.4 cu.m and 170.6-93.5 cu.m). These indices for irrigation of 300 metre-long furrows made up 125.7-102.1 cu.m, for standard technology they were 172.0-136.3 cu.m. The discrete technology of cotton irrigation is cost-effective: conventionally the net profit from cotton irrigation of 100, 200 and 300 metre-long furrows was 12,279, 14,982 and 11,256 sum per hectare respectively.

## **7.4 Drainage and Subirrigation**

Since about 52% of irrigable lands in the RU are to this or that degree salinized, they use a great quantity of river water to remove harmful salts against drainage. For land reclamation they have built collector-and-drainage network extending hundreds of kilometres. Drainage is necessary to avert secondary salinization even in places of deep occurrence of subsoil waters. Utilization of natural resources, especially of soils and water, needs methods and approaches capable of averting degradation.

Land reclamation needs to be correctly done. Irrigation and drainage are to be differentiated taking into account soil-and-climatic conditions and agricultural crops cultivated.

Deep drainage in many regions is not duly substantiated. It is wanted where soils are much salinized and subsoil waters are of moderate and high mineralization. Maintenance of the level of moderately mineralized subsoil waters at the depth of 3-5 and more metres is not economically expedient. Such a depth raises many objections as regards ecological and soil degrading aspects. Drainage should be looked upon both as a method of diverting surplus waters

and as a means providing for favourable growth and productivity of crops cultivated. Moderately mineralized subsoil waters in rooting layers cut down the ratio of irrigation and land working.

Results of investigation of the Fergana Valley territory and the data of the oblast water management institutions indicate that drainage and subsoil waters in the territory of Fergana, Namangan and Andizhan oblasts contain some quantity of salt.

These data are indicative of the fact that it is possible to make use of subirrigation on these lands aiming to conserve river waters, economize fuel and lubricants and protect the environment. To materialize the objective it is necessary to lift artificially the level of moderately mineralized subsoil waters by making a coffer-dam in the collector-and-drainage network.

Experiments on subirrigation have shown that the present way of farming enables the level of subsoil waters to rise to the depth of 1.3-1.5 metres from the soil surface. This gives both moisture and feeding to the plants. The irrigation ratio of river waters and row-width soil cultivation during the vegetation period diminish about twofold. Erosion processes diminish as well. Pollution of collector-and-drainage networks, irrigation canals and reservoirs discontinues. Productivity of crops cultivated is on the rise. The environment is kept clean.

Lands liable to subirrigation are practically found in all oblasts of the RU. It is important to keep an eye on the processes taking place in the soil and on the state of land reclamation to be able to define how soon after subirrigation the soil will need leaching to be done. This is a way to prevent degradation of agrolandscapes.

## **8. Proposals on Rational Use of Water Resources**

### **8.1 Recommendations Relating to the Water Resources Management**

Problems of inefficient utilization and ecological safety of water resources are largely the result of an imperfect mechanism of the Republic's water resources management: structural subdivisions concerned with water management are out of tune in their work, some subdivisions do not get full or timely information. For instance, the State Committee for Environmental Protection of the RU has no data available on the Chadaksai mine, the place where it dumps industrial waste, the latter's influence on the environment. The Committee's excuse is that the territorial inspectors have no right of entry to the establishment.

Failure to realize in full the relationship between development, control, use and treatment of water resources may create situations not any less complicated and critical from the viewpoint of ecological, economic and social security. According to experts as from 1995 the Ministry of Agriculture and Water Management keeps no statistical accounts 2TP on utilization of water resources for financial difficulties.

Also, latterly the Kyrgyz party does not present data on yearly precipitation and snow reserves which impedes prognostication of the Syr Darya water availability and hence distribution of water in the republic. This means that for three years running the republic has not made a thorough analysis and monitoring of the state and prospects for water resources utilization. This fact is fraught not only with ecological, but economic and social consequences. The role played by the government needs to be changed. The fundamental principle here is that management at the lowest possible level is effective in any given situation. At the same time this principle presupposes decentralized approach to control over water, involving institutes of power which could be concerned with water problems and be able to ascertain priorities, political trends, objectives and, where it is possible, to command standards.

### **8.2 Particularization of Power Relating to Water Resources Use**

The following needs to be done in the sphere of interstate relations on water resources use:

- to deepen the regional integration by setting up a regional alliance in Central Asia; as regards Kyrgyzstan the alliance must be based on strictly fixed conditions of functioning;
- for optimal solution to the problem of deepening the integration processes between our states it is expedient to establish close economic contacts at the level of local authorities;
- assistance to and state support of financial-and-industrial groups to be established with terms precisely defined.

**In the sphere of effective use of water resources:**

- to raise the productivity of the present land reserves liable to irrigation;
- to diminish losses of water resources in all the economic spheres by introducing water conservation technologies;



- to change sectorial structure of the economy by transferring it to little water extensive and waterless technologies of production;
- to plan the development and rational use of water resources in a complex including ecological, economic and social factors based on the principle of stability.

#### **In the sphere of water resources protection, water quality and ecosystems:**

- uninterrupted monitoring providing reliable, complete and accurate data on the quality of both internal and transborder basin waters, promotion of international cooperation of the states on the territory of the basin in the sphere of monitoring. Cooperation should be based on estimates on the basin scale, regular provision of the necessary data, first and foremost, by states of the transborder basin, institutes and general public;
- taking measures for development and utilization of new facilities and methods of evaluation and prognostication of not high cost, measurements in field conditions, continuous automatic monitoring, as well as promotion of international cooperation in this sphere;
- adoption of relevant legislative acts reinforcing economic mechanisms of protection and rational use of water resources, preventing transborder pollution of water; assistance to regional agreements to this effect;
- elaboration of strategy for ecologically stable control over water resources and ecosystems.

#### **In the sphere of state control over water resources:**

- definition of priorities in the sphere of state management of water resources in the republic;
- state support and further development of legislations and institutional mechanisms providing operation of the water management complex, for coordinated management of water resources aimed to ensure stable development;
- state support and promotion of international organizations and structures, regulating interstate relationships regarding joint utilization of water and power resources in the RU, aimed to harmonize the policy, strategies and programs related to water.

Abundant atmospheric precipitations of 1996-1998 have considerably increased water run-offs down the Syr Darya and Amu Darya rivers to the Aral Sea (up to 30-33 cu.km) and stabilized the sea level at the mark 37.0 m. With some years of little water coming, the water flow to the Aral Sea will be sharply decreasing and reach the limits of 8-10 cu.km and lower. To make up for the flow shortage it is advisable to divert the collector-and-drainage discharge from both banks of the Amu Darya (around 15-16 cu.km) and the Syr Darya to the Aral Sea instead of to Arsanai.

Implementation of this measure would result in ecologically pure water ( it becomes drinkable, irrigation water gets demineralized). But the country's leadership has not analyzed this proposition since 1990.

## Proposals:

- to begin forest reclamation work on the dry bed of the Aral Sea and to create protective, reclamation-fodder and soil protecting planting. To restore, if possible, rush thickets in the delta for the animal kingdom by feeding them on subsoil water of close range bedding;
- the irrigation area of Uzbekistan is 4 million hectare, over 2 million hectare of which needs reclamation. In the current situation in the region they ought to stop entirely the development of new lands for irrigable crop-growing;
- they apply lift irrigation for over 30% of the Republic's lands. Owing to transition to a market-oriented economy lift irrigation of lands for agricultural crops costs more than gravity flow irrigation. If they use an average of 13,000-14,000 cu.m of water per hectare at present, then with the introduction of the penalty systems, fixation of prices of water use and application of up-to-date technology this usual rate may go down to the minimum (4,000-5,000 cu.m/hectare);
- water resources of the Aral Sea are common property. To get water for irrigation they erect kyarizs, chighizs, sardobs, watering wells in desert localities (along the Great Silk Road).

Unpractical attitude to water management, a low technical level of utilization of unique water-development projects and hydroamelioration systems, general deterioration of the water quality have brought about an ecological crisis in the region.

Rational, expedient and economical utilization of water resources in Central Asia will, evidently, lead to a confederation of states. It will be necessary to set up a high independent scientific and technical council composed of competent specialists. The council could solve global republican and interrepublican problems, the urgent ones of which are:

- an increase in water-carrying capacity of the Syr Darya river up to 1,800-2,000 cu.m/s or more downstream from the Chardarya hydro scheme in order to limit the water flow to the Arsanai depression where it simply gets evaporated. The Chardarya hydro scheme, which has a hydroelectric plant of 100 thousand kW, passes 1,850 cu.m/s, while that of Arsanai up to 2,100 cu.m/s of flood waters to the Syr Darya river. This arrangement of hydro schemes 30 years earlier at Chardarya reservoir was brought about by high cost of protective measures against flooding the Central Asian railway in the area of Kazanzyak and Chiili channels. Downstream from the Kzyl Orda dam, for silting reasons, the river could not pass more than 1,500 cu.m/s of water discharged from the reservoir before the freshet in March 1969. Renovation of the river-bed capacity with the help of drawing operations would restore life in the lower reaches and delta of the Syr Darya and would stabilize the volume and level of water in the Arsanai river. Simultaneously part of the Arsanai flow could be diverted through the Amu Darya left bank collector to the Aral Sea.

It is necessary to amend the general basis of rational and complex use of water resources of the Aral basin: to speed up the construction of the Ragun reservoir on the Vakhsh river where it is possible to have extra 5 cu.km of irrigation water through the perennial regulation of the flow.

Taking into account the limited quantity of heat power resources and large reserves of hydropower resources in the region which are at present used only by 10-12%, in order to provide the economy with guaranteed water resources it will be necessary to envisage extension of the

single hydropower system of Central Asia and implementation of hydropower projects with flow regulating capacities under mutually beneficial conditions without any decrease in power generation and agricultural output in 5 republics.

One of the investor's certificates describes a device having a shape of a huge "pot". The device is made as follows. First they dig a pit of 10 cu.m in capacity. Then it is filled up with fertile fine-grained earth. In conditions of Central Asia they can use loess-like loam enriched with organic and mineral fertilizers. It is advisable to add some quantity of fertile soil containing useful microflora. The whole mass is to be slightly tamped and levelled with the field surface.

Then they arrange a 10-12 cm thick layer of stones over the pit to serve as a heat removing shield. The shield is designed to intercept the sun energy and to reflect it in the form of infrared radiation. Thus the heat does not get into the "pot". But then, inside the device there is a process of moisture condensation taking place, new amounts of moisture keep coming from the heated air.

In the centre of the stone circle they plant fruit trees. In his experiments N.Lukin has ascertained that the sun heat is intercepted most effectively by a layer of 1-10 cm pebbles. About 150-200 condensers of this kind are laid out on every hectare of land. With minimum cost the barren stony waste land turns into a highly productive orchard, which does not need any canal to be taken to or water brought in tanks.

Materialization of N.Lukin's ideas would give a possibility of intensive development of dry-farming lands at the altitude of 3,000 metres above the sea level. Besides, it is possible to expand considerably the area of irrigated lands through increasing the resources of irrigation and elaboration of techniques of its more practical use. These are not simply technical solutions. They are of great social importance for the Republic as they enable thousands of people to get jobs.

Of interest is a unique project of hydraulic engineer I.Druzhinin which was approved of by the international ecological congress in Almaty, the Interstate Council on the Aral Sea problems and the International Foundation on the Aral rescue.

I.Druzhinin suggests creating a ramified network of underground kyarizs (drainage galleries or adits) and restore the dying sea owing to subsoil waters. This can be done within a year. Complete purification of the Aral Sea from chemicals will take 6-7 years. The project's cost is \$350 million. The classical country of kyarizs is Iran which has the same natural and climatic conditions as Turkmenia where they plan to make use of the Kara Kum subsoil waters. First water will be supplied to the Sarakamysh depression, then, by gravity flow, down the ancient channel to the Amu Darya and the Aral Sea. However, authorities of the coastal states lost the hope to save the sea and have started dividing its remains into the sectors of "theirs". They have begun to erect dams, dividing the Aral into "Uzbekistan" and "Kazakhstan" sectors. The construction is being funded by the international American foundation "Ecology" and the administration head of Kzyl Orda oblast. But calculations made by the experts are indicative of the fact that no dam shall save the "Aral Minor". This is confirmed by the sad experience of dams construction on the Caspian and the Gulf of Finland.

### **8.3 Optimization Model of the River Basin Water Allocation**

The optimization model of water allocation in the river basin consists of 3 assemblies: data base of the geographical information system, optimization module and module of the model layout.

The GIS data base has the following shells: division of the territory into districts by climatic conditions, hydromodular division, soil fertility, geographical web including major assemblies of the irrigation and collector-and-drainage network, deposits of subsoil waters and geofiltration diagrams of the basin under consideration. The model design contains methods of water resources management: regulation of water run-off in reservoirs, reallocation of water within the irrigable tract along the available allocation system; utilization of subsoil reservoirs for water resources regulation, recurrent use of collector-and-drainage waters. Controlled unproductive water losses comprise surface discharge from irrigated fields, infiltration losses from irrigation lands and filtration from the irrigation system, evaporation from the level of mineralized soil waters.

For every unit of the system claiming for water they calculate the water-and-salt balance of the zone aeration and the water-saturated zone of top fine-grained earth where the flow moves vertically. The above said constructions have additional restrictions on water storage in reservoirs, sanitary drawdowns along channels, water quality in the river on lower dam locations and the river water-carrying capacity and water-development works. A feature of particular importance for such models is consideration of the dynamic state of the system, i.e. a possible change in the meliorative state of lands, quality of water on surface and subsoil channels. The mission of the water allocation model consists in optimum allocation of the basin water resources for minimization of the effect resulting from water use considering the ecological state and aversion of water resources exhaustion. They give an expert evaluation at the module preparation stage and offer methods of management and purpose of utilization.

### **8.4 Complex Restructuring of Irrigation Lands**

The current water management situation in the basin of the rivers Amu Darya and Syr Darya is rather critical due to ununiformity between the available water resources, annual volumes of water diversions and requirements of environmental protection. Especially grave were the consequences of this disparity observed in the Pre Aral zone: sharp deterioration of the land reclamation state, expansion of deserts, degradation of ecological systems and other unfavourable phenomena.

The current situation makes it necessary to reconsider the earlier-developed approaches to the problem of irrigable farming. First and foremost it is necessary to ascertain all the reserves of an irrigated hectare, regulate the water management, switch over to water conservation technologies, guarantee the effectualness of nature protecting measures. Simultaneously water conservation is provided for by introducing the most up-to-date technology of irrigation.

A problem of the water management, difficult and contradictory: the ever increasing shortage of water resources in the RU on the one hand and availability of great volumes of discharge waters on the other. They are caused by losses in the irrigation network and in the fields on account of low technological level of the system, operational drawbacks and unpractical

use of water by consumers.

Therefore the water management institutions are forced to take care, first and foremost, of providing the necessary quantity of water supply, meet the demands of water users, take back return water the greater part of which is reused. At present there is an evident tendency to increase the volumes of recurrent utilization of drainage-waste waters, since it is the simplest way of having additional resources of water. But in recent years this brought about an increase in the areas of irrigated lands with obvious secondary salinization observed.

Measures aimed at reducing the losses of irrigation water were considered separately for arterial and interfarm canals, intrafarm irrigation network and irrigation technology. This made it possible to determine entities of more efficient capital investment.

Complex restructuring of intrafarm systems is considered to be the most efficient. Implementation of restructuring will ensure: water conservation; increase in the agricultural produce; growth of useful irrigable area.

Problems of water use in the Central Asian region owing to objective reasons are directly tied up with problems of generation and distribution of electric power. This presupposes the necessity of brief evaluation of a complex utilization of water and power resources as the problems are posed and solved.

## **9. Current Trends in the Operation of Hydroelectric Plants under Regional Conditions in Uzbekistan**

Production of electrical power at hydroelectric plants (HEP) in the republic is directly connected with water content available in the rivers. The proportion of the electrical power produced by HEP in the total volume of the primary power output has been cut from 3.8 % to 3.2 %.

In the near decade Uzbekistan is planning to build and run 141 small-scale hydroelectric plants (SHEP) within the framework of the Ministry of Agriculture and Water Management (MAWM) with the total output of 1170 MW. The efficiency of the SHEP construction at irrigation projects rises due to available facilities of pressure front (dams, spillway works, water conduits). This allows a 4 to 6-fold cut of unit capital investments in 1 kW of the rated power of SHEP compared to arranging such hydroelectric plants at new sites.

One of the factors hindering the development of hydropower engineering is the high cost of power-generating equipment manufactured in Kharkov, Saint-Petersburg and Syzran). The problem is being solved via joint ventures arranged on the basis of the existing facilities of industrial works in Uzbekistan including those in the town of Talimarjan which are engaged in the repair of such equipment for pumping plants. The aim of the cooperation is to manufacture certain parts and units for power-generating equipment and further to build multipurpose modular units in the Republic.

New more efficient units are under construction at the Novo-Angrensk and Talimarjan state district power plants. The remodeling of turbines in the power-generating units at the Syrdarya state regional power plant will make possible to raise the generating capacities of the plant and to achieve saving of around 10 % of fuel.

### **9.1 Toktogul Hydraulic System**

1. Toktogul Hydraulic System (THS) on the Naryn river is an integrated irrigation and power-generating project. Its construction started in 1962. Temporary operation began in 1974 with the uncompleted dam and first 954 million m<sup>3</sup> water in the dead storage (DS). As the beginning of the DS filling coincided with a disastrously dry year, the whole time of subsequent operation of THS can be split into 3 stages:

First – The mode of operation not stipulated in the project. This kind of operation could not provide for proper yield of water and for the economic effect under the project.

Second – The period of conventionally normal operation of THS because the water stages in the reservoir were higher than the dead storage (LDS), but did not reach the designed full supply level (DFSL). Due to breaking the design in the irrigation and power applications (overrated planning of the HEP output exceeding by 20 % the output recommended in the start-up period) the hydraulic system operated with lowered water and power yield. This is the reason of extending the time of primary filling of the THS reservoir up to DFSL for 15 years instead of 3-5 years as planned.

Third – This is a stage in progress though with a reserve (the total capacity of 5 basic water reservoirs in the Syrdaria river basins – THS, Kairakum, Chardaria, Charvak and Andijan appeared to be filled only by 89 % instead of full volumes – up to 32). It can be considered normal. The primary filling of the reservoir has been completed.

However, the economic effect of the project cannot yet be achieved because of delayed rearrangement of GMS in the basin. The extraordinary situation in the beginning of the THS operation, extreme hydrologic and water management conditions, every possible deviations from the design norms as well as the unique nature of the project itself gave rise to the development of special methods and specific analysis.

The productive effect of the flow controlled by the reservoir is evaluated by the gain in the guaranteed water yield as compared to the maximum deficit-free yield of an uncontrolled waterway. The economic effect is evaluated by extra production and respective profit due to water use in water industries. For irrigation it is calculated through the aggregate product of agriculture and its intensification, and therefore gross production yield is also considered in these calculations. In the calculations the most difficult is to evaluate the volume of the irrigation water supplied because it cannot be measured directly. It can only be calculated via a water balance.

**Table 3**  
**THS Share in the Total Industry Income**

Stage and measure	Aggregate gross product, M roubles	Net income (M roubles). Aggregate through the industry	Net income (M roubles). Share of THS
Stage 1 (1974-1979)	548	327	19.6
Stage 2 (1979-1987)	5,914.0	3,528.4	211.7
Stage 3 – 8 years (from 4 <sup>th</sup> quarter of 1987)	1,400	6,120	367.2
Total	16,862.0	9,975.4	598.5
Average for 21 year	803	475	28.5
The same for the last period	1,300	765	45.9

The analysis of the calculations allows to state that the economic effect of the irrigation control of the flow in the Toktogul reservoir averaged for 21 year is at least 28.5 million roubles/year while the estimated values for the near future taking into consideration that the THS itself is at the stage of normal operation can equal approximately 50 million roubles (prices of 1984).

## **9.2 Uzbekistan Power System Operating in Parallel with Power Systems of Other CIS States**

Uzbekistan power system operates within the Central Asian Energy Pool (CA EP) including power systems of the Kyrgyz Republic, Republic of Tajikistan, Turkmenistan and southern regions of the Republic of Kazakhstan.

CA EP has been arranged in order to provide reliable power supply for the region taking into consideration the rational use of the resources available in the region.

The formation of CA EP has been completed in 1980s. By that time the required infrastructure has been set up comprising sources of electric power and a network of high-voltage power lines of 220 –500 kV with nodal and distribution substations. In the same period of time the work was aimed at joining CA EP to the parallel operation of the Energy Pool of the former Soviet Union. For this purpose it was planned to build a number of power lines of 500-1150 kV in Kazakhstan allowing to exchange the power up to 2,000 MW between North Kazakhstan and CA EP. This work has not been completed before the collapse of the Soviet Union and actually stopped in 1990s.

With the transfer of the power industry of Central Asian states to the market relations, the parallel operation of CA EP, power systems of North Kazakhstan and Energy Pool of Russia becomes a matter of topical concern because it will allow to expand the market of electric power due to the users in Russia and other states of CIS. Parallel operation of CA EP and Energy Pool of Russia can be provided when fulfilling a number of requirements:

- In CA EP and in Kazakhstan the main power line network of 220-500 kV has to be included into the transit routing. Apart from this, to ensure the parallel operation in CA EP, Kazakhstan and Russia requires the remodeling of failure control automatic systems and frequency and energy transfer control facilities.
- In 1997 the first stage of design work has been done that determined the structure of failure control automatic systems (PAU) for integration in future. To implement the PAU structure requires the completion of the next stage of the design work. This stage includes making of working drawings for modification or remodeling of the failure control automatic systems at substations of Shymkent and other projects in North Kazakhstan (Republic of Kazakhstan), at substations of Frunzenskaya, Golovnaya, Bystrovka, Karabolta (Kyrgyz Republic), at the Tashkent GRES and Syrdarya GRES (Republic of Uzbekistan). Without this work the parallel operation will be ineffective. Implementation of the project will make possible for the Uzbekistan power system to enter the market of electric power not only in the states of Central Asia but as well in other states of the CIS. In addition, this facilitates entering the markets of foreign countries, China among them.

Tentative cost of the remodeling of failure control automatic systems is estimated as USD 5,177 thousand including the projects in Uzbekistan – USD 54,000, in Kazakhstan – USD 4,256,000, in Kyrgyzstan – USD 518,000 and in Russia – USD 349,000. Implementation of the project will allow to exchange the power of around 600 MW between CA EP and power systems of Northern Kazakhstan.

Further increase in energy transfer anticipates construction of new power network entities in Kazakhstan requiring considerable investments.



Parallel operation of the Uzbekistan power system within CA EP will allow to raise the reliability of power supply due to change-over with other power systems and to reduce the required power reserves in the power system.

Apart from this, implementation of the project could be a serious factor in rational distribution of water resources taking with regard for actual demands of water and power users in the region.

Programmes of rational water use at national levels require to raise the efficiency of cooperation in water and power use at an interregional level.

## 10. Economy, Ecology and Water Resources of Central Asia

Within the territory of Central Asia (basins of the rivers of Amudarya, Syrdarya, Shu, Talas), the Eastern Pamirs, Tien Shan and cutoff areas of Turkmenistan there are 5.5 thousand lakes with the total area of 14.5 thousand km<sup>2</sup>. Most of the lakes are situated in the middle reaches of the Syrdarya river basin and in the middle and lower reaches of the Amudarya river. The biggest lake system – the Arnasai – comprises the lakes of East Arnasai, Tuzkan and Aidar. The origin of these lakes is connected with the beginning of intensive development of the new irrigation area in the Golodnaya Steppe and construction of main collectors. The major changes in the lake regimes occurred when about 21 km<sup>3</sup> of the Syrdarya water were evacuated from the Chardarya reservoir into the Arnasai.

The water resources are used by Central Asian Republics, Afghanistan and Iran. The territory of the region considered occupies 1,279 km<sup>2</sup>. With regard to water services the Aral Sea basin is divided into 11 irrigation areas including those in the basin of the Syrdarya-3 and Amudarya-8.

Prior to 1960s the economies of the Central Asian states were developing without disturbance of ecosystems. The dynamics of water content available in the rivers, water transfer into the Aral Sea and water consumptive use by the republics is shown in Tables 4 and 2.

By late 1970s completely exhausted the volume of water resources ensuring the retention of the Aral Sea at the absolute level of 53 m; while by 1995 water use by economic entities exceeded the volume that could preserve the sea at the absolute level of 40 m.

**Table 4**  
**Dynamics of Average Long-Term Water Storage in the Aral Sea Basin and Transfer of This Water into the Aral and Pre Aral Zones (km<sup>3</sup>/year)**

Period	Average long-term water storage being formed	Volume of water feeding into the Aral and Pre Aral zones	Water diversion for economic needs
1911-1961	113.2	55-56	58.2
1961-1970	113.6	43.3	70.2
1971-1980	107.7	16.7	91.1
1981-1985	108.2	2.0	106.2
1986-1990	110.12	9.6	100.5
1991	114	16.5	97.5
1992		33.5	
1993		39.76	

**Table 5**  
**Dynamics of Water Use in the Aral Sea Basin Split among the Republics (km<sup>3</sup>/year)**

Republic	Water resources of 50-percent supply for natural flow	1940	1960	Water diversion from rivers 1985	1990	1990 to 1960	1990 to the year of 50 % supply
Uzbekistan	60.3	26..2	30.78	60.62	63.60	32.82	3.30
Kyrgyzstan	5.1	4.8	5.21	9.3	5.46	0.25	0.35
Tajikistan	12.23	7.3	10.2	12.9	13.9	3.7	1.67
Turkmenistan	25.17	6.2	8.1	24.7	24.35	16.35	0.82
South Kazakhstan	10.99	7.8	9.75	10.1	11.32	1.57	0.33
	113.7	52.3	63.89	117.07	118.63	54.6	4.93

Starting with 1986 a period of higher water content available in the rivers began. The republics made arrangements to increase the limit of water discharge into the Aral. From 1986 to 1990 in average up to 10 km<sup>3</sup> per year have been discharged while in 1991-1993 up to 30 km<sup>3</sup> have been fed into the Aral and Pre Aral zones. In recent years due to discharge of considerable amounts of return flows for reuse into rivers, the quality of surface and underground water degraded. In a number of areas in the middle and lower reaches of major rivers water is unsuitable for drinking purposes without special treatment and even for irrigation and other technical purposes without special engineering work.

Current water facilities in the Aral Sea basin is a multipurpose industrial branch with fixed assets estimated in 1990 as equaling 28 billion dollars. The amount of water resources in Central Asia estimated as the total volume of the river flows coming out of the mountains is approximately 150 m<sup>3</sup>/year. Water is used for irrigation of 7.4 million hectares including 4 million ha in the Amudarya basin and 3.4 million ha in the Syrdarya basin, which makes possible to produce every year from 7 to 7.5 million tons raw cotton, about 1 million tons vegetable oil, about 6 mln tons vegetables and potatoes, about 3 million. tons fruit, berries, grapes and other food products.

The freight turnover of the inland water transportation is insignificant (around 100 million tons). Lake and pond fishery is developed. Water diversion for irrigation ranges depending on water content through the year from 89 (P = 90 %) to 102 km<sup>3</sup> (P = 50 %). Percentage of water distribution among the republics does not vary much: Uzbekistan – 55.8 to 57.3 %, Tajikistan – 11.9 to 12 %, Kyrgyzstan – 44.4 to 5.0 %, Turkmenistan – 17.8 to 24.7 %, South Kazakhstan – 10.5 to 10.8 %.

Water resources of the Aral Sea basin are distributed by the Interstate Coordination Water Commission (ICWC) subordinating Basin Water Associations (BWA) of the Amu Darya and Syr Darya. The ICWC is under the executive committee of the Interstate Counsel formed by the leaders of Central Asian states.

**Table 6**  
**Structure of Water Intake by Central Asian Republics and Industries (1990) (km<sup>3</sup>/year)**

Republic	Total	Industry	Utilities	Agriculture, total	Including irrigation	Fishery
Uzbekistan	63.6 100	1.3 2.0	2.4 3.8	58.88 92.6	58.16 91.4	1.08 1.7
Kyrgyzstan	4.36 100	0.07 1.6	0.098 2.2	4.18 95.9	4.1 94.0	0.01 0.01
Tajikistan	13.9 100	0.6 4.3	0.5 3.6	12.45 89.6	11.76 84.6	- -
Turkmenistan	24.35 100	0.06 0.2	0.12 0.5	24.05 98.8	24.0 98.6	0.11 0.48
South Kazakhstan	11.3 100	0.38 3.5	0.24 2.3	10.48 92.7	10.14 89.7	0.15 1.4
Aral Sea Basin	117.5 1 100	2.41 2.1	3.36 2.86	110.05 93.6	108.16 92.1	1.35 1.15

That time the policy-making authorities of the former USSR have made a decision to recharge water resources in the region by transfer of a portion of Siberian rivers flows. In accord with this decision the planning bodies of the former USSR in the period of 1961 to 1980 have made investments into the development of the irrigation crop farming in the region at the expense of cutting water feeding into the Aral Sea. By early 1980s this water storage has been actually depleted as well.

In 1986, with no regard for the interests of the states in the region and for the water situation actually formed, a decision has been adopted to suspend the development and other work for recharging water resources in the Aral Sea basin from of a portion of Siberian river flows.

At the same time the world science and practice have gained sufficient experience for establishing intrabasin and interbasin systems of river flows transfer for the needs of irrigation, hydropower industry, navigation and water supply. Multipurpose systems have also been known.

**Table 7**  
**Transfer of River Flows in Some Countries (km<sup>3</sup>)**  
**(Data by I.A.Shiklomanov, and O.L.Markova)**

Country	Year							2000-2020 (future projects)	
	1900	1920	1940	1960	1970	1980	1985	Min. option	Max. Option
Canada	7	7	10	14	25	90	140	260	700
USA	-	2	20	26	27	27	30	150	250
Ex- USSR	-	-	8	10	25	47	60	100	220
India	15	15	18	18	22	37	50	130	310
China	No data					(10)	(10)	30	40

I.A. Shiklomanov and O.L.Markova present data characterizing 61 operating system of flow transfer. The same data show that the volumes of river flows transferred have increased significantly in different countries in 1960-1985. The dynamics of increase in river flows transfer in some countries is given in Table 7.

By present time in the countries of the world on the whole the volume of river flows transfer have increased up to 400 km<sup>3</sup>/year and by 2000-2020 its increase up to 800-1200 km<sup>3</sup>/year is anticipated. However most of the project operating currently relate only to national program. Meanwhile world practice indicates that there is urgent need in carrying out joint study of this problem and concept development of projects of interstate integrated use of a portion of free flows of full-water rivers. Thus, NAVAPA project (1964, USA) stipulates to transfer a portion of river flows from the Alaska region to a distance of over 8 thousand km. The volume would be from 100 to 300 km<sup>3</sup>/year and cost approximately \$ 100 billion. This would envisage water supply for seven provinces of Canada, 33 states of the USA and three states of Mexico. The project included the development of 370 integrated hydraulic systems including construction of one dam 520 m high and six dams 450 high as well as a central water distribution reservoir with the capacity of 600 km<sup>3</sup>. The system envisaged building of more than 150 thousand km irrigation, diversion and navigation canals, about 3 thousand km tunnels, 20 big pumping stations etc.

An alternative project of NAVAPA (1959, USA) envisaged to build an estuary at a part of the James Bay. That would provide decrease in the water salinity due to the flows of incoming rivers with the volume of 360 km<sup>3</sup> for long-term control. Water for southern regions had to be supplied from the above reservoir through existing river systems.

In accord with the agreement between Pakistan and India (1960) over 40 km<sup>3</sup>/year (taking into account flood flow) of water from big eastern tributories of the Indus – Satledj, Bhias, Ravi – were transferred to be used in India (prior to 1947 14.8 km<sup>3</sup>/year of these rivers flows were used by Pakistan). In exchange Pakistan got the right to use the water of western rivers – Indus, Djelam and Chinab. For the years of independence in Pakistan a number of dams have been built on the Indus and its tributories that provided control of flow in water reservoirs, as well as barrages to improve water diversion and big irrigation systems of Pakistan and India.

Of big interest are the schemes of national water network and Big Water String developed in India and providing for solution of major water problems in India and Bangladesh.

Taking into consideration recent years of low water the government of South Africa started to implement the project developed as early as in 1930. This project envisaged to transfer a portion of flow of the Zambezi river from Zimbabwe with the water rise by 1300 m with regard for the interests of Botswana.

Tables 7-10 show the characteristics of a number of operating and future projects providing for transfer of river flows in Canada, USA and India.

**Table 8**  
**Existing and Under-Construction Transfer Systems for River Flows in Canada**  
**(Data by I.A. Shiklomanov and O.L. Markova)**

Province (project title)	Water source	Water recipient	Volume transferred km <sup>3</sup> /year	Main purpose	Date of transfer beginning
Manitoba (Churchill)	Churchill river	Nelson river	24.0	Hydraulic power	1976
Ontario	Otoki river	Lake Nipigon	3.6	Hydraulic power	1943
Ontario (Weland- canal)	Lake Erie	Lake Ontario	7.0	Hydraulic power, navigation	1829
Quebec (James-Bay)	Eastmane river	La-Grand river	25.2	Hydraulic power	1980
Quebec (James-Bay)	Kaniapisco river	La-Grand river	24.6	Hydraulic power	1983

**Table 9**  
**USA Internal Water Flow Transfer Projects**  
**(Data by I.A. Shiklomanov and O.L. Markova)**

Project title	Water source	Region (river basin)	Volume transferred, km <sup>3</sup> /year	Length of transfer route, km
Hudson Plan	r. Mississippi and Arkansas	South-Western states	42.0	1,800
Beck Plan	r. Missouri	Six Middle- West states of US	12	1,000
Texas Water Plan	r. Missouri and rivers of	Western Texas, New-		

	eastern Texas	Mexico	14-20	1,700-2,500
Submerged Pipeline	r. Columbia mouth	South of California	15	1,800
Submerged river-bank aqueduct	Mouths of r. Columbia and Rog	South of California	13	1,000

**Table 10**  
**Operating and Under-Construction Systems for River Flows in India**  
**(Data by I.A.Shiklomanov and O.L.Markova)**

Project	Water source (river)	Water recipient (state) from river basin	Volume transferred, km <sup>3</sup> /Year	Start of transfer (state of readiness)	Route length km	Main purpose	Area irrigated, M ha
Canal Ganges	r. Ind	Rajsthan	3.0	1927	914	Irrigation	0.3
Radjasthan canal system	rr. Bias, Ravi, Bhandra (r. Indus)	Rajasthan, Haryana	2.0	Under construction since 1960; readiness 50 %	470 1,400	Irrigation	1.8
Ramghangha	Ramghangha (r. Ganges)	System of canals Ganges, Delhi	4.7	Completed	200	Irrigation, water supply	0.56
Sarda	Ghara	Plain part of Ganges	15	Completed	260	Irrigation	1.2
High-head canal Narmada	r. Narmada	Gujarat	13.0	Under construction	1,000	Irrigation	1.44

In Central Asia with the present level of irrigation efficiency water resources are used almost fully. This is an adverse factor for further social and economic development of the region. Geographical distribution of water demands is in inverse proportion to the distribution of water resources: overwhelming majority of water use refers to the area of flow dissipation.

Yearly diagram of water demands also drastically differs for mountainous and plain areas of the region. Mountainous areas possess significant hydropower resources. A part of hydraulic resources is used without decrease in the volume of the resources. In this case the demands in

power production are much high in cold seasons. On the other part the major and a consumptive user of water is irrigation, with sharp increase in the water demand during warm seasons. A portion of water running through irrigation systems is returned to rivers and therefore used for several times. This markedly deteriorates the quality of water since it becomes saturated with salts and pesticides available in soil. And this, in its turn, has an adverse impact on the health of people who use water in the lower reaches of the rivers.

In some areas with insufficient drainage secondary salinization and underflooding of soils occur leading to big losses in land resources. Water diversion for irrigation permanently increasing over last decades caused the biggest in the world ecological catastrophe connected with the Aral Sea condition: drastic and stable lowering of water level, increase in water salinity, full loss of fish productivity and considerable decrease in the living conditions and health of people.

Giant redistribution of water within the region because of irrigation causes the same big transportation of salts washed-out from soils and deposited in the lower parts of the area of flow dissipation, including natural and anthropogenic reservoirs. Decrease in river flows in the area of flow dissipation due to diversion for irrigation, draining of riverside bushes, river deltas and Aral Sea bottom, coming out of regenerated water to the ground surface and other processes connected with water use for irrigation, - all this cause great and often adverse changes in landscapes.

To solve a number big economic and political problems for interstate cooperation, certain work is being carried out including: use of water resources; water quality assurance control; integrated use of water and land resources; degradation of the Aral Sea; adverse impact of water economy on natural and agricultural landscapes and their components including soils.

In the use of water one of the most serious problems is the development of agreed rules and procedures of water resources distribution among the states. This requires to taking into consideration not only of the interests of all countries but also maintaining of ecological balance in the basins of rivers and lakes. The problem cannot be solved at once and on the whole for the region (if only the decision is not made to leave the rules valid at present). It has to be solved for every river basin covering several nations with understanding of the need to manage the basin as an integrated entity and with regard for the interests of both “upper” and “lower” countries.

There are no general rules of water division in international river basins adopted for the whole world. For every basin these problems must be solved individually depending on historic and current circumstances, especially flow formation in the basin area, demands and interests of “upper” and “lower” countries, actually adopted water distribution among the states, regard for the issues of water quality, ecology and many other factors. In water availability per capita (around 3,000 m<sup>3</sup>/year) the region is poorly supplied. However many countries with irrigation farming as the most important sector of economy situated within the Asian and African arid belt possess still less water amount per capita. It is accepted that 500 m<sup>3</sup> water per capita per year is a limit defined by water resources for stable development. It means that under intensification of water economy water reserves are still quite considerable and this field of interstate cooperation can be very fruitful.



One more top priority problem at a regional level is water quality. Towards the lower reaches of rivers the content of salts and pesticides in water increases. As a result river water in the lower reaches of the Syrdarya and Amudarya are not suitable for drinking purposes. River water in the area of flow dissipation also contains a lot of various pathogenic bacteria. Water from mines and tailing dumps, including water of increased radioactivity, deteriorate water quality. The number of diseases connected with the use of water including children's diseases and deaths is extremely high. These indices are much higher than should be for the countries of Central Asia characterized by a relatively high level of education and economic development.

Interstate cooperation in water quality management is of top priority. Water quality could be an important criterion in working out international regulations for apportionment of water as already adopted in a number of international river basins.

A regional level problem of no less importance is integrated use of water and land resources of the region. On the whole in the region land resources suitable for irrigation exceed the available water resources. This raises the task of optimization in using lands of different quality with the existing restrictions for water. The problem of the Aral Sea degradation is to the same extent the problem of the Amudarya and Syrdarya basins, and the Sea management is primarily provided via the activities in the river basins, i. e. by joint efforts of all countries of the region.

Water resources from interrepublican waterways of Syrdarya and Amudarya are distributed in compliance with the decision of the Interstate Coordination Water Commission relating to the limits of water diversion. The industries experiencing urgent need in water include: land irrigation, industrial production, water supply for population for drinking purposes and ecological activities. Of all water sources 85 % are spent for land irrigation. Land surface of Central Asia is in the arid area, that's why artificial irrigation is needed with washing of salinated lands.

In 1993 the leaders of five Central Asian states have signed an Agreement on joint activities aimed at solving the problem of the Aral Sea and Pre Aral zones, environmental improvement and provision of socio-economic development of this region. In order to integrate efforts to rehabilitate the basin of the Aral Sea, five countries of Central Asia: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, - have undertaken to implement a long-term programme for the Aral Sea basin development. This programme includes 7 special subprogrammes and its target is to develop the general strategy of water apportionment and to work out on its basis interstate legislative and normative documents, to ensure rehabilitation of areas of disaster, supply of good drinking water for the population, improvement of sanitary and epidemiological situation, stabilization and improvement of the environment management and harmonic socio-economic development of the region.

In 1993 the International Fund of Aral Sea has been established with its branches in all countries-founders. The basic objective of the Fund is formation of financial resources due to the attraction of the resources of the founders, international organizations and donor-countries to finance programmes and projects for ecological improvement of the Aral Sea basin.

In 1993 the UN General Assembly has established the Intergovernmental Commission to develop an International Convention for Desertification signed in Paris in October 1994. The

countries of Central Asia which territories are in the arid area have entered the Convention and commenced to develop their programmes.

To implement the agreements signed in 1993 in Almaty for integrated information space for CIS and other neighboring Asian countries, the following has been suggested:

- With the aid of international organizations to set up a united Central Asian information center for collection, analysis and synthesis of the total bulk of information on water resources at the regional level and a reliable system of information transfer to the users of different levels.
- The newly established service jointly with the Hidromet services of the republics of Central Asia will develop a unified set of methods and methodology for forming a bank of information on water resources at regional and national levels and for preparing and issuing information massifs for users of different levels.
- Under transition to the market economy and state independence, sufficiently clear have appeared the differences in the interests of the republics regarding the regimes of using the river flows in the Aral Sea basin. The states situated in the area of formation of the main river flows (Tajikistan and Kyrgyzstan) not possessing fuel and power resources have already defined top-priority state programmes stipulating the development of their hydropower potential. The states situated in the middle and lower river flows (Uzbekistan, Turkmenistan and Kazakhstan) have interest in the regime of using river flows for irrigation and discharges, to preserve the Aral Sea.

Starting with 1994, to solve the problems of the Aral region, Central Asian countries have allotted USD 37,753.5 million received from different sources of financing. Since that time in the Pre Aral zones there have been commissioned hospitals for 4,320 beds and water and gas supply networks extending for 3,215 km and 7,448.8 km respectively. In 1997 Central Asian states have allotted and spent USD 1,067.5 mln to implement national programmes.

The problem of water in Central Asia is inseparably connected with the problem of hydropower because most of the water resources are formed in the territory of Kyrgyzstan and Tajikistan and regulated by the availability of hydropower plants

## 10.1 Power Resources of Central Asia

Potential power resources of the rivers in Central Asia (excluding Kazakhstan) are estimated as 56678 thousand kW with the production of 396 billion kWh of electrical power per year. The major water-power potential is concentrated in Tajikistan – 31,875 thousand kW, Kirghizstan – 14,900 thousand kW and Uzbekistan – 12,231 thousand kW.

The total capacity of all power plants in Central Asia is 28.3 million kW including hydraulic power plants – about 8.6 million kW. In 1990 189.8 billion kWh of electrical power have been produced including over 33.0 billion kWh produced by HPP. The rated capacity of hydraulic power plants provides for the output of 25 billion kWh of electrical power.

Kyrgyz Republic is referred to the countries with plenty power resources. It possesses 75 % of estimated reserves of coal and 30 % of potential reserves of hydraulic resources of Central Asia that equal 24.4 billion ton and 162.7 billion kWh per year respectively. The extracted reserves of oil and gas are insignificant and the level of their use is extremely low. This has led to the republic's power dependence on other regions.

Plenty water resources have become good prerequisites for rapid development of the republic's power complex that starting with 1980s has become a big producer of hydropower in Central Asia and up to 50 % of the electrical power produced were supplied to the Central Asian Energy Pool (CA EP). That time coal mining was kept at a high level of 4 million tons per year providing for the republic's demands in solid fuel by 40 %. Around 50 % of the coal mined were supplied to adjacent areas of neighboring republics of Central Asia. At the same time every year 2.8 million tons were brought to the north of the republic from Kazakhstan and Russia while the amount of oil products and gas reached 2.6 million tons.

Currently the Kyrgyz power system numbers 18 operating power plants with total rated capacity of 3.6 million kW including 16 hydropower plants and 2 thermal power plants. The share of HEP in the total rated capacity of generating sources makes up over 82 % or almost 3 million kW. Five big hydraulic power plants (Toktogul, Kurpasai, Tashkumyr, Shamaldysai and Uch-Kurgan) with the total capacity of 2.87 million kW are concentrated in the lower reaches of the Naryn river. Atbashy HEP with the capacity of 40 thousand kW is situated on the Atbashy river, a tributary of the Naryn. Ten other hydropower plants with the total capacity of 40 thousand kW are of diversion type and are placed on irrigation canals.

Deliveries of fuel have been sharply cut in 1992-1995 because of difficulties in interstate relationships and mutual settlements, adoption of national currencies, growing prices of oil, coal and gas and railroad transportation rates. All this radically affected the changes in the structure of fuel and power balance. At the same time fossil fuel mining in the republic was drastically cut and supply of thermal power decreased 2 times. As a result consumption of fossil fuel has fallen, and this led to the rise in the consumption of electrical power in 1991-1995 by 13 % despite the decrease in the output in industry, construction, agriculture and freight turnover in the transportation system of the republic. The rise in the electrical power consumption is caused by the fact that it is used by the population for heating, hot water supply etc because of high prices of coal, gas and oil products. Because of reduced deliveries of fossil fuel, production of electrical power at thermal power plants was cut from 4.4 billion kWh to 1.1 billion kWh (by 75 %) and electrical power transfer to CA EP – from 5.9 billion kWh (1989) to 1.3 billion kWh (1995) – by 78 %.

At the same period the structure of electrical power consumption has significantly changed in the republic when the share of consumption by industry decreased 1.5 times while that of the population increased 4 times. With the change in the structure of electrical power consumption the volume of electrical power consumption in autumn and winter seasons also changed. If in 1990-1991 the share of consumption in the 1<sup>st</sup> and 4<sup>th</sup> quarters was 53 % of the yearly amount, in 1995-1996 this figure reached 70 %. In autumn and winter seasons the power plants of the power system operate with the maximum load, practically without any reserve and only for their own users, they do not export electrical power. This trend of growing loads in winter will remain up to 2000, and to meet the demands with own sources of power is possible only due to priority development of generating capacities in the republic and reconstruction of existing networks of all classes of voltage, especially distributive. In 1994 and 1995 on the basis of earlier formed reserves two hydropower units, 80 MW each, have been commissioned at the Shamaldysai HPP.

Despite the uncompleted construction of two hydropower plants: Tashkumar and Shamaldysai and gap in the capacity, - these two power plants are actively involved in covering the daily schedule of the power system loads. Under shortage of fossil fuel for thermal power plants, to supply electrical power for the users in the republic the regime of operation of the Toktogul Cascade HPP has been changed since 1992, especially of the Toktogul reservoir being the main source of hydraulic power.

The analysis shows that if prior to 1991 the share of electrical power production at HPP was 60-65 % in average, in the period of 1992-1996 it increased up to 91 %. In the same period the amount of winter use of the reserves of the Toktogul reservoir for the needs of power industry rose from 0.3 billion m<sup>3</sup> to 5.7 billion m<sup>3</sup>. Intensive use of water reserves from the Toktogul reservoir in winter periods causes serious complications in the middle and lower reaches of the Syrdarya river. Resulting from one-sided solution in Kyrgyzstan of more intensive use of the Toktogul reservoir in the power regime, water inflow into the Aral Sea decreased by 3.4 km<sup>3</sup>.

If this regime of operation is kept under low-water conditions, the efficient capacity of the Toktogul reservoir will be depleted fully within two autumn and winter seasons. Following that both the Toktogul HPP and all hydropower plants of the Nizhne-Naryn Cascade would cut the available capacity and the output almost by two times and this would cause serious consequences in the Central Asian Energy Pool. Apart from this water users in the basin of the Syrdarya river would lose a source of safe water supply, especially in dry years. Because of the low water in the Naryn river basin in 1995-1996 and use of 65 % of the efficient capacity from the Toktogul reservoir, a real threat arose that the remaining reserves of water would be lost in the forthcoming autumn-winter period. To prevent complete depletion of this reservoir is one of the top-priority tasks both for the needs of power industry and irrigation. In order to abate the arisen contradictions in the use of water of the Toktogul reservoir, in 1995-1996 there were concluded interstate agreements between the Republic of Kazakhstan, Kyrgyz Republic and Republic of Uzbekistan stipulating mutual supplies of electrical power, natural gas, coal and water.

To achieve the optimum use of power from Nizhne-Naryn Cascade is possible due to commissioning new hydropower plants situated in the upper areas of the Toktogul reservoir. First of all this would be Kambartinsk hydropower plants, free of irrigation restrictions and intended for operation in the mode of seasonal power compensation of the power system, replenishing

decreased output of electrical power and average monthly capacity of the Nizhne-Naryn hydropower plants in winter seasons. In this case the Toktogul reservoir would operate as a counter-regulator of power consumption of Kambartinsk hydropower plants and to change those according to the irrigation schedule.

Kyrgyz Republic has good prospects for the development of hydropower construction. Only on the Naryn river, in addition to the operating cascade of 5 hydraulic power plants with the total rated capacity of 2,879 MW, seven more cascades could be built consisting of 33 hydropower plants with the total rated power of 6,450 MW with a yearly output of 22 billion kWh. This could provide for high flexibility and reliable reservation of power in the Central Asian Energy Pool and Kazakhstan.

In the republic there is a big building and erection administration of JSC Narynhydroenergostroi with all organizational and engineering structures that provide the fulfillment of all set of construction and mounting operations in building cascades of hydropower plants. To implement the development of hydropower construction in the republic this year intergovernmental agreements have been signed with RAO EEC of Russia and enterprises of Saint-Petersburg on the readiness for cooperation and deliveries of hydropower and hydromechanical equipment to build new HEP. Taking into consideration common interests in the use of fuel-power and water resources in the near future, it would be reasonable for the states concerned to take part on a share basis in the construction and joint funding of hydropower projects, and first of all Kambarty hydropower plants (the cost of K-1 – 627 million roubles, cost of K-2 – 157 million roubles in the prices of 1984).

Proceeding from the above it is suggested as follows. Development of water and power resources should be implemented through the construction of hydropower plants in the Naryn river basin. In order to provide safe power supply to all categories of users in the republic, these efforts have to be done with regard for the interests of other industries.

Among hydropower projects of utmost importance for effective development of power industry is Kambaraty HPP #1 with the reservoir of seasonal control of the Naryn river flow. Commissioning of this HPP would completely exclude discrepancies among the republics in the basin concerning the use of water and power resources. To achieve this, it would be reasonable: to work out and adopt at an interstate level an agreement between the countries concerned on joint construction of Kambaraty HPP #1; to work out an interstate effective structure of fuel and power balance taking into consideration mutual economically justified deliveries of electricity, gas, coal, oil products and water; to prepare justification of economic expediency and mutually beneficial interests of the state in the construction and joint funding of hydropower projects and first of all Kambaraty HPP; to develop the techniques and methods of sharing in the funding of the operation of fuel-power and water projects; prior to commissioning of Kambaraty HPP #1, in order to abate the discrepancies and provide for the efficient use of water resources of the Naryn river, the operation schedule of the Toktogul reservoir must be set up by interstate agreements taking into account interests of water and fuel-power complexes of the states involved and these agreements should stipulate appropriate mutual deliveries of fuel and power; in order to preserve the Toktogul hydraulic system as the basic regulator and compensator of water flow in the Syrdarya basin and a big power-generating source that provides not only production of power (energy) but also control of electricity frequency in the Central Asian Energy Pool.

Water and power regimes should not permit complete depletion of the reservoir. The volumes of possible depletion and accumulation of the reserves must be considered every year with regard for water content in the basin. To ensure reliability in power industry and irrigation, it is necessary to consider possibilities and conditions of reserving a portion of the effective capacity of the Toktogul reservoir. Provision of further safe operation and reliability of the biggest hydraulic facilities and power plants requires to consider possibilities and conditions of sharing the states interested in the reconstruction of these projects.

Kazakhstan experiences serious shortage of electrical power while Kyrgyzstan and Uzbekistan permanently suffer from seasonal deficit of electricity. In this connection, though there is certain dependence on exporting the lacking electricity from neighboring countries, all states are developing the plans of remodeling of the available equipment and of building new equipment for electrical power supply (facilities to generate and transfer electrical power). Kazakhstan and Kyrgyzstan, in particular, alongside with active privatization of electrical power industries, set up systems required for attraction of foreign investments in the power generation sector.

The scale of electricity supply facilities is fairly big in the three states. For instance, in 1996 the capacities of electricity generating facilities per capita in Kazakhstan have been 1.12 MW, in Kyrgyzstan – 0.76 MW and in Uzbekistan – 0.50 MW, while in Japan where economic level is higher by 1-2 orders the power-generating capacities are 1.86 MW. However the facilities available at present to supply electricity have been built not for the requirements of the states established following the collapse of the USSR, but for electricity supply of the former USSR. Therefore, “the boundaries of demand and supply of electrical power” do not necessary coincide with the borders of the states. For instance, the electricity transfer system in the former USSR consisted of numerous district systems of transfer and one of them – North Asian system of electrical power transfer – was serving North Kazakhstan and South Russia, while Central Asian system of electrical power transfer was completely serving South Kazakhstan, Kyrgyzstan and Uzbekistan. On the other part, the link between the North Asian and Central Asian systems of electrical power transfer was weak, and therefore the demand and supply of electricity between South and North Kazakhstan were divided into two portions and electricity supply through localities was limited.

When aiming only at the maximum efficiency of electricity demand and supply, it is necessary, in order to provide mutual turnover of electrical power among the states irrespective of their borders, to develop electricity supply and facilities construction in accord with established earlier “boundaries of electricity demand and supply”.

Interregional cooperation in the sector of electrical power has the meaning as follows: to provide balance in electricity sources; to ensure diversification of power sources; to raise stability in electricity supply; to provide on the whole more averaged options of load than with the loads through individual countries. As a result it provides for the increase in the amount of investments into the building of electricity supply facilities. Apart from this, it would permit to avoid worsening of foreign trade balance between the states. Every state possesses wealthy power resources and arranges electricity supply with the maximum use of its own resources. Namely, in Kazakhstan most of power plants are coal-operated, in Kyrgyzstan – they are hydropower plants and in Uzbekistan – they run on natural gas. The capacities of hydraulic, thermal and atomic power plants of these countries are given in table 11, as well as the sources of electrical power. When assuming that these systems of electricity supply are managed provided that they

are integrated as a result of cooperation of these countries, the water power would account for 20 % and thermal power – 80 %, this being actually beneficial with regard for control of demand and supply. One of approaches to electrical power sources control could be use of water resources of Kyrgyzstan as peak sources of electricity for Kazakhstan and Uzbekistan and vice versa to meet the basic demand of Kyrgyzstan with the thermal power of Kazakhstan and Uzbekistan. As fuel for thermal power coal, natural gas and oil would be used, this allowing to implement “power sources diversification” at full.

**Table 11**  
**Structure of Electrical Power Sources in Three States of Central Asia**  
 (Unit: GW)

	Kazakhstan		Kyrgyzstan		Uzbekistan		TOTAL	
Water power	2.2	11.9%	2.9	82.2%	1.4	12.6%	7.5	21.3%
Thermal power	16.2	87.7%	0.6	17.8%	9.8	87.4%	27.8	78.5%
Atomic power	0.1	0.4%	0.0	0.0%	0.0	0.0%	0.1	0.2%
<b>TOTAL</b>	<b>18.5</b>	<b>100.0%</b>	<b>3.6</b>	<b>100.0%</b>	<b>11.3</b>	<b>100.0%</b>	<b>35.4</b>	<b>100.0%</b>

Such a structure of electrical power sources and diversification of those would itself raise the stability in electricity supply. In addition, maximum use of the Central Asian system of electrical power transfer with a train-shape pattern would make possible, under regional cooperation, to ensure effective stability of electricity supply to South Kazakhstan, Uzbekistan and Kyrgyzstan.

Though the total scale of developing the electrical power sources on the basis of integration of supply of these sources for both regions would be less than with separate development of electrical power sources by the regions with different patterns of electricity demand, this could be suitable for Central Asia because of the difference in time. Apart from this, as Kazakhstan and Kyrgyzstan and Uzbekistan and Kyrgyzstan would mutually carry on export and import of electrical power, transactions of mutual repaiment deals are possible and this would allow to avoid deterioration of the foreign trade balance with maximum efficiency. In addition, taking into consideration the scales of electricity demand and supply of the three states, import of peak electrical power of Kazakhstan and Uzbekistan could be redeemed by the import of basic electrical power of Kyrgyzstan.

To achieve maximum efficiency requires working out of the plans of electrical power demand and supply and investment plans for the facilities unified for every state. It is also necessary to think thoroughly over the forms of electricity transactions between the states and as well over such problems as methods of pricing, methods of defining export and import prices, ways of export payments. In addition it is necessary to achieve agreement in the use of water resources and pricing concept.

## **10.2 Economic and Environmental Problems of Sustainable Development of the Central Asian Region**

Limited water resources do not allow to use a significant portion of the land resources potential. Therefore it is necessary to intensify and optimize the utilization of different types of lands with the available water restrictions. This requires joint efforts of the countries in the basins of Amudarya and Syrdarya rivers in order to overcome the ecological crisis and to search for the ways of stable development of the region.

In the decree of the Upper House Zhogorku Kenesh of the Parliament of Kyrgyz Republic “On Interstate Use of Water Resources of Kyrgyzstan by Uzbekistan, Kazakhstan and Tajikistan” (July 1997) it is stated that Kyrgyzstan possesses huge storages of fresh water and is one of the richest states of the world in these natural resources, however it does not use its rights in this sphere of economy. The total flow of water sources being formed in the territory of Kyrgyzstan amounts in average to about 51 billion cubic meters per year, and the republic itself uses only 20 % of this amount, while 80 % are consumed by neighboring countries – Uzbekistan, Kazakhstan and Tajikistan.

In the opinion of a number of deputies based on the Helsinki Convention of 1966 and 1992, all water within the territory of Kyrgyzstan is the property of the republic and any joint use of it with other countries is possible only on the basis of concluded agreements. In this connection the Assembly of People’s Representatives put forward to the government of Kyrgyzstan the issue of revising the interstate agreement signed on February 18, 1992 by five ministers of water management of the Central Asian states. Questionable appears to be the part of the text where “rivers (waterways) of Kyrgyzstan are by mistake called transborder and interstate”. The leadership of Kyrgyzstan insists on defining inner rivers and underground water of Kyrgyzstan as “transnational waterways” because they originate only within the territory of Kyrgyzstan.

1960s, 1970s and 1980s were the years of construction in the territory of Kyrgyzstan of interstate hydropower facilities of Toktogul, Kurpsai, Tashkumyr, Shaamaldy-Sai and Uch-Kurgan and interstate water reservoirs of Andijanskoie, Papanskoie, Karkidonskoie, Kasansaiskoie, Kirovskoie and Orto-Tokoiskoie. The total water capacity of these hydropower facilities is 22.9 m3 and only 7 % of these possessions of Kirghizstan are used by the republic itself. In the opinion of the leadership of Kirghizstan, the republic should be paid for the water resources.

However in the international practice of using transborder water resources of over 100 water basins there is no single example of paying for natural water resources in the run-of-river or jointly developed mode of operation. There are examples of paying for the transfer of a portion of a limit – both in the relationships between Turkey and Bulgaria with regard for the Laplata river, and between USA and Canada and even between separate states of the USA, or of payments for sharing the services relating to changes in the regulation and practices in international waters.

All these provisions are stipulated in the “Basic Provisions of the Regional Water Strategy” worked out by experts from all countries of the region and at the same time in three draft agreements. Water is really involved in the process of public production, but it itself is an element of the rotation in nature. Water can be taken from this rotation in limited amounts or can be redistributed in reservoirs, but on the whole, running through the territories of transborder states it has to meet age-old needs and at the same time to remain and an object of nature. If one



and the same water goes through Kyrgyzstan, Tajikistan and Uzbekistan, it cannot be an object of trade. Otherwise the countries of the region, basing on their sovereignty also will not permit to use rivers in their territories and will demand payment for transit or, what is more, for losses caused by this water during ineffective periods. Is the provision of the use of transborder water a violation of national sovereignty? In constitutions and laws on water it is said that “water resources of a country are all kinds of surface and underground water concentrated in water systems of the country”. But a special feature of transborder water is the fact that this water is not in a static stationary state, it moves running through the territories of one or another or even third state. This water can many times be used by every country if in doing so these countries do not change the amount, regime and quality of transborder waterways, and if they do change, then only by strict agreement with all other countries concerned. International water relationships stipulate to observe three basic principles: right of former use; right of equal and mutually beneficial use; and slogan “do not make harm”.

Prior to the construction of Toktogul and Andijan systems about 1.4 million hectares of lands were irrigated directly from the main river stream and from its basic tributaries. As a result of the integrated control of the flow by Toktogul, Andijan and Charvak, this area increased up to 1.8 million ha or by 400 thousand ha. There appeared a possibility not only to increase the irrigation area but at the same time to produce huge amounts of electricity – 12 billion kWh (if to transfer all the facilities to the power generating mode only), or 8 billion kWh if they operate in the same mode as earlier.

When these rivers are transferred to the power-generating mode the rights of water use would be violated and downstream countries would be deprived of 6 billion m<sup>3</sup> water for irrigation and this would decrease water availability in 1.8 mln ha lands by 35 %, or irrigation farming of other republics would experience direct loss of almost 360 million dollars and aggregate losses exceeding \$ 300 million, the total equaling around \$ 770 million. This directly contradicts to the right of “former use” and to the principle “do not make harm” because the harmful impact is caused not by the regulation regime, but by breaking the natural regime of waterways even with no regard for the planned regime.

On the other part, with the acceptance of the irrigation regime the power industry loses products worth 20 million dollars and 100-160 million dollars gross income at world prices. With current instability of financial and payment mechanisms an original solution could be setting up of an international finance body that would insure mutual compensations and deliveries of electricity, gas, coal and financial resources.

At the same time it requires a clear-cut detailed border and definition of the limits of transborder water management, on the one part(hand) and that of the national water, on the other part, as well of the share of transborder water resources. This is the aim of the development of the first stage of the Regional Water Strategy that would start in 1998 and of two agreements on the Amudarya and Syrdarya that have to be prepared within the framework of this strategy.

In the preparation of the first stage of “Basic Provisions of the Strategy” more than 150 representatives of all countries of the region took part. In the next two years the basic phase planned for implementation would include the activities of the countries at regional and national levels for a medium-term period primarily as a mechanism of stable relationships between water users of transborder water and for a long-term period – based on new construction work.

Over the years of independence the governments of Kazakhstan, Kyrgyzstan and Uzbekistan have signed agreements on efficient use of water and power resources of the Syrdarya river basin and on joint use of water and power resources of the Naryn-Syrdaria reservoir cascade in 1998". In accord with the agreements signed and in order to ensure agreed mode of operation of hydropower facilities and reservoirs of Naryn-Syrdaria cascade and to supply water for irrigation it has been resolved to coordinate every year and to make decisions on water draft, electricity generation and transfer and on compensation of power resources losses on an equivalent basis. The parties undertake not to carry out activities that could break the regime of water utilization and power resources supply or that would restrict the rights of other parties to get mutually agreed amounts of water, deliveries of power resources and transit of those through their territories.

In Kazakhstan within the framework of the programme of the Aral Sea basin "Clean Water and Health" the feasibility analysis of the project "Water Supply, Sanitation and Public Health" has been done. At the same time in the republic implementation of a pilot project has started envisaging water supply to populated localities of the Aralsk and Kazalinsk districts in the Kyzylorda province owing to the loan of USD 7 mln granted by IBRD.

In Kyrgyzstan there has been developed national programme "Drinking Water in 1997-2015". To implement this program the government has granted 252 million soms.

Meanwhile the development of the irrigated land fund in the Aral region actually stopped and big amounts of money are spent to operate water supply and water treatment systems in order to provide the population with good drinking water. However expenses for the region environment improvement grow every year.

Areas of irrigated lands to farm crops for food products keep decreasing despite considerable cut of the areas sown by cotton plants (from 3.3 million ha to 2 million ha). At present to provide one inhabitant of the region 0.10 ha of irrigated lands are used while by 2000 this figure will be cut to 0.08 ha.

These circumstances have determined the top-priority directions in the new strategy of socio-economic development and environment improvement in the Aral Sea basin. The directions include:

- to raise productivity of existing irrigated land fund;
- to cut non-productive losses of water resources in all spheres of economy and to improve the quality of this;
- to modify the structure of economy by branches of industry by transferring these low water consumptive and water-free processes;
- to search for extra sources of water both inside the region and in adjacent countries for possible joint use of a portion of river flows on a mutually beneficial basis.

In all directions purposive searches are being carried on. However it should be taken into consideration that the first three of them have technologically and economically justified limits and can cut the tension in the water economy only in the near 15 to 25 years at the cost of high financial expenses, means and resources.

### **10.3 Proposals for Rational Use of Water Resources in Central Asia. Economic Measures to Improve Water Use**

It is anticipated that rational water use requires to take the economic measures as follows:

1. To determine (at a national level) economically justified values and the order of fixing and collection of charges for the use of water resources including payments for the use of water resources for the needs of economy, payment for water services, payment for quality of the water supplied. Payments are required to get investments into water-saving and nature-conservation technologies and to set up mechanisms of motivating the employees to search for low-capital-consumptive ways of implementing the reserves of raising the water use efficiency.
2. To adopt economic sanctions relating to irrigators for breaking water supply duties and diversion limits.
3. To determine efficient principles and methods of mutual financial settlements between an operational water agency (OWA) and water users.
4. To determine principles and methods of arranging the self-supporting of OWA on their main activities. It is reasonable to use full self-supporting. At the initial stage ordinary and expanded reproduction of assets and labor and ordinary reproduction of working capital are carried out at the expense of the resources of OWA. Ordinary and expanded reproduction of basic production assets, and expanded reproduction of working capital of OWA is carried out through payments from the government budget.
5. To set up a system of insurance funds of OWA and to conduct insurance calculations. There are objective reasons of differences in the actual water availability in the sources of irrigation and in the planned one. These differences should not affect the results of economic activities of working teams of OWA. Under any conditions the cost-supporting balance of OWA has to meet the requirements of self-financing. It can be achieved with the aid of a financial reserve (insurance fund) of OWA.
6. To use an efficient method of compensation of water users' expenses for their payment for normative water use. There are three ways of compensation: to raise purchasing prices of crop farming products; to cut proportionally payments into the government budget from water users' income by the amount of payment for normative services of water supply and water diversion and from special-purpose state-budget funds.
7. To determine justified principles and procedure of fixing and use of limits of water use, water distribution among the states and within the states through territories and industries with regard for different water content available. For the industries of irrigated crop farming water has to be distributed on the basis of economically efficient norms of agricultural structures.
8. To determine the amount and procedure of fixing and payment of compensation to water users for income losses because of reducing by the government of the irrigation norms below the optimum of self-supporting running.

### **10.4 Measures to Raise Receptivity of Irrigated Farming to Water-Saving and Environment-Protection Activities**

1. To provide direct government-budget funding and crediting of water-saving and environment-protection activities under privileged conditions.
2. To set depreciation privileges for water-saving and nature-conservation technologies and facilities (policy of accelerated depreciation).

3. Setting up of joint-stock companies to carry on water-saving and environment-protection activities.
4. Leasing of water-saving and environment-protection technologies and facilities.
5. Establishing of tax privileges for water users implementing water-saving and environment-protection policy, such as investment allowance and investment deduction.

To carry out successfully special-purpose economic activities requires: to determine a list of top-priority water-saving and nature-conservation activities zoned/// by the conditions of application and ranking by economic indices; to determine the amounts of annual expenses and effects of the activities for the government and water users; to determine sources of funding for every activity.

Every country of the region has developed water programmes, and the problems of using these resources have to be solved on an integrated basis with regard for the interests of every party's concerns.

Pre Aral zone in Kazakhstan is declared an area of ecological disaster. Leaders of Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan and Kyrgyzstan have signed the Agreement for joint activities to solve the problems of the Aral Sea and Pre Aral zone, for the environment improvement and provision of socio-economic development of the Aral region.

In Kazakhstan, under the order of the government, worked out has been the draft concept of preservation, stabilization and rehabilitation of the Aral Sea and multipurpose projects of environment improvement of the Kazakhstani part of Pre Aral zone. In effect is the Law of the Republic of Kazakhstan "On social protection of the population suffered from the Aral catastrophe".

The problem of the Aral Sea had broad international repercussions. Due to this the 4<sup>th</sup> session meeting of the International Ecological Counsel has adopted the appeal to the UN Programme for Environment Protection (UNEP) with the request to render aid in the preparation of international conventions for the Aral Sea and Caspian Sea.

The top-priority nature-conservation rehabilitation activities in the area of disaster in Pre Aral zone include: to work out interstate water balance providing for conservation and in the years of high water – raise of the Aral Sea level; to increase water availability in the lower reaches of the Syrdarya river providing for the rehabilitation of the natural rural potential of the delta, bed clearance and building of artificial canals allowing to provide extra amounts of water coming into the delta and the Aral Sea; to supply the population of all localities with water for drinking and domestic purposes in compliance with sanitary and health standards; to introduce into the agricultural production high water-saving technologies and optimum selection of less irrigable crops; to treat drainage water of irrigation systems to the level permitting their reuse and discharge into the Aral Sea; to introduce the results of research and development work done in the Aral region for the improvement of the ecological situation.

In Tajikistan in connection with the growth of population water use is expected to increase 2-2.5 times. By the year of 2000 it can reach 3-4 million m<sup>3</sup> per day. At present, for the purpose of efficient use and protection of water resources, there has been worked out "Concept of Water Resources Protection by the Year of 2005" and "Programme of Multipurpose Use and Protection of Water Resources up to the Year of 2010". In addition worked out has been the long-

term programme of the development of water supply and sewerage facilities of the Republic of Tajikistan up to the year of 2000. In accord with this program the capacity of treatment facilities of towns and populated localities in the republic would increase from 1,199.2 thousand m<sup>3</sup>/day in 1988 to 1,333 thousand m<sup>3</sup>/day by 2000.

For long time the channels of the Syrdarya river were not used for water passing, they were sanded and silted. Therefore the attempts to pass into the sea big amounts of water in 1995 caused flooding of huge territories and arose the necessity to discharge them into the Aral depression. This caused protests on the part of Uzbekistan which territory was partially flooded as a result of these efforts. The states of Central Asia take measures for partial saving of the Aral. Kazakhstan is building a dike separating the Small Aral whereto the remaining unused water of the Syrdarya have to be discharged. Uzbekistan is performing work on arranging flooded hayfields and pastures in the delta of the Amudaria river whereto the unused river flows would be diverted. Sufficiently stable and efficient method of stabilizing saline lands of the drained sea bottom appeared washing of these lands with brackish water and further growing of salt-resistant plants. After two spring washings of soils carried out in Muinaksky and Rybatsky bays there successfully grew and vegetated valuable fodder plants and some crops.

For timely provision of seed material, preparatory work is being carried out to arrange in the coastal part of the Amudarya delta seed nurseries of draught- and salt-resistant plants and to arrange expeditions to collect the seeds of wild plants in Pre Aral zone in autumn months. With efficient efforts strengthening with vegetation of the southern part of the Aral could be completed by the years of 2000-2002. Such work could be done simultaneously in the northern part of the Aral. As estimated, this effort requires about 200 million soums. In making models of such favorable conditions for the growth and development of vegetation on high salinated soils of the drained sea bottom green cover is created consisting of various vital plants which are not only a shield protecting from dust and salt precipitation but also provide beneficial fodder base for animal farming.

In the Aral Sea basin from the time of the USSR for every republic limits of water diversion have been set. However these limits have been based on the area of the irrigated lands available in every republic. This base of determining the limits promotes the governments to increase the areas of irrigated lands, this still worsening the situation. Nobody is responsible for unobservance of the limits set, and though in water apportionment the Aral Sea is determined as a separate water user, it actually never got all the quota allocated to it. All extra water withdrawals by the states of the region are covered at the expense of the Aral. A stimulus to cut water consumptive use could become payments for it. In the region charges for water supply services have been introduced and collected by water organizations providing these services. These organizations of course find it advantageous to sell as much water as possible with no care that the water is diverted from natural sources.

The situation arisen in the basin of the Aral Sea is in much determined by the attitude of the users to water. In planning the consumptive use of water every state proceeds first of all from its own interests. Such a situation is reflected in the current structure of the bodies dealing with water resources management. All the most important decisions on apportionment of water among the states of the region are adopted by the Interstate Coordination Water Commission (ICWC) that includes the leaders of the departments responsible for observing water interests of the countries they represent. These decisions are implemented only through BVO "Syrdarya" and "Amudarya".

The Aral Fund set up in accord with these decisions is not also of great importance in financing the activities aimed at the stabilization of the ecological situation. The adopted mechanism of the Fund resources formation by allocation of one percent of the national income of every state-participant has proved inefficient. Under the existing situation the Aral Sea as a natural water body will inevitably die in the near future, and it will become a reservoir of collector-drainage and waste water.

Without modification in the regional system of water management the states of Central Asia will not be able to avoid negative ecological and political consequences. It is necessary to change the structure of water authorities by closing the existing ICWC and basin water associations (BWA) being under the Commission, to transfer all head intakes on the rivers of the region to the Committee for Water Protection (CWP) that has to be established on the basis of the existing executive committee of the Interstate Counsel on Aral Sea Problems, and the executive committee of CWP will carry on its activities under the Interstate Counsel.

At the meeting held in 1994 in Nukus the leaders of the Central Asian states with the participation of international organizations discussed global problems of the region on the whole. One of the problems is separation of the Aral Sea into two reservoirs by a dike. Due to this water of Syrdarya stopped coming into the western part of the sea while the eastern stage started rising. From time to time the Kairakum and Chardarya reservoirs become overfilled and big amounts of fresh water are wasted into the Arnasai depression. Water rises and some collectors become underflooded. This can harmfully affect the land reclamation in the Djizak and Syrdarya provinces.

In September 1995 the leaders of 5 states have passed the Nukus Declaration for the stable development of the Aral Sea basin. The Nukus Declaration of Central Asia states and international organizations raises the issue of urgent need to work out International Convention on the stable development of the Aral Sea basin in order to settle the problem of joint water use in the basin. This basic document has not been worked out till present time.

In 1996 on the initiative of the Directorate in cooperation with the World Bank worked out and implemented has been the Programme for Urgent Aid to the Population worth USD 2 million. Within the framework of this Program the epicenter of the Aral catastrophe has received 70 ambulance cars, 44 water carrying trucks, 5.2 thousand water treatment filters, 3.5 thousand sets of fishing nets, tools and equipment for children's and medical institutions, and material aid for the population of Uzbekistan and Kazakhstan amounting to USD 473.9 thousand

Special session of the UN General Assembly held in New-York in June 1997 has been devoted to cooperation aimed at solving problems of stable development and environmental protection in Central Asia.

In late February 1997 Presidents of five Central Asian States at the meeting in Almaty have noted that despite serious economic difficulties activities aimed at the improvement of the ecological situation in the Aral Sea Basin are being carried on. They have admitted that it is necessary to work out an integrated program of environmental safety including the Aral problem and adopted a decision that annual contribution to this fund would amount to 0.3 % of the budgets of every country. In the next five years World Bank will allocate investments amounting to USD 380 thousand to prevent ecological crisis in the region.

On February 28 1998 at the meeting in Almaty the leaders of five Central Asian states have declared the year of 1998 as the Year of Environmental Protection in Central Asia and approved the intensification of social purposefulness of the activities carried on in the Pre Aral zone attaching great importance to the elimination of poverty and provision of stable development in the region.

On March 26 1998 in Tashkent the leaders of Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan have confirmed their intention to carry on planned and agreed activities on environmental protection, elimination of consequences of natural calamities and disasters, improvement of ecological situation in the Aral Sea Basin and Pre Aral zone.

In 1998 in Tashkent there was held a meeting of the Board of the International Fund for Aral Sea. The participants of the meeting were Deputy Premiers of the Central Asian countries, representatives of UN and World Bank.

At the meeting they discussed the activities of the Fund and its branches in 1997 and the activities planned according to the programme in 1998. The other issues discussed were supply of the population with good drinking water and payment of fees by the states participating in the Fund.

In 1997 they have discussed the progress in the implementation of the Programme of specific activities adopted by the leaders of the Central Asian states in Nukus in 1994 and determined the priorities in implementing the Aral basin projects. In all states of Central Asia the Fund branches have been open. In course of negotiations with UN, UN specialized organizations, World Bank and various international structures and local enterprises definite results have been achieved in the formation of the Fund resources and in the analysis of ecological and epidemiological situation in the region.

In accord with the Fund agreement with the UN Programme for Development, the second phase of the project "Raising of the Aral Sea Basin Potential" has been approved in January 1998. The main goal of the project is to work out effective mechanisms for consolidation of interdepartment relationships to improve land and water use in the Aral basin.

In 1997 there were held negotiations with the Global Economic Fund (GEF), foundations of Sweden, Netherlands, Canada, European Commission and World Bank. The Washington Head-Quarters of the World Bank has discussed the GEF project of water resources and environment management in the Aral Sea basin. The value of this project exceeds USD 20 mln and it will start in summer 1998.

Environment protection practices in Pre Aral zones are being worked out by a number of research and development organizations including Research and Production Center "Ecology of Water" under the State Committee for Nature of the Republic of Uzbekistan. The project of UNESCO International Hydrologic Program is aimed at building of controlled low-water tandem reservoirs with dense bulrush in the deltas of the Amudarya and Syrdarya as well as on the dried bottom of the Aral Sea. Such a reservoir has appeared spontaneously in the southern Pre Aral zones on plain depression of former sea bay Zhylytyrbas. The total area of the floods in Zhylytyrbas is 40-45 ths. ha. The objective of the Center "Ecology of Water" is to arrange a system of low-water reservoirs with controlled regimes. River water would pass from top to down as a cascade. Every step of the cascade will have several artificial low-water ponds and floodings. Water stage

in upper reservoirs sited in deltas will be set at the mark of 56 m while the water areas of the lower ones will be at the level of 40-43 m. The area of such lands will be 350 thousand ha.

The advantages of the project: building of well-drained low-water and marsh systems will provide bulrush pasture lands and stocking up of fodder bulrush; water and marsh lands will improve the ecological situation in the region; low-water reservoirs will permit to expand fishing, fur farming, hunting; bulrush bushes could be a base of high-quality paper manufacture and building materials production in the Pre Aral zone; formation of additional vacancies. Implementation of the project requires investments of 769 million soums (in process of 1991) - up to 2010 and 20-22 cubic kilometers of water. Competent operation of the complex will provide repayment of the investments in 6-8 years.