4th WORLD WATER FORUM

Interstate Commission for Water Coordination of Central Asia (ICWC)

Global Water Partnership Central Asia and Caucasus (GWP CACENA)

IWRM as a Basis for Social and Economic Development in Central Asia

CONTENTS

WATER RESOURCES MANAGEMENT IN CENTRAL ASIA: FROM KIOTO TOWARDS MEXICO

V.A. Dukhovny, D.R. Ziganshina, A.G. Sorokin

Scientific-Information Center ICWC

Tashkent, Republic of Uzbekistan

The World Water Forum's session dedicated to Central Asian outlook represents a certain review and addresses outlook of future cooperation in the area of transboundary waters in the Aral Sea basin among the Governments of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Present report states the regional vision of joint water management by synthesizing challenges and priorities addressed in the national reports.

In recent years, joint activity of the states was expressed in many efforts that strengthened a common understanding and orientation of actions and, at the same time, ensured deep insight into the needs and ways of future development, building on both the national experience and the international water approaches and trends. Undoubtedly, the global aspects play a great role in this movement.

The unique regional cooperation is characterized by the fact that, despite practically similar initial economic level of the five newly established Central Asian states, they have begun to show considerable differences on political and economic approaches and on social and environmental development over 15 years. Continuing the common interstate management is undoubtedly a greatr challenge, but even the UN report 2005 "Bringing Down Barriers: Regional Cooperation for Human Development and Human Security" highlighted progress in this respect.

The positive results of cooperation in solving the issues of interstate water relations in the basin are recognized by the Central Asian states themselves. **The path traversed by the countries** regarding settlement of issues of joint water management is summarized as follows:

- On 18 February 1992, in Almaty an Agreement was signed between the Republic of Kazakhstan, the Republic of Kyrgyzstan, the Republic of Tajikistan, Turkmenistan, and the Republic of Uzbeki-

stan about cooperation in the area of joint management of water use and protection in the intestate sources. The Agreement was adopted by the Head of States in March 26, 1993 in Kzyl-Orda. With such Agreement, the parties decided to establish an Interstate Commission for Water Coordination (ICWC) with its executive bodies, such as Basin Water Organizations – BWO "Amudarya" and BWO "Syrdarya".

- Three consecutive meetings of the Heads of Central Asian States – in Kzyl-Orda in March 1993, in Nukus in January 1994, and in Tashauz in March 1995 – resulted in establishment of the International Fund for Saving the Aral Sea.
- In 11 January, 1994, in Nukus the Heads of Central Asian States made a decision to adopt the Program of Concrete Actions for environmental improvement in the Aral Sea basin over the next 3-5 years, as well as to approve the main provisions of a Concept for addressing problems of Aral, Priaralie and the Aral Sea basin in light of regional socio-economic development.
- In 20 September 1995, in Nukus the Heads of Central Asian States signed "The Nukus Declaration of Central Asian states and international organizations on sustainable development in the Aral Sea basin". With this Declaration, the Heads confirmed that they recognized the earlier signed and effective treaties, agreements and other regulatory acts regulating water relationships between them in the Aral Sea basin and took these documents for execution.
- In 17 March 1998, the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan signed Agreement about water and energy use in the Syrdarya river basin. Later, Tajikistan has signed the Agreement too.
- In 17 March 1998, the country-members of Central Asian economic cooperation concluded an Agreement on cooperation in environmental conservation and rational nature use.
- In 1999, agreement was signed on exchange of hydrometeorological information, as well as agreement on parallel operation of CA power systems.
- In 9 April 1999, in Ashgabad the Heads of States signed Agreement on the status of IFAS's agencies, by which values and rights of its agencies (ICWC, CSD, SIC, BWOs, etc.) were re-affirmed.
- In 6 October 2002, the Heads of States approved The Program of Concrete Actions on environmental and socio-economic improvement in the Aral Sea basin for 2003-2010 (ASBP-2).

Over the past period, cooperation between the CA countries in water management within the framework of ICWC allowed shaping of

methods, style and order of cooperation in water use and management in the Amudarya River and the Syrdarya River. To a certain degree, these approaches are unique in the world practice since even on bilateral basis, as we know from the experience of 250 transboundary river basins all over the world, there are very few examples of continuous work on planning, adjustment and actual water allocation rather than simply coordination and planning of actions and certain regulation. This is proved by positive **progress of local actions** made by the regional water institutions over the period passed since the Kyoto Forum:

- ICWC Training Center, as established under support of the Canadian International Development Agency (CIDA) and the McGill University, jointly with two BWOs developed both its activities in new directions (information technique, hydroecology, water and education, gender) and a network of its branches - in Osh, Urgench, Almaty - and training points in Andijan, Fergana, and Hojent. As a result, more than 1000 specialists of water institutions and water users were trained through this network in 2004…2005;
- Under support of the Swiss Agency for Development and Cooperation (SDC), an information portal and information system CAREWIB and CAWATER-Info were established and turned into a common tool of cooperation, credibility and enrichment between the CA countries in terms of information exchange on land and water resources;
- Stage II of the Project "Integrated Water Resources Management in the Fergana Valley" (IWRM-Fergana) was completed successfully. This project is a unique example of comprehensive implementation of IWRM covering all scopes of activity and all hierarchical levels and providing for radical improvement of productivity of water abstracted from the sources;
- Joint initiatives of the ICWC and the Global Water Partnership of CA and Caucasus were brought up to a quite new level promoting wider involvement of all stakeholders in activities of water-management institutions in all the countries. Thanks to this fact, implementation of the National IWRM Plan for Kazakhstan is under progress, and pre-project developments of similar plans are under way in Kyrgyzstan, Tajikistan, and Uzbekistan;
- Activities related to automation and implementation of SCADA system are widely developed both in the main structures of BWO "Syrdarya" and in the main canals that allow sharp reduction of unproductive losses and, at the same time, improvement of water distribution evenness;
- With support of the Asian Development Bank (ADB), we managed to open discussions on the regional water policy and undertake measures for improvement of effective interstate agreements on

transboundary water management in the Aral Sea basin and on capacity building of national and regional water institutions.

The successful fulfillment of these activities became possible in many respects owing to responsibility and purposefulness of the whole water management in the CA countries. This is reflected in their reports and publications prepared for the Fourth World Water Forum.

What is important in understanding of presentations prepared by the five leaders of water agencies in Central Asia?

Each of them is responsible for complex and multidimensional functioning of the sector in his respective country and, at the same time, as a representative of the respective country in ICWC, is responsible for joint water management in the basins of the two rivers – Amudarya and Syrdarya. Therefore, the reports of ICWC members reflect the sense of water as a tool of international relations and an element of national economic security.

They also reflect complete **recognition of the IWRM concept** as the most right way to regional survival under growing water shortage and a set of measures for rational water use at a national level. Pilot implementation of IWRM in the three irrigation systems in the Kyrgyz Republic, Tajikistan, and Uzbekistan (IWRM-Fergana project) has demonstrated efficiency and practicability of this approach, as well as its high effectiveness from the perspective of integrating efforts by water users and water-management institutions. Here, one should note the pioneer activity of the Kyrgyz Republic, as detailed in the report by Mr. J.B. Bekbolotov (ICWC member from Kyrgyzstan), related to the development and support of Water User Associations (WUA) on hydrographic basis but with greater support of the Government and, at the same time, for the first time in Central Asia, the organization of joint public and governmental management of canals using Aravan-Akbura canal as an example.

While pointing to achievements, ICWC members also highlight issues of their concern that call for the following actions:

- **Analysis of availability and use of all types of water, first of all, return and ground waters.** In the Syrdarya and Amudarya basins, which demonstrate great dependence on an amount and schedule of return water inflow, particular attention should be paid to management of transboundary return water, including their formation mode, dependence on water supply and other factors, salt and pollutant contents, and control over their releases and use. More than 51% of total return water is disposed via collectors to the rivers; about 33%, to depressions; and, only 16% of return water is reused in irrigation. Lower share of reuse is explained by pollution of the return water. Due to lack of the legal framework,

ICWC has not yet managed to control transboundary water quality.

- **Continuous reduction of unit water inputs, based on the fact that this figure is twice as high as that in advanced countries**. The specific character of the region and the ever growing water demand puts in the forefront a need for all-round shift to water saving and demand management, as well as for elaboration of general path towards water conservation. This is the only way of future regional development, which is the focus of reports by Mr. A.A. Nazirov (ICWC member from Tajikistan) in terms of food security and by Mr. T.A. Altyev (ICWC member from Turkmenistan) in terms of water resources use for future CA development.
- **Coordination of actions between all the countries regarding development, construction of new and reconstruction of existing infrastructures and joint reduction of total water withdrawal.** The recent two extremely humid years and three extremely dry years demonstrate the good example of work in this way, where intensive and harmonious efforts for coordination of actions and mutual assistance between the riparian countries both helped to avoid conflicts in management, allocation and use of water resources among the countries and, as a result of rational water use, led to reduction of total water withdrawal from 110 to 103 km^3 in the basin. In general, the improvement of management system at basin and interstate levels should inter alia include preparation and mandatory fulfillment by the countries of their obligations on joint financing of regional and basin measures, provision of hydrometeorological services, maintenance of catchment zones, joint management and protection of water resources, development of joint projects for compensation of costs regarding repair, maintenance and modernization of the structures of regional importance.
- **Alongside with implementation of IWRM, transfer to hydroecological management**. An importance of finding trade-offs between the economy and the environmental conservation is addressed in the report by Mr. Sh.R. Khamrayev (ICWC member from Uzbekistan). Some of riparian countries have already incorporated certain positions on ensuring balanced hydroecological management in their national legislations. Water Code of the Kyrgyz Republic makes provision for establishment of "minimum requirements to in-stream flows in order to save fish stock and aquatic ecosystems". Water Code of Kazakhstan envisages environmental releases to sustain natural state of water bodies. Undoubtedly, these are only the first steps that need to be further developed with wider stakeholder involvement. In this context, SIC ICWC has prepared a project proposal on "The integrated management of the Amudarya river delta with wider public in-

volvement and the biodiversity preservation", which envisages more wider participation of the public in rational use and management of regional water resources - from involvement of NGO, movements and parties with different baseline platforms in environmental improvement to provision of WUA, Basin Councils, etc. with wider powers. The general project objective is to develop feasibility study on establishment of a system of integrated hydroecological management in Amudarya delta.

- **Transition to river regime planning on the basis of specificity of water shortage or floods rather than based on normal year**. The consequences of floods and droughts are described in the report by Ryabtsev A.D. (ICWC member from Kazakhstan). Moreover, it should be noted that recent practices in the Syrdarya river showed that current regulation does not meet the downstream countries in low-water years and the upstream countries in normal years and poses a threat for all the riparian countries in high-water years. Therefore, we need to improve the mechanisms of basin management under extreme conditions: passing the floods of more than or close to 1% probability or the water discharge under low-water level with less than 75% probability (water allocation procedure, utilizing other types of water under water shortage, etc.). This work should be associated with activities concerning establishment of river regimes and water allocation on the basis of seasonal and over-year flow regulation.

The region has a potential to solve the above-mentioned problems. The **system analysis** conducted by SIC ICWC and based on alternative model research (using a set of models ASB-MM) of current situation in the region and probable future changes **proves that it is possible to coordinate needs of all water users in different, in terms of water availability, years** and gives positive answers to many issues.

Would it be advisable to solve water management in Syrdarya and Amudarya basins through strict measures fixing obligatory release volumes from Toktogul or Nurek reservoirs (including Rogun reservoir in the future) during growing and non-growing seasons? Whether such policy would lead or not to increasing risk of forced reservoir drawdown in low-water period (and to associated losses of electric energy generation) and to superfloods in autumn-winter period under high-water level? How would change the future flow regulation pattern by large reservoir facilities if we followed existing "rules" of management (developed for normal year) under conditions of low-water or high-water levels? Finally, how are important the irrigation releases from Toktogul and Nurek during growing season in high-water years when lateral inflow and water availability in the whole basin are substantial?

The computations were based on the assumption that before observed years, including extreme ones in terms of water availability, may occur in the future. Scenarios of extreme water availability - MIN - "low-water N-year period", MAX - "high-water N-year period" – were developed, and their exceedance probability was assessed for the observed period.

Table 1. Amount of natural water resources in the river basins as accumulated by 20-year periods – sampling of 5 and 95% flow probabilities from the observation series (1911…2005)

Basin, river	Years	Scenarios MIN and MAX	Flow probability, %	Mean flow for period, km^3/year
Syrdarya	1925-1944	Low-water 20-year period	95	22.1
	1952-1971	High-water 20-year period	5	26.8
Amudarya	1970-1989	Low-water 20-year period	95	63.6
	1951-1970	High-water 20-year period	5	69.5

For each of water availability scenarios, three future regional development scenarios (business as usual, national vision, optimistic) characterized by respective demands and return water amounts were run. Besides, reservoir and HEPS operation modes for the Syrdarya basin were assessed using 8 options. Among those options, the first five ones characterize probable alternative reservoir operation under current composition of structures, while the last three, for the future under putting into operation of new reservoirs and HEPS (Kambarata, Rezaksai, Tenkulsai, Arnasai, Koksarai).

Table 2. Syrdarya and Amudarya river runoffs as computed for water availability (MAX , MIN) and development scenarios, mean value for 2006-2025, (km^3/year)

Development scenarios per basin	MAX	MIN	Diff
Amudarya (Samanbai gauging station)			
1. National vision	7.51	6.04	1.47
2. Business as usual	8.24	6.96	1.28
3. Optimistic	11.47	9.08	2.39
Optimistic – National vision	3.96	3.04	
Syrdarya (Kazalinsk gauging station)			
1. National vision	3.98	2.91	1.07
2. Business as usual	5.27	4.02	1.25
3. Optimistic	7.22	4.96	2.26
Optimistic – National vision	3.24	2.05	

Thus, computation results from the mentioned SIC's research show the following for Toktogul waterworks facility:

- If hydrological situation occurs as in scenarios "low-water 10- or 20-years period" and under annual releases from the reservoir at 12 km3, forced drawdown takes place during 6…8 years, and if releases increase to 13.5 km^3, the period of reservoir's net storage drawdown would decrease to 3…4 years (see Fig. 1):
- If hydrological situation occurs as in scenarios "high-water 10- or 20-years period" under annual releases from the reservoir at 12 km3, the mean annual excess water amounts would be 1.2…1.4 km^3 that should be accumulated in the reservoir (this is not always possible) or additionally drawdown through reservoir releases of up to 13.5 km^3/year.

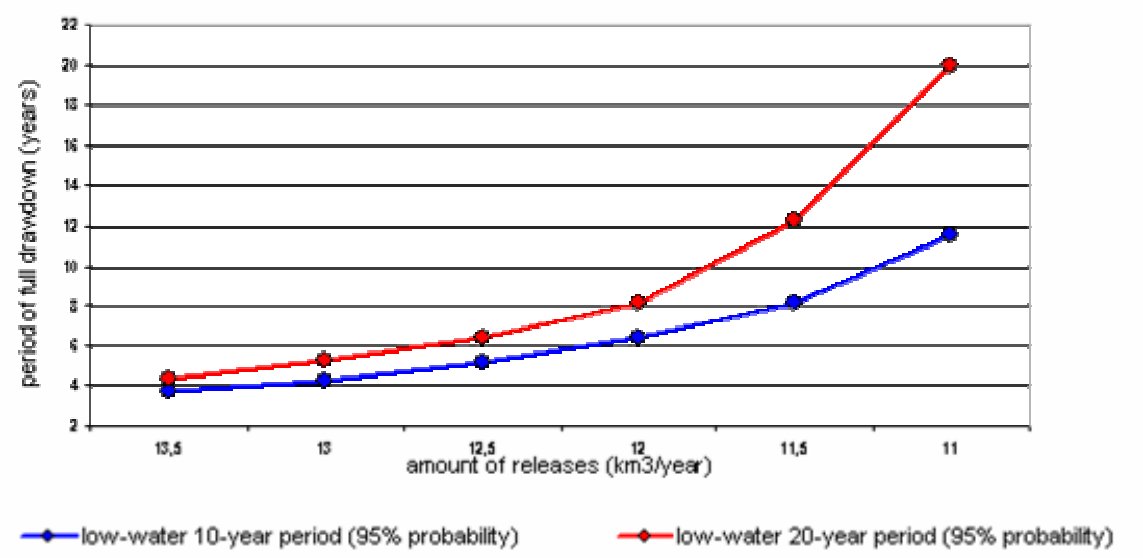

Fig. 1. Relationships between the full reservoir drawdown and the releases from Toktogul waterworks facility for low-water level periods (10 and 20 years)

Table 3. Assessment of the consequences from flow regulation in the Syrdarya river basin

Options	Irrigation deficit (km^3/year)				Electric energy deficit (billion kWh)	
	Uzbekistan		Kazakhstan		Kyrgyzstan	
	mean	max	mean	max	mean	max
Power (optimization)	1.17	2.12	0.53	1.29	0.05	0.85
Irrigation (optimization)	0.07	0.51	0.05	0.46	2.41	4.40
Irrigation-power (simulation)	0.19	0.77	0.12	0.62	1.94	2.50
Irrigation-power (optimization)	0.17	0.70	0.11	0.53	1.29	2.10
Irrigation-power (compensation)	0.17	0.70	0.11	0.53	0.05	0.85
Power + irrigation compensation	0.67	1.40	0.10	0.60	0.05	0.85
Power + Kambarata	0.80	1.82	0.40	0.96	0.00	0.00
Irrigation-power + Kambarata	0.00	0.00	0.00	0.00	0.00	0.00

Table 4. Evaluation of alternative operation modes of the Toktogul waterworks facility

Indicator	Power (optimi-zat.)	Irrigation (optimi-zat.)	Irrigation-power (simula-tion)	Irrigation-power (optimi-zat.)
Releases from Toktogul, km^3				
• growing season				
Maximum	4.5	8.5	7.5	8.5
Minimum	3.5	3.0	6.0	4.0
• non-growing sea-son				
Maximum	9.0	5.0	5.0	6.5
Minimum	7.0	2.0	4.5	4.5
Irrigation deficit				
• mean, km^3	1.7	0.12	0.31	0.28
• % of limit	6.0	0.4	1.1	0.9
Number of irregular years, %	80	15	35	30
Electric energy deficit				
• mean, billion kWh	0.05	2.41	1.94	1.29
• % of demand	0.5	25.6	20.6	13.7

The computations (see Tables 3-4) determined scope of search of rational modes limited by purely power generation or irrigation options (the first and second computation alternatives). Irrigation-power modes as computed at fixed releases (the third alternative which can be treated as "tough") and determined through optimization (the fourth alternative, which is more "liberal") fall into this scope. The fourth alternative was found as the best one since it showed the mean power deficit for Kyrgyzstan of about 1.3 billion kWh, which is ***0.9 billion kWh less than figure set in the Agreement for compensation (2.2 billion kWh)***. The fifth alternative replicates the fourth one but envisages also compensatory supplies to cover energy deficit.

The computations showed that the best option for the prospective structures is the last (eigth) one, which stipulates commissioning of Kambarata HEPS's ***provided that Toktogul waterworks facility***

operates in irrigation-power mode. If Toktogul operates in power-generation mode (the seventh alternative), the irrigation deficit will occur. This cannot be eliminated completely even under operation of irrigation compensators (sixth alternative).

Regulation by Toktogul reservoir according to purely power-generation scenario, which is aimed to full meeting of current electric energy demand in Kyrgyzstan without accounting of the over-year regulation specificities, ***should not be considered as beneficial for Kyrgyzstan itself*** let alone inadmissibility of such scenario for Uzbekistan and Kazakhstan.

The above-mentioned indicates that the region has a potential for ensuring equitable, wise and environmentally-sustainable water use and allocation. Moreover, **an international water-power consortium** may become an important element in strengthening the cooperation provided that it is established as a financial mechanism instead of substituting it for functions of other regional institutions, in particular ICWC. It is assumed that the consortium would be - a financial mechanism, which (a) solves problems related to lack of funds from the side of electric energy and fuel buyers for water compensation, and (b) guarantees timely making of payment; - an insurance institution covering probable damage, which is not caused by human activity.

The reports of ICWC members clearly define **the collective line of conduct** in form of:

- preparation of strategic planning plans at national level with account of the general regional policy and regional limitations;
- wide public participation of stakeholders in planning, financing and implementation of rational water use plans and making use of both their efforts and potentials;
- implementation of a program for water conservation and reduction of total withdrawal in the basin down to 90…93 km^3/year against current 103 km^3 so that to develop the environmental dimension of management.

The ICWC members recognize a need for further activities on water management improvement at both regional and national levels and plan specific measures in this direction. Particularly, they point to importance of **feasibility estimations and social studies** in order to have clear insight of benefits and losses. This may serve as one of real possible ways for approaching positions and establishing cooperation between the states in joint management of water and power resources in the Aral Sea basin.

As a whole, larger focus is planned on the **Amudarya river basin issues** in light of: (a) lower regulation and presence of huge flow

losses along the river channel; (b) relatively complex socio-economic conditions in downstream areas (Dashoguz province, Turkmenistan; Horezm province and Karakalpakstan, Uzbekistan), (c) presence of big transboundary water bodies and structures (Karshi main canal and Amu-Bukhara pumping canal, Tuyamuyun waterworks facility, interstate collectors, the Aral itself, etc.), (d) negative impact and deterioration of ecosystems in catchment area; (e) Afghanistan's interests as one of the riparian countries. Vagueness of channel losses in the Amudarya river basin becomes a reason of distrust and, the worst, calls the consistency of regional institutions in question.

In order to improve quality of decisions made by ICWC members, there are measures under way for **development of SCADA system and automation** of intake regulation on the basis of agreed quotas without human interference. This is particularly relevant for the Amudarya river basin.

From this perspective, an important task is to **intensify information support to the regional water management**, including for appropriate coordination of the data from national hydrometeorological services (NHMS) and the data from national water-management institutions and BWOs and for improvement of flow forecasting accuracy.

In general, for effective functioning it is necessary to **strengthen the base and develop capacities of regional institutions**. Unfortunately, some external institutions express preconceived opinion on inability to settle jointly the regional water management by IFAS and ICWC. This is illustrated by attitude of the World Bank to regional projects and by exemption of regional water cooperation issues from CIDA and other donors' programs.

In the meantime, given the multiple positive results of donor's activities, one cannot but note poor coordination of donors themselves in the region. SDC's attempts to organize appropriate coordination of donors have not yet been successful. Abrupt shifts in aid priorities turn into inconsistency and duplication of projects. Therefore, a **long-term strategy** is needed for both the external agencies providing assistance to the region and the national and regional water institutions.

Resting on the long-term strategy would allow smoothing over the destabilizing factors such as growth of population and water demand, environmental problems, climate change and its effect, more active position of Afghanistan, and intensifying the counteractions in form of development models, public conscience creation, strategic development plans, general regional projects, water use decrease, training, wider stakeholder involvement, etc.

At present, we need to develop a new legal framework and economic mechanism in the area of water relations. Effective legal mechanisms and rules for water management in the region should address inter

alia implementation of IWRM principles as a basis of management. The key points are integration into the law of the "polluter pays" principle and ecosystem approach to basin water management (minimum releases, sanitary and ecological releases, etc.), establishment of single water monitoring system, joint actions under emergencies, public involvement, notification and consultation procedures, access to and exchange of information among the riparian countries, etc.

Finally, ICWC members' reports can be summarized that any measures for water management in the region should be based on IWRM principles in order to achieve practical results, the major of which are as follows:

- achievement of stable water availability; uniform and equitable water allocation under substantial reduction of unproductive water losses;
- implementation of democratic water management principles through involvement of representatives of all players and sectors interested in water use and consecutive transfer of guidance to them at lower levels of water hierarchy and active participation of them and the government, on partnership basis, in system maintenance and development;
- settlement of some social problems associated with equitable, uniform and sustainable water supply to population and, first of all, this relates to drinking water supply;
- solution of environmental problems associated with water-management activities, including state of lands;
- as end objective, improvement of land and water productivities.

RISK (FLOOD AND DROUGHT) MANAGEMENT – CONSEQUENCES FOR THE DOWNSTREAM

A.D. Ryabtsev

Chairman,

State Committee on Water Resources,

Ministry of Agriculture, Republic of Kazakhstan

At present meeting dedicated to "Implementation of the integrate water resources management for common weal and future development in Central Asia" I would like to focus your attention both on current interstate relations in area of water use in the Syrdarya basin and on annual economic consequences for the downstream zone.

Currently one can literally say that water becomes a crucial tool in the international relations and one of the elements of national economic security. In this context, Kazakhstan is not the exception. National economic development per spatial-industrial system, province and city depends largely on water supply. This is particularly evident in the Syrdarya river basin, where Kyzyl-Orda and Southern Kazakhstan provinces are located.

Many participants know well about the problems related to sharing of this river and the difficulties faced by Kazakhstan recently. First, these are excess releases of water along the channel in winter period and water shortage in the growing season.

Large-scale construction of irrigation and drainage systems in Central Asian republics and in the south of Kazakhstan was started in 1966 after the Plenum of C.P.S.U. Central Committee where a program of large-scale land reclamation in USSR was adopted. According to this program, development of new hundred thousand hectares of irrigated land and construction of hydraulic structures such as reservoirs, river regulating and intake structures, pumping stations, etc. were planned every five years. Necessary fund were allocated to republican and Union's budgets.

In eighties, water use increased in irrigated agriculture since expansion of irrigated areas was maintained at the same rates. As population growth in this region was the highest among other republics in the Soviet Union, new facilities were implemented in industry and other economic sectors and, as a result, water consumption in non-

irrigation sector increased as well. Thus, in the Syrdarya river basin, consumptive water use in non-irrigation sector rose from 2.25 m^3 in 1985 to 2.50 m^3 in 1990.

Under such conditions, a need for regional management of water resources in Amudarya river and Syrdarya river became apparent in the second half of eighties. A decision on adoption of a new management plan was made in 1986 in order to ensure water resources management and strict observance of inter-republican water allocation that are free of local interference. Thus, in 1987, Basin Water Organizations (BWO) were established for the Amudarya river and the Syrdarya river. They became responsible for management of all headworks at these rivers and their main tributaries, with discharge in the structures of more than 10 m^3/s. BWOs controlled water resources according to rules and schedules agreed among the republics and approved by the Ministry of Water Resources of USSR. Hence, as early as in Soviet period, basic conditions were created for current mechanism of the interstate water management in the Aral Sea basin.

Water use in all economic sectors (especially for irrigation and power generation) was based on centralized control within the united country. Moreover, the former Government of USSR made compensations in form of fuel and electricity supplies to the Kyrgyz Republic.

The establishment of new independent states in Central Asia and the accompanied breach of former economic relations made mutual supplies of energy resources more problematic. Thus, national interests were added to already emerging regional problem, i.e. to the crisis of the Aral Sea and its coastal zone. Moreover, this was accompanied by breach of the coordinated operation of reservoirs in Naryn-Syrdarya cascade that was initially oriented to supply of irrigated lands.

Under such conditions Kyrgyzstan had to increase electric energy consumption due to lack of own fuel resources. Since major power generating facilities in Kyrgyzstan are based on hydropower of Naryn-Syrdarya basin, the country naturally started to use water accumulated in Toktogul reservoir. Thereby, operation of the reservoir shifted from irrigation to power generation mode. Now, power generation by Toktogul HEPS reaches maximum in winter when 6.0–8.5 km^3 of water are released from the reservoir, and to accumulate water releases are reduced to 4.5–6.5 km^3 during the growing season.

The specificity of the regional water sector is a multipurpose nature of water use. The main water consumer is irrigated agriculture, which uses more than 90% of the total usable amount. Along with irrigation, an equal component of water sector is hydropower; therefore, all major hydropower works in the Syrdarya basin are multipurpose. Hence, rational linkage of contradictory interests of irrigation and power gen-

eration related to different, in terms of season, demands for river flow forms the basis of basin water management.

The widespread contradiction in the Syrdarya basin is that most regional water resources are formed in upstream, where hydropower interests of water users prevail, and water is mainly used in winter, whereas downstream users need water for irrigation in summer.

The complexity of water management in the Syrdarya river refers to its interstate nature, The river has flown within the boundaries of one country, that is first Russian empire and then the Soviet Union for about 125 years. Since 1991, with the occurrence of new independent states, the Syrdarya river has been flowing through 4 states. Water quantity and quality crisis has been aggravated due to abrupt changes in political and economic conditions in the region.

Since 1995, in order to resolve the contradictions, the Interstate Agreements on Water and Energy Use in the Syrdarya river basin have been signed between the Republic of Kazakhstan, the Kygyz Republic, and the Republic of Uzbekistan. Those agreements fixed amounts of water releases from Toktogul reservoir during the growing season for irrigation purposes and set compensation supplies of energy resources (natural gas, electricity, black oil, coal) from Uzbekistan and Kazakhstan to Kyrgyzstan in autumn and winter in exchange for supplied excess of energy generated by HEPS from additional releases in summer.

Despite the Inter-governmental Agreements on rational use of water and energy resources, partial change of operation mode does not solve the problem in general. Without comprehensive approach, seasonal distribution of hydro-resources for energy and irrigation needs steadily leads to reduction of water storage in Toktogul reservoir. So, in 1995–1997, by the beginning of growing season 1998, water storage in the reservoir dropped to 7.2 billion m^3 and to 8.6 billion m^3 in 2001 (dead storage is 5.5 billion m^3). Only partial implementation of the agreements also contributed to the problem. In non-growing seasons 1999-2001, due to additional load on cascade's HEPS, amount of drawdawn of Toktogul reservoir increased by 2.7 billion m^3 and caused additional releases from Shardara reservoir to Arnasay depression. These facts prove a need both for observance of annual inter-governmental obligations and for shift to long-term regulation of Toktogul reservoir.

Since 2001, water availability in the Syrdarya river basin has been higher than the average annual one, and the last two years were high-water years. In November 2004, due to high inflow to Shardara reservoir amounting to 1400 m^3/s (similar to 2003), very tense situation occurred in river downstream related to water releases reaching 700 m^3/s. According to average annual data, releases from Shardara reservoir to downstream zone did not exceed 380-400 m^3/s dur-

ing freeze-up. Numerous negotiations with the Governments of Kyrgyz Republic, of Uzbekistan and Tajikistan regarding reduction of releases from the reservoirs of Naryn-Syrdarya cascade did not lead to desirable result. In order to prevent emergencies in downstream zones, the Government of Kazakhstan undertakes all possible measures and annually allocates funds for rehabilitation and repair of protection dams along the Syrdarya river in Kyzylorda province: 178 million tenghe in 2003; 200 million tenghe in 2004. Besides, in order to reduce flow, water has to be diverted by irrigation canals and old channels and exported to desert and non-populated areas. As a result, repair and rehabilitation was not undertaken for those canals. Moreover, excess winter flow caused water-logging of adjacent areas and, consequently, complicated timely fulfillment of spring-field works.

Despite a set of preventive measures for flood mitigation, the region has suffered huge damage. Settlements and irrigated land were waterlogged, hydraulic structures and road sections were destructed, residents were evacuated from the waterlogged area, and so on. The total damage over two provinces cost about 2 billion tenghe.

In order to prevent such emergencies in the future and avoid forced evacuation of water into Arnasai, as well as to improve environmental conditions in Priaralie, activities under the Project "Syrdarya River Training and the Northern Aral Sea Preservation", First Phase are being finished. The Committee for Water Resources at the Ministry of Agriculture in Kazakhstan has approved investments for the second project phase, which includes: second stage construction of the dam in the Northern Aral Sea to raise water level in the Small Sea up to 46.0 m; construction of hydropower plant within Aklak waterworks to generate annually up to 23 MW; rehabilitation and construction of check dams, 500 km long in total; Syrdarya river-channel straightening; repair-and-renewal operations in headwork of Kyzylorda Left-bank main canal; rehabilitation of Aksai-Kuvandarya lake system; construction of Raim waterworks facility; construction of two bridges across the Syrdarya river instead of existing pontoon bridges. Besides, it is planned to study water balance and develop simulation model of the Syrdarya river.

Another quite contrary problem having the same causes as that of excess winter releases is shortage of water for irrigation during the growing season. The problem of water supply in downstream area is multiplied during the series of extremely dry years, when Toktogul reservoir, under reduced inflow in summer and forced drawdawn in winter, loses its value as a long-term regulation reservoir. This case, its water storage is not enough to supply Syrdarya downstream zone with water.

The equally sensitive issue in the downstream zone and the delta system of the river could be construction of additional reservoirs by Uzbekistan to accumulate 2 billion m^3 of water.

Artificial shortage during the growing season because of reservoir operation in power-generation mode causes big limitations for irrigated agriculture. This implies non-observance of irrigation regimes, leads to drying up and under-irrigation of crops and, finally, to low yields.

In this context, the very important issue for Kazakhstan is water use in the Syrdarya river basin and sharing water with riparian states according to international water law and based on mutual respect, trust and constructive cooperation. Thus, the interstate water use in Central Asia should be based, first, on common international conventions and framework agreements since those, as a rule, are comprehensive and fix general obligations for all state-participants and, at the same time, limit the parties by setting the prohibited actions. Such conventions as "Convention on Protection and Use of Transboundary Waterways and International Lakes of 1992", "Convention on Non-Navigation Use of International Waterways of 1997" should form the basis for regulation of the interstate relations in area of water sharing in the region. Those international law norms set general principles of state's conduct in joint use of transboundary waters and are important for ensuring legal rights of water-user states.

It is necessary to note that Kazakhstan is the only Central Asian country, which ratified the Convention on Protection and Use of Transboundary Waterways in 23.10.2000. Recognition of the Convention by other Central Asian states should be viewed as one of the important steps in the system of interstate relations regulating water sharing. Later on this will allow us to elaborate a common approach to subjects of international law or to parties of agreement in Central Asia. Unfortunately, this step has not been yet made in the regional cooperation. It would be legally justified to follow general norms of the international law in area of joint water use and protection.

Water conservation, water allocation and transboundary water management should get institutional, legal, and financial provision both at interstate level and at national policy level in order to lead to successful regional development. A number of projects are being supported by the Republic of Kazakhstan through the Committee for Water Resources so that to increase the Syrdarya river capacities and improve ecosystems and land reclamation systems.

At the interstate level, we consider as necessary to:

- raise status of ICWC and BVO "Syrdarya", internationalize BVO composition and introduce rotation of its management board in the future;
- revise water balance in the Syrdarya basin based on current conditions, i. e. when Toktogul and Kairakkum reservoirs are operated in power-generation mode for different years, in terms of water availability;
- develop a mechanism of water allocation where water consumption is reduced proportionally in dry years;
- redouble efforts in development and approval of the Agreement on Establishment of Water-Power Consortium, which, through market mechanisms, could resolve contradictions between the main actors of water sector in the Syrdarya basin;
- develop basin water cadastre, general database on all water users so that to ensure transparency and general access to information in the basin;
- implement automation in large intake structures throughout the Syrdarya basin;
- establish central server and connect national water-management organizations to the regional Hydrometcenter established under IFAS;
- develop an optimal legal framework that would ensure liabilities of all parties in the inter-governmental agreements for observance of agreement;
- severe discipline of execution and absolute fulfillment of all interstate agreements; maintain stability in interstate relations.

PUBLIC PARTICIPATION IN WATER RESOURCES MANAGEMENT (IN TERMS OF WUAS IN KYRGYZSTAN)

J.B. Bekbolotov

Director General,

Department of Water Resources,

Ministry of Agriculture, Water Resources and Processing Industry,

Kyrgyz Republic

Present-day water resources management should be based on an integrated approach and participation of managerial agencies at different levels and from different sectors. Participation of users is necessary to establish realistic prices for water use and to implement water protection measures with maximum efficiency and effectiveness. The public should be informed of water resources quality and quantity as a water user and a partner in water resources protection.

Thus, integrated water resources management includes a substantial organizational component: preventing or settling conflicts through involvement of stakeholders in decision-making processes.

The basin approach and prevention of conflicts between various water users require complete participation of and cooperation between all the stakeholders. To reach a common agreement on to decisions made, it is necessary to involve not only governmental, local and municipal authorities, but also the private sector and public, and strive for a consensus. It would be much easier to implement a strategy and legal, administrative and technical actions under well-established consultation procedures.

The main objectives of the public participation in integrated water resources management are:

- to ensure use of the knowledge and experience of the public and other stakeholders in planning and management processes;
- guarantee identification of decision quality and adaptation to specific conditions;
- provide adequate planning and identification of problems while implementing decisions in practice;

- ensure consideration of public needs and priorities in making managerial decisions.

Basic principles of the public participation in integrated water resource management are:

- actively involvement of all the stakeholders and the general public, directly or indirectly;
- the process should be **open** and **transparent**, be conducted fairly and impartially, based on exchange of information, data and knowledge, using all appropriate information media; it is necessary to foresee certain conflicts and solve them;
- suitable mechanisms should be adapted to local conditions, problems and needs of all participants, focusing attention on reaching a consensus;
- participants should adopt a long-term vision on an acceptable condition of studied water body, watercourse or shore, recognizing the differences in their interests, working together and learning from each other;
- the participation should not only consist in solving problems, it is necessary to provide opportunities of **economic welfare** and **nature conservation**, compatible with broader acceptable development objectives.

The Kyrgyz Republic is admittedly a leader in the region in establishing Water User Associations (WUA), involving them in water resources management, and in governmental support to WUAs.

After achieving independence, Kyrgyzstan began implementing land reform. According to the decree No. 23 of the President of the Kyrgyz Republic, 22 February 1994, about the "Measures for land reform intensification", households earlier being governmental property were transferred to the ownership of peasants. Former collective and state farms were liquidated. Peasants received allotments. A part of peasants united in peasant (private) farms, agricultural cooperatives, but another part kept working independently. Under these conditions, irrigation network earlier belonging to former collective and state farms remained masterless. Instead of one water user, represented by collective or state farm with an average irrigated area of about 2 000 ha, 10 to 2000 water users exploiting a common irrigation network emerged. In such a situation, it was almost impossible to normally operate irrigation network and equitably allocate water. In the latter half of the 1990s, the Kyrgyz Government considered the development of WUAs as a potential solution to these problems. In this period, three independent grants were given by the ADB, FAO,

and Japanese Government for developing pilot WUAs and studying international experience.

WUA is a voluntary union of farmers, peasant farms, and other water users for joint operation and maintenance of on-farm systems, regulation and use of water resources, meeting of irrigation water requirements of WUA members, carrying out of reclamation and environmental measures. Based on field data gathered by the staff of the "On-Farm Irrigation" Project, it was revealed that 255 WUAs were formed (169 registered and 86 non-registered) in the republic. Unfortunately, almost all of them were set up without assistance, and, consequently, knew a little about functions of active involvement of farmer organizations. As a result, many of them held the old collective/state farm management system, and for the purpose of WUA management, often chose people that earlier worked in executive positions on former collective/state farms. Many of these managers began playing a dominant role in WUA that caused a number of serious problems regarding approach to development. Afterwards, WUAs applied to WUA support units at the Water Department for settling this situation.

At present, there are 409 WUAs in the Kyrgyz Republic. Under the project, a long-term strategy for WUA development in the country has been developed.

The long-term strategy for WUA development foresees:

- finishing the process of privatization of state water agencies and establishing, on their basis, systems of O & M enterprises with diverse patterns of ownership: governmental, private and joint;
- completing WUA formation, and their active participation in water system management and water resources protection;
- finally differentiating functions and powers of entities in water relations;
- limited participation of governmental bodies in maintenance at the expense of state budget, only O&M of strategically important water-management systems and facilities. Management and maintenance of the remaining part of water infrastructure is fully imposed on farmers or their unions.

With a view to develop water relations under market economy, the government is consecutively carrying out measures aimed at:

- adapting water users to market economy;
- supporting water users through allocating loans and grants, providing technical and methodical assistance, training and advanced training, providing information, helping to conduct construction, repair, renewal work, introducing new technologies and so on;

- supporting water user rights;
- stimulating establishment of water user associations (unions);
- reducing risks of water users in agricultural sector, through improving the insurance sector;
- gradually transferring the most basic assets of water-management systems to the ownership and jurisdiction of water users or their public unions.

The activities of water user associations (unions) are regulated by the effective Law on Water User Associations and subordinate acts developed in accordance with this Law.

According to the plan for implementing the "On-Farm Irrigation" Project, WUA support units, which after the completion of the project are to join the structure of basin and district departments for water resources, are being set up in 19 districts through project funds. Similar services are expected to be organized in other districts of the country in the future.

For operation and maintenance of on-farm irrigation infrastructure, about 500-600 WUAs able to voluntarily unite in Water User Federations are to be established in the republic.

Positive aspects of establishing Water User Associations

Establishing and strengthening Water User Associations in the Kyrgyz Republic have a number of positive and negative aspects. Below we will consider such aspects existing in our republic.

Positive aspects:

- farmers and other water users participate in management of water resources, particularly in irrigation stock;
- farmers and other water users combine efforts and facilities for concerted actions aimed at effective water resources use in irrigated and reclaimed lands;
- farmers and other water users participate in setting charges for irrigation water supply;
- farmers and other water users participate through Water User Association and its structures in making water policies;
- farmers and other water users have complete control over irrigation infrastructure and right of possession;

- farmers and other water users have complete control over O&M, financing and resolving conflict situations;
- farmers and other water users bear prime responsibility for financing, O&M, rehabilitation and modernization;
- farmers and other water users themselves develop strategies and rules submitted for approval;
- openness of administration, operations and activities is achieved in Water User Associations;
- Water User Associations, as a new institutional structure in rural areas, began demonstrating their prospects and viability.
- All control bodies of Water User Associations are dependent and responsible to each other that means efficiency of top-down and bottom-up control.
- Each farmer participates in decision-making within WUA, raises its sense of responsibility for executing decisions made.
- Water User Associations show a good example of management to other types of local communities.
- Water User Associations are an initial stage of reform in water sector and in restructuring governmental management of water resources.

Conclusions on the implementation of the "On-Farm Irrigation" Project:

- Thanks to the assistance of specialists from support units, the number of legally registered WUAs increased to 409 in comparison with the project start;
- Moreover, many of non-acting WUAs were newly established, some of relatively small WUAs in Chui and Djalal-Abad provinces voluntarily united in accordance with the new law. Average irrigated area serviced by one WUA is 1735 ha, and number of WUAs with irrigated area coverage of more than 2000 ha is 74.
- With the help of specialists and in accordance with the new law, a package of documents was prepared for re-registration of 310 acting associations, of them 301 were re-registered;
- Kick-off meetings on the "On-farm Irrigation" Project and development of WUAs were held with the participation of representatives from governmental, provincial, and district administrations, district department for agriculture, provincial and district centers for land reforms, provincial and district structures of the State Real Estate Inventory Agency, heads of rural councils, heads and mem-

bers of WUAs in 7 provinces and 26 districts in the republic, where the participants of the meetings were familiarized with the essence of the project and necessity to establish WUAs. Furthermore, tens of workshops were held on the experience exchange between water user associations and the interactive communication. 7 training courses were provided at central level for specialists of provincial and district departments and representatives of some developed WUAs, for the purpose to train them as instructors for WUA staff.

- Training was started and is provided at local level for WUA Councils and Direction staff in districts, where personnel of about 100 WUAs is covered. Moreover, consultative and practical assistance is rendered to all existing WUAs in the republic.
- Over the project implementation period, design estimates for irrigation infrastructure in 12 WUAs were made, rehabilitation work was completed in 1 WUA, and is undertaken in 24 WUAs, and design estimates for 12 viable WUAs were completed.
- 2 subordinate acts were prepared and signed by the Kyrgyz Government, and among them there is a Decision of the Kyrgyz Government on "Transfer of irrigation systems to the ownership of Water User Associations".
- Office work was put in order in almost all acting WUAs, their offices were established.
- At present, the trust of farmers in management bodies of economically viable WUAs is rising.
- By now, reporting forms have been developed of National System for Monitoring and Assessment of Water User Associations (NSMA WUA) with output data per district, province and the republic. This system is now being improved.
- WUA Regulating Body that was stipulated in provisions of the Law on WUAs has started functioning in full (its functions are entrusted to the Department of Water Resources by the Decision of the Kyrgyz Government).

The involvement of the public in water resources management in the Kyrgyz Republic has other direction as well. Within the "Integrated Water Resources Management in Fergana Valley" Project, in pilot Aravan-Akbura canal in Osh province, a Canal Water Users Union (CWUU) was set up. The Board of Union includes representatives of water users and suppliers, governmental structures and others. At present, the issue on joint management of canal by water users and suppliers is being considered. A draft agreement on joint management is being developed. The CWUU is now involved in consideration of a cost estimate for canal management, in approval of a candidate for Head of Canal Administration and so on. As its financial contribu-

tion to canal maintenance increases, the CWUU will be given more rights to solving principal issues.

The experience regarding pilot canal is proposed to be spread to other structures in the republic. There are similar pilot canals in Tajikistan (Gulyakandoz Canal) and Uzbekistan (SFC), covered by the IWRM-Fergana Project as well.

The provisions in the Water Law envisage gradual increase of public participation in water resources management through Basin Councils.

All the above-mentioned is an illustrative example for public involvement in water management process, the next step to establishment of a partnership between water managers and water users in joint management, use and maintenance of waterworks and water resources.

CENTRAL ASIA: WATER FOR FOOD

A.A. Nazirov

Minister,

Ministry of Land Reclamation and Water Resources,

the Republic of Tajikistan

It is well-known that food production is one of the crucial elements of development and prosperity.

In this context, the first-priority objective of every sovereign state is to ensure national food security. As UN General Secretary underlined, "We need revolution in agriculture that would improve productivity per unit water – more yield per drop of water".

Irrigated agriculture is the most productive agricultural sector. The productivity of an irrigated hectare is 3-8 times higher in arid zone compared to that in naturally humid land.

The key condition of high bio-productivity is two main components of agro-biocenosis – thermal and water resources. Under 50 % of flow probability, the total water resources are estimated to be 105-115 km^3/year. It is about 2200 m^3/capita/year, that is three-fold of the worldwide figures: 700 m^3/capita/year, of which approximately 70 % or 485 m^3/capita/year is used for irrigation. In Central Asia, under 85-90 % of water used for irrigation, it is almost 1900 m^3/capita/year, which exceeds the world value 3.8 times.

Certainly, in general, regional aridity is above the mean world one; however, countries in Persian Gulf are characterized by extra-arid conditions but their specific indicators are lower than the mean world one.

Let us consider another one indicator – water volume in the Aral Sea. In 1960, it was 1064 km^3; 4,5 million ha were irrigated and 60 km^3 of flow was diverted from the two rivers supplying water to the Aral Sea.

Since 1966, when period of intensive irrigation construction was started in the region, additionally 2.5 million ha have been developed. The rest of about 60 km^3 of basin flow was taken for irrigation of this new area and this has led to the Aral Sea disaster. In addition, such large-scale diversion of water turned to be ineffective. However, it is a matter of specific analysis.

Before "large-scale" irrigation, less than 7-8 thousand m^3/year were used for irrigation of one hectare in Central Asian region. As irrigation area expanded, irrigation norms increased and, finally, reached 12-14 thousand m^3/ha. As to specific irrigation water use, and more precisely regarding ineffective water use, the Central Asian countries hold the first position all over the world. At the same time, our water professionals are of very high international authority and created by them hydraulic structures and irrigation systems are often unique in the world practice.

Previously, the Aral Sea basin was an inland water body within an area of one state. All relevant problems in the basin were solved on centralized basis through various compensatory measures. Since formation of new independent states in the region, the basin had become shared by five and in the nearest future, probably, six states with their own priorities and water demands but, in general, with common problems. Just under such conditions, in 1993, five Central Asian states at their summit in Nukus have made a very vise decision – still follow the quotas that were set in Soviet time. To this end, the well-known regional institutions were established to ensure implementation of these decisions.

As we see food security in the region depends on the main resource of water, which use and management take new shapes. In general, in the region, food supply took a turn for the worse and led to changes in land use patterns and, consequently, in water use.

According to dietitians, human needs 2800 kcal, 100 g of protein, 100 g of fat, and 400 g of carbohydrate for normal nourishment. Actual food consumption was estimated to be 2615 kcal in 1985, 2240 kcal in 1990, and 528 kcal at present. Diet patterns are much worse. For example, the average resident consumed 31 kg of meet out of 68 kg of physiological norm in 1985, but this figure reduced to about 7 kg or 10 % of the need in 2003. The same situation is observed regarding other foodstuffs, except bread. Certainly, these indicators relate to intra-republican production of basic food resources. Besides, the UN World Food Program has provided to the republic more than 400 thousand tons of foodstuff as humanitarian aid over the last 10 years of its operation.

Food shortage is partially compensated by foodstuff import, which increased from 18.7 to 70.0 million USD or 3.7 times over this period and led to a new problem of food bio-security.

Given the demographic growth, higher population density (up to 500 person/km^2) and shortage of arable land, the selection of priority directions in agriculture and its specialization becomes particularly important. Current opinion that food situation may be improved through reduction of cotton production cannot lead to positive results since even complete reorientation of cotton-production system to-

wards food production would not solve all the problems. Economic return on land would be several times less than in case of former agricultural specialization since cost parameters of food production are much lower than those of cotton production. This means that market exchange will provide ten times more food from a hectare of land under cotton than food production from the same area of irrigated arable land.

According to the UN's medium-term assessments, by 2025 the world population will reach 7.8 billion, i.e. 38 % more than present population. By assuming that subsistence standards become improved in many countries, IWMI estimates (IWMI, 2000) that in order to feed the population, 40 % more food would be needed. To what degree irrigation needs to be improved? According to scientific estimations, irrigated areas need to be expanded by 29 %, and due to increased productivity and more effective water use, agricultural withdrawals would be raised by 17 %.

Under market relations, cost of water is very important. Researchers from Tajik Research Institute for Irrigation and Land Reclamation calculated the weighted-average costs to get additional (saved) 1000 m^3 of water by different ways.

The weighted-average costs to get additional 1000 m^3 of water, USD

#	Ways for getting additional water	Costs, USD
1	Saline water desalination	1000±250
2	Rehabilitation of irrigation and drainage systems	800±100
3	Spatial re-distribution	750±200
4	Waste water treatment	120±20
5	Reservoir regulation	70±20
6	Application of water-conservation technologies	3±2

The calculation results showed that the cheapest way was application of water-conservation irrigation technologies and cost only 3-5 USD to get 1000 m^3 of water.

Therefore, under water shortage and the established water limits, we need to achieve rational irrigation use through the following: improvement of soil reclamation and water allowance zoning principles; development and implementation of scientifically-based irrigation regimes; identification of crop water consumption patterns; application

of advanced water-efficient irrigation technologies; improvement of the state of lands; development and implementation of innovative irrigation technique and technologies and their optimization in order to increase yields, raise production per irrigated hectare, and input new irrigated areas in agricultural production.

National economy in Tajikistan uses annually 11,5-12,8 km^3 or 18-20,0 % of flow formed in Tajikistan, while the rest of water flows to neighboring states such as Uzbekistan, Turkmenistan, and Kazakhstan.

Because of irregular distribution over the area, as well as of insufficient river flow regulation, out of available 720 thousand ha of irrigated land, 20 % suffers from water shortage that could be compensated only through internal sources. About 300 thousand ha is irrigated by pumping stations. Analysis showed that 92 % of water is used in irrigated agriculture and generated 90 % of crop production.

At present, in order to solve the national food security problem and to improve public welfare, besides intensive development method we need to apply extensive one, i.e. input new irrigated areas in agricultural production. Prospective areas suitable for irrigation are estimated to be 500-800 thousand ha. For irrigation of this area, water use needs to be increased again by 3-6 km^2. In general, the total prospective withdrawal for all economic sectors would be 18 km^3 or 28,1 % of river flow in Tajikistan. Such prospects could just aggravate critical conditions related to water shortage.

Tajikistan, located in flow formation zone of the largest in CA Amudarya river, plays an important role for sustainable development of agriculture and other economic sectors in Turkmenistan and Uzbekistan. Irrigated agriculture in Kazakhstan is linked with Kairakum reservoir located in the Syrdarya river. Water relations between Tajikistan and other CAR countries are based on before concluded agreements. However, those agreements establish only procedures of the interstate water allocation as existed in Soviet time and do not regulate economic relations as concerns use of water and hydropower resources in transboundary rivers.

In Soviet time, priority for new irrigated land development was given to the republics that had the largest cotton and rice production. Therefore, the largest water quantity was allocated to the republics located in Amudarya and Syrdarya downstream. As a result of such policy, Tajikistan is the least provided with irrigated area and water resources and has 0.116 ha/capita and 1843 m^3/capita, respectively.

Water use efficiency throughout the Aral Sea basin

Country	Specific water use per capita, m^3	Specific irrigated area per capita, ha	Specific water use per irrigated hectare, m^3	Water use per unit yield, m^3/t
Kazakhstan	1943	0,30	11350	1220
Kyrgyzstan	1371	0,14	10120	2410
Tajikistan	1843	0,11	13580	6170
Turkmenistan	4044	0,41	12370	2370
Uzbekistan	2596	0,19	12380	1350
Total for the basin:	2524	0,20	11870	2320

Note: source: WUFMAS project data. The highest indicator of specific water use (6170) per unit yield is achieved in medium-stony soil (1st hydromodule district) Sogd province of Tajikistan.

At present, due to lack of anti-filtration coating in conveyance and distribution system, of primitive furrow irrigation and inefficient farming, the mean farm irrigation efficiency is 0.42 or 58 % of water withdrawn from the irrigation source is lost in canals and irrigated fields. This leads to field subsidence, salinization and water-logging of downstream lands and to other negative effects.

Assessments and analysis of monitoring data have identified the following:

- Use of huge water quantities for irrigation for both the whole growing season and individual irrigation events;
- Irrigation depths vary within 2.0-2.5 thousand m^3/ha in farms;
- Irregular irrigation water use;
- Irrigation water losses through filtration achieve 40 % and field outflow amounts to 32 % of gross inflow to the field.
- Irrigation water use efficiency is very low and ranges from 0.4 to 0.6.
- Decrease of water productivity due to yield losses caused by various farming and organizational factors;

The main cause of such situation is poor discipline in water use. Long ago, labor-management relations in this area have collided with productive forces and prevented future development of the latter.

WUFMAS Project's data obtained by monitoring of crop yield formation factors in 220 control fields under representative Central Asian conditions can be shown as an example. According to those data, the annual irrigation water losses at the level of "field inlet-cotton rooting zone" average 51 %, varying from 42-43 % in Kazakhstan, Turkmenistan, and Uzbekistan to 67 % in Kyrgyzstan and Tajikistan.

The scientifically-based and environmentally sound level of total water consumption in the region is estimated to be 80 km^3 a year. This is a limit established by the nature itself. In some or other way we should learn to keep within this limit. Experience of the countries that have similar natural and climatic conditions and obtain up to 4 t of raw cotton per hectare under specific water use not exceeding 5 thousand m^3/ha indicate to huge potential of water conservation.

Comparative analysis of irrigation water productivity data estimated on the basis of gross margin shows the following: water productivity is 0.06-0.16 US dollars per 1 m^3 in Central Asian countries, while it is 0.52 USD per 1 m^3 in Israel. Despite the fact that these data reflect local market conditions, most of all food market, they are quite significant.

From the above-mentioned, it follows that:

Implementation of water-conservation ideology as the basis for regional water strategy and all efforts related to future water development and management requires that great preparatory activities be undertaken. For every planning zone determined by river reach and its command irrigated area and, then, for the whole country within the basin area, the following indicators and factors should be determined, analyzed and estimated:

- potential land and water productivity – on the basis of available advanced experience, especially in low-water years;
- specific water consumption under minimum water use per unit production – by using common technical approaches;
- causes of yield shortage (related to reclamation and water management factors) and possibilities of overcoming it, with rating of measures undertaken;
- salt and water balances of a planning zone on the basis of previous data – probably, bringing their parameters to the values that ensure environmentally sustainable development of processes;
- possibility of utilizing waste and ground waters, as well as waters in all local sources that are not used currently;

- possibility of reducing organizational water losses at all chains of distribution system;
- non-productive water losses in all chains of irrigation system and, first of all, in irrigated field; the estimation will help to identify less capital-intensive water-conservation measures;
- reduction of return water discharge into rivers and lakes and improvement of water quality as a result of water-conservation measures.

Analysis of organizational water losses caused by mistakes of water allocation, specifically, due to poor information, is a particular task.

Regional and national experts should jointly identify such losses measured as billions cubic meters and elaborate a mechanism for their avoidance and prevention.

Accurate information should be prepared on the basis of the above-mentioned analyses and estimations for different social groups to convince decision makers, investment and water efforts planners, environmentalists, and water users of a need to follow steadily water-conservation principles by bringing water use rates to biological use level, of a profitability of such policy for every water consumer and for the society as a whole in economic, ecological, and social terms.

Because of international nature of the water-related problems, market relations of water consumer-riparian countries should be build on consideration of all principles laid by the international water law. With reference to transboundary waterways, this means that any above-limit use should be compensated. Water saving is more profitable for consumer that transportation of outside water at higher price.

However, we need more radical solutions and one of the ways should be transfer to Integrated Water Resources Management (IWRM). The World Summit for Sustainable Development (WSSD) appealed to all the countries for development of IWRM strategies and effective water use by the end of 2005. To transfer to such complex system, five countries, having different and, at times, quite opposite interests, need a long way for not so much agreements as development of their national IWRM, with thorough calculations, economic analysis, and research that would gradually bring together positions through mutual concessions. Finally, this could lead to development of **regional** IWRM, with a single interstate center (commission) to deal with all water-management issues.

Regional view and joint efforts to solve the problems

The main points that need to be considered in the region are the following:

- Development of policy and strategy for water resources use and protection in national interests, with observance of international water law norms.
- Improvement of legislation in water and agricultural sectors; Bringing together national legislations near to regional one and development of integration process;
- Shifting interstate water project management to IWRM principles
- Establishment of Water User Associations and new forms of relations between water users and water managers on market basis;
- Transferring water project management to special institutions of different ownership categories;
- Rationalization of water use and protection management system's structure and functions;
- Establishment of a consortium and development of cooperation in production and supply of foodstuff, etc.
- Improvement of economic mechanism of water pricing;
- Elaboration of the interstate Program on development and application of water-conservation technologies in Central Asian countries, with specified dates and scopes;
- Attracting investments to development of new irrigated lands and improvement of their efficiency through application of new technologies.
- Rehabilitation of irrigation and collector-drainage systems, including the most vulnerable structures and pumping irrigation.
- Finishing construction of Ragun reservoir, with a volume of 13.5 km^3 at Vaksh river
- Construction of new reservoirs at Pyandj river with a volume of 35 m^3
- Cleaning of Nurek reservoir from siltation (annual siltation is 165 Mm^3)
- Development and application of a long-term program to prevent natural disasters in littoral zones, to provide systematic construction of bank-protection structures and to restore landscapes in mountain river catchments;

- Rehabilitation and development of high-quality drinking water supply to population; development of mountain fresh, mineral, table and medicinal water.
- Monitoring of water ecosystems (glacier studies and flow probability forecasting)
- Water allocation, which was adopted during the Soviet period, does not meet now regional and national interests. Therefore, new water allocation principles and mechanisms need to be developed and adopted at the interstate level. Besides, it is necessary to make provision for proportional compensations to prevent adverse water effects in flow formation zone.

Nowadays, water conservation is the only way to prevent soil from salinization, help the Aral Sea, save beauty and diversity of the nature in the form close to that left by our parents.

WATER FOR DEVELOPMENT IN CENTRAL ASIA

T.A. Altiyev

Minister,

Ministry of Water Resources, Turkmenistan

Rational and careful use of water resources, especially freshwater resources, is of primary importance throughout the world. These problems are important in Central Asia as well, where water resources are one of limiting factors for economic growth in the countries. The problem of future development is in the center of interests of all the countries in the region, and it relates to major strategic decisions of the states. Here, it is necessary to determine how the regional economy would be developed, what role would be given to agriculture, particularly to irrigated farming in future development, in what direction the irrigated farming would be improved, what water policy would be pursued by Central Asian states in view of that, what position would be taken by each state to strengthen interstate cooperation.

Central Asia is located in the center of Eurasia, on an area of 3 882 000 km^2 with population of over 53 million (2004). It borders upon the Ob (Irtysh) river basin in the east, Caspian Sea basin in the west, Tobol and Ishim river basins in the north, and Aral Sea basin in the south.

The analysis of global water availability dynamics shows that from year to year water deficiency is growing in many regions leading to environmental instability and social tension. Such situation has arisen first of all in the Middle East and Northern Africa where water resources per capita amount to 1000–1240 m^3 a year, and about 500 m^3 in some countries as opposed to 18 700 m^3 in South America and 23 000 m^3 in Latin America.

The table shows this indicator for river basins in Central Asia (by Prof. N. Kipshakbayev).

River Basin	m^3 / person / year
Aral Sea	2 580
Balkhash-Alakol	2 950
Irtysh	7 070
Ishim	520
Kura-Sarysu	680
Tobol-Torgai	650
Chu-Talas	3 740
Caspian Sea	1 120

Taking climate aridity, water consumption pattern, and the ongoing environmental crisis into account, the most stressed situation is in the Aral Sea basin.

Water resources in the Aral Sea basin are formed of renewable surface and groundwater, as well as of anthropogenic return water. The average annual total river flow in the basin is about 116 billion m^3 a year, of which 79 billion m^3 accounts for Amudarya and 37 billion m^3 for Syrdarya. Annual surface water flow varies, depending on water availability in year:

- from 58.6 to 109.9 km^3 for Amudarya;
- from 23.6 to 51.1 km^3 for Syrdarya .

Total regional groundwater supplies are estimated at 43.5 km^3, including 25.1 km^3 in the Amudarya basin and 18.4 km^3 in the Syrdarya basin. Total available volume amounts to about 17 km^3, and actual withdrawal is about 11 km^3.

Return water is not only an additional reserve for use, but also a source of environmental pollution. About 95% of total return water is collector-drainage water. Over 51 % of total return water is disposed to rivers, about 33 % to depressions, and 16 % is reused for irrigation.

As a result of return water disposal to depressions, hundreds of water bodies formed. Among them, there are Aydar-Arnasai depression with a capacity of more than 20 km^3, Sarykamysh with a capacity of about

100 km^3, Dengizkul, Solyonoye, Sudochie and many other water bodies containing up to few million cubic meters of water. These water bodies do not have flowage, and so their water quality is deteriorating year by year.

In the recent decade, rapid growth of population and intensive expansion of irrigated lands led to significant increase in water use and withdrawal from water sources.

The main parameters of water and land resources use in the Aral Sea basin are given in the table below.

Parameter	**Unit**	**1960**	**1970**	**1980**	**1990**	**2000**
Population	million people	14.1	20.0	26.8	33.6	41.5
Irrigated area	th. ha	4510	5150	6920	7600	7990
Total water withdrawal	km^3 a year	60.61	94.56	120.69	116.27	105.0

The table below shows the dynamics of water resources use in the Aral Sea basin states (million m^3).

Country	**1960**	**1970**	**1980**	**1990**	**2000**
Kazakhstan	9750	12850	14200	11320	8235
Kyrgyzstan	2210	2980	4080	5155	3291
Tajikistan	9000	11170	10750	9259	12521
Turkmenistan	8070	17270	23000	23338	18075
Uzbekistan	30780	48060	64910	69611	62833
Total the Aral Sea basin	**60610**	**94560**	**120690**	**116271**	**104955**
including:					
Amudarya	***30970***	***53220***	***66950***	***69247***	***66079***
Syrdarya	***29640***	***41340***	***53740***	***47024***	***38876***

Annual increase in river water withdrawal led to drying-up of the Aral Sea, environmental degradation in river midstream and downstream. Some of large rivers have almost completely lost their environmental significance. Tributaries of the Syrdarya river such as Chirchik, Keles, Karadarya, as well as some of the Amudarya tributaries practically

lost connection with major rivers. At the same time, considerable disposal of collector-drainage water from irrigated lands resulted in rise in river water salinity. This was accompanied with changes in river deltas including substantial shrinkage in areas of freshwater lakes and increase in number of man-made saline water bodies.

Great quantities of untreated or poorly treated industrial and domestic wastewater are discharged into watercourses and water bodies that has led to noticeable deterioration of their water quality. Many rivers have lost ability to self-purification.

The situation is becoming complicated also by the fact that there is no coordinated and efficient system for monitoring over water quality and assessment of pollution impacts on human health and the environment in the region. It is well known that water quality management should be based on quantity monitoring data. However, at present, regional organizations are dealing with this issue, and moreover they are acting without coordination, and there is no information exchange system.

The environmental situation in flow formation zone is unsatisfactory as well. Over the past decades, the upper reaches in the basin lost about 50% of forests. The intensification of erosion processes leads to negative changes in hydrological regime of rivers, reduction in agricultural productivity, and acceleration of reservoir sedimentation. Mudflows and landslides occur too.

How to approach to solving tasks to determine future development? Studies conducted under the GEF and WARMAP Projects showed that each country has its views and prospects for irrigation development, which often do not meet capabilities of the region and conflict with the interests of other riparian countries. Kyrgyzstan and Tajikistan consider that their interests were infringed in the previous Master Plans of integrated water resources use and protection, and in this connection in the future they have right to enlarge irrigated areas to a great extent, especially Tajikistan, where area of irrigated lands amount to less than 0.1 ha per capita. Regardless of great irrigated area per capita in Turkmenistan and Uzbekistan, these countries are also planning to expand irrigated lands. Hydropower development planned by upstream countries is the second significant growth direction, very important for these countries in view of shortage of carbonate raw materials and resources there. However, now the transition of individual tributaries with high-capacity reservoirs of long-term and seasonal regulation from the previous irrigation regime to power regime led to some temporary water deficit in summer and water excess in winter. In case of constructing additional hydropower plants in the basin and exporting energy generated by them beyond the region (China, Pakistan and others), it may cause quite complicated situation with water supply to other sectors and basin states.

The research conducted by the joint project "Strategic Planning of IWRM in Central Asia" revealed the principal impact on the strategy and direction of the future development of the following destabilizing factors:

- population growth and prevalence of rural population (more than 60 % all the countries except Kazakhstan where this percentage is less than 30 %);
- possible growth in water withdrawal from Amudarya in Afghanistan is several times more than at present;
- change in water resources available for use in the future that is expected, according to different predictions, to be from 4 to 30 % in the next years under the influence of climate change. Glacier melting represents a special hazard in future that since 2030 may sharply reduce ice component of natural runoff;
- growing environmental requirements, especially in downstream zone owing to the construction of a set of water bodies here as well as due to raising of environmental awareness of population.

Future economic development of the six riparian countries under these conditions will depend on their respect and attitude to mutual interests, their aspiration for joint coordinated solving of future tasks through cooperation and political will, aspiration of the governments to develop a water conservation concept for their development and implement respective water, economic and social policies. The concept should include:

- Analyzing availability and actual use of various water sources, giving a special attention to return water use. For example, Israel uses 25 % of municipal sewage through treating and transporting it via special pipelines to place of consumption. In our region, the percentage of used return water does not exceed 15 % of its total volume. Meanwhile, step-by-step construction of water-management systems provides great opportunities for such use both directly and in combination with fresh water. The same reserves are available in use of slightly saline groundwater.
- Continually reducing specific water use in all water use sectors, with focus on approaching to potential water productivity, which can be achieved by implementing a demand management policy in addition to applying IWRM. Today, specific water use per unit production in Central Asia is twice as much compared to Jordan and Israel, and 30-40 % higher than even in India and Egypt. A good example is given in the region by Turkmen water organizations, which over the last 8 years have increased the irrigated area by 20 % without increasing total water withdrawal.

- Matching the main directions of water use development in the region, including joint construction of hydraulic structures of interstate importance, areas of planned irrigation development, measures for reducing non-productive water losses in transboundary water bodies.

Joint management of both surface river water and return water is of particular importance since the management is important for maintenance of sustainable water supply in the region, both in terms of quality and quantity. Improving the accuracy of water supply from transboundary sources through installation of SCADA system in all transboundary waterworks and organizing of satellite-based collection and transmission of information from transboundary gauging stations may enable us to reduce organizational losses at basin level and ensure stable water supply at the upper level of water hierarchy, where water losses amount to cubic kilometers.

The first-priority step in this direction should be completion and approval of regional and national water strategies not completed under the GEF project "Improvement of water resources and environment management in the Aral Sea basin", adoption and signing by the states of a set of Agreements establishing rules for development and interactions of the countries as concerns transboundary waters, and approval of the Principal Action Plan.

Solving complicated environmental problems in the Aral Sea basin should be based on an ecosystem approach, at which the vital requirements of people and economy should be considered from common agreed positions regarding meeting environmental needs.

The recognition of water requirements of the environment objects and possible increase in water withdrawal outside Central Asia will lead to rise in the existing water deficit in the Aral Sea basin. Problems of water supply sustainability in the riparian countries may be solved only through water conservation in all sectors and use of all water resources including collector-drainage, industrial and domestic sewage.

Water supply should be aimed at achieving peak level of water productivity in all water using sectors. It will be possible, first of all, by universally implementing integrated water resources management and undertaking a series of measures to control non-productive water losses.

By using advanced world experience, the counties in the region should provide maximum use of municipal and industrial wastewater, take effective measures to reduce quantity and use collector-drainage water in place of their formation.

Respecting the aspiration of each state for meeting their water demand for future development, and based on the principle of using their own water resources and share of water from transboundary water sources at own discretion, the development of economy, including irrigated farming, should be based within common limits and supplies of water resources in each country. This may mainly occur as surplus water is received through water conservation, modernization of water use sectors, utilization of additional water sources and so on.

Taking into account the considerable share of irrigated farming in water use and relatively low engineering standard of irrigation systems, it is necessary to place emphasis on improving irrigation water productivity. It especially relates to selection of less water-resistant and cost-effective crops, support of farmers and long-term land rent orientated to market economy, organization of high-productive seed-growing, provision of sustainable favorable reclamation background, economical incentives to provide high water productivity and so on.

The important element in implementing the mentioned measures is to create a system of pilot representative projects with high water and land productivity, use them as reference sites for training and transferring experience to new generation of water and land users.

At the same time, it is important to show not only possibilities to achieve high crop and water productivity, but also economic effectiveness of water-conservation technologies and other measures for improving water use efficiency.

The orientation to water conservation in irrigated farming is the basis for sustainable economic development and improvement of environmental situation in the region.

Based on the necessity of sustainable water supply to population and economy in the countries in the region, today and in future it is necessary to use an ecosystem approach, providing for the following principal directions of environmental development and water resources use:

- improving river water quality, first reducing water salinity down to limits not posing damage to water users;
- creating new environmentally sustainable anthropogenic-natural systems of wetlands in degraded river deltas;
- organizing and implementing measures against further degradation of natural systems in flow formation zone;
- carrying out measures to prevent salinization and water-logging of irrigated lands;
- maintaining and improving bio-diversity.

Central Asia has sufficient supplies of renewable water resources, reasonable and effective use of which would provide worthy living conditions and well-being not only for present population, but also for future generation. In this connection, coordinated mutually acceptable joint management of transboundary water resources is a source of our development and prosperity.

WATER FOR ENVIRONMENT AND NATURAL COMPLEX OF CENTRAL ASIA

Sh.R. Khamrayev

Chief,

Central Water Resources Administration,

Ministry of Agriculture and Water Resources,

Republic of Uzbekistan

An intensive development of economical activity in the Aral Sea basin has been accompanied with an increase of irrevocable water withdrawals from the Amudarya and Syrdarya rivers, mainly, for irrigation needs. Since sixties of XX century, this intensive withdrawal has led to sharp reduction of inflow from those rivers into the Aral Sea and to radical changes in delta.

Professionals note that by the end of the past century, inflow to the Amudarya delta decreased almost by 80 % as compared to the mid of the century (1931-1960). This resulted in drying of the Aral Sea, breach of stability of natural hydroecosystems in river downstream and degradation of huge areas in Southern Priaralie (Aral Sea coastal zone).

Dynamics of inflow to the Aral Sea and of sea water level (Fig. 1) shows river flow quantity trends for the second half of XX century and their consequences.

As a result of decrease of the Amudarya and Syrdarya flow and increase of discharge of return water, particularly drainage and waste water from irrigated schemes into the rivers, river water quality deterioration, especially abrupt increase of salinity have been observed since 1980.

For example, in March 1985, river water salinity was 575 mg/l in Kerki section of the Amudarya river, while it amounted to 2700 mg/l in Kyzyldjar section that is 2,5 times more than maximum permissible level. The same situation is observed along the Syrdarya river.

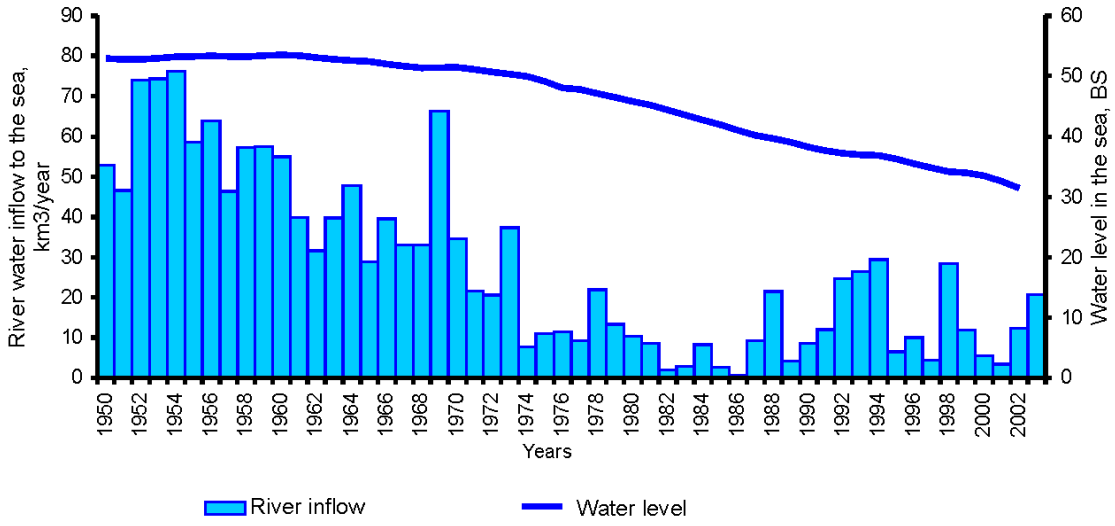

Fig. 1.Dynamics of inflow to the Aral Sea and of sea water level

Understanding the acuteness of backlog of environmental problems in eighties led to general conclusion regarding priority of environmental improvement in all water sources located in Central Asian region.

Water quantity and quality

Surface water resources in the Amudarya and Syrdarya basins amount to 114.4 km^3 (Djalalov A.A. et al., 2000) under flow probability of 50 % and 90,6 km^3 under flow probability of 90 %, and the average annual flow is **123.08 km^3** (Glavgidromet's data) (Table 1).

Table 1. Average annual water resources in Central Asian rivers

River – section	Surface runoff		**Ground-water inflow**	**Total**
	accounted	unaccounted		
Amudarya river basin				
Vaksh-Tutkoul	20.29	0.05	0.07	20.41
Pyandj-lower Pyandj	34.02	-	-	34.02
Kafirnigan- sum of rivers	5.63	0.12	0.05	5.80
Surkhandarya- sum of rivers	3.77	0.06	0.22	4.05

River – section	Surface runoff		**Ground-water in-flow**	**Total**
	acco-unted	unacco-unted		
Sherabad-Sherabad	0.23	-	-	0.23
Kunduz- Askarkhana	4.11	0.01	-	4.12
Total in Amudarya river	**68.05**	**0.24**	**0.34**	**68.63**
Kashkadarya- sum of rivers	1.07	0.03	0.07	1.17
Zarafshan-Dupuli+Magiandarya-Sudji	5.29	0.30	-	5.59
Rivers of Northern Afghani-stan, rivers of Turkmenistan	6.10	-	-	6.10
Total over Amudarya ba-sin	**80.51**	**0.57**	**0.41**	**81.49**
Syrdarya river basin				
Naryn-Toktogul+lateral tribu-taries	14.02	0.40	0.30	14.72
Fergana Valley rivers	11.89	0.67	0.69	13.25
Chirchik, Angren, Keles	8.82	0.30	0.33	9.45
Midstream rivers	0.36	0.50	0.35	1.21
Total up to Chardara	**35.09**	**1.87**	**1.67**	**38.63**
Rivers of Kazakhstan	2.45	-	0.51	2.96
Total over Syrdarya basin	**37.54**	**1.87**	**2.18**	**41.59**
TOTAL in the region:	**118.05**	**2.44**	**2.59**	**123.08**

Source: Glavgidromet, Uzbekistan, 2001

About 6 % of Amudarya basin runoff and 13 % of Syrdarya basin runoff are formed in Uzbekistan. Water quantity flowing to the republic from neighboring countries is 8 times more than its own resources in the normal year.

Fixed available water volume over two river basins as a whole is estimated to be 133.6 km^3, of which 72.4 km^3 is Uzbekistan's share. Out of this share 61.6 km^3 are used in irrigation and 11.3 km^3 for non-irrigation needs.

The mean annual changes of runoffs in Amudarya and Syrdarya are shown in Figures 2 and 3.

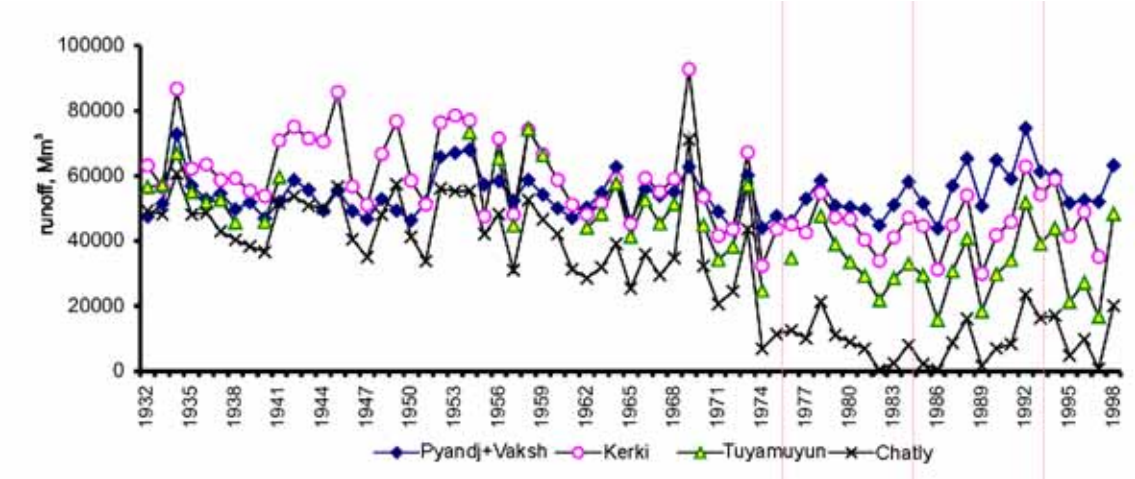

Fig. 2. Dynamics of the mean annual runoff in Amudarya river, 1932-1999

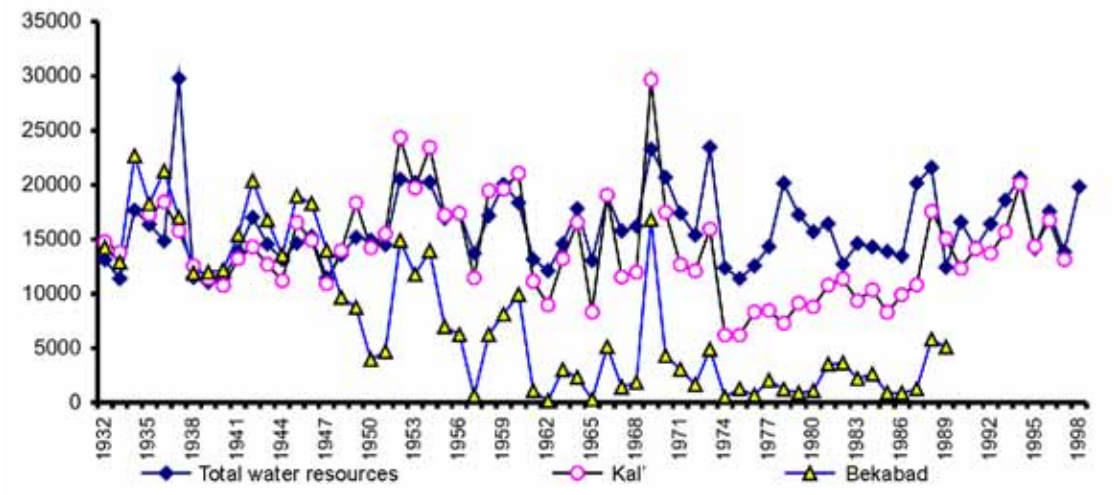

Fig. 3. Dynamics of the mean annual runoff in Syrdarya river, 1932-1999

When river runoff changes, water quality changes as well.

Observations over water quality in Amudarya and Syrdarya over long-term show that in 1950-63 salinity of these rivers varied all over the year within 330 - 715 mg/l, i.e. met acceptable norms. During mentioned period, other river water quality indicators such as major ions, organic compounds, biogenic elements, pH, pesticides, oil products, etc. did not exceed the maximum permissible values.

Lately, in particular, since seventies, the salinity have started to increase gradually and in some of months, especially in winter (January-March) reached up to 2800 mg/l (Amudarya river, Kyzyldjar section).

The mean annual changes of salinity in the Amudarya and Syrdarya rivers per river section as shown in Figures 4 and 5 indicated to salinity growth trend in both time and space. The figures show that salinity started to increase since initiation of river flow regulation and intensive land development.

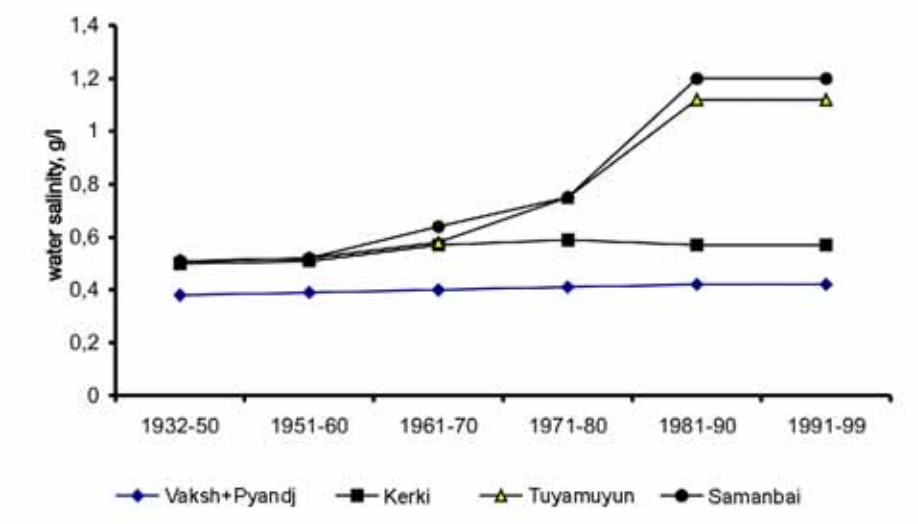

Fig. 4. Mean annual salinity changes in Amudarya per river section

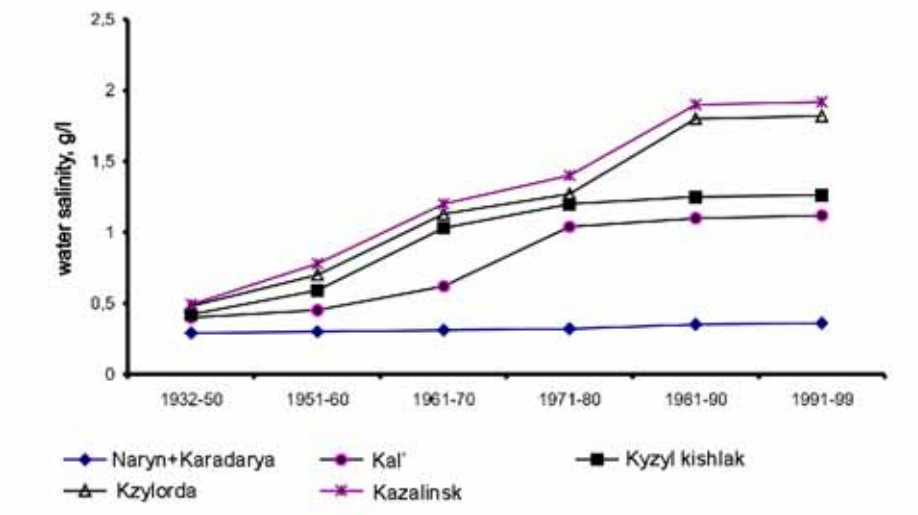

Fig. 5. Mean annual salinity changes in Syrdarya per river section

Thus, higher salinity is observed in downstream river sections, for example, during certain periods in a year the mean monthly salinity reaches 2.0-2.5 g/l in Kyzyldjar section of the Amudarya.

As to the Syrdarya river, high salinity is observed in section located at the outlet from the Fergana Valley, where it is 1.2-1.4 g/l in several months. Water salinity is 1.4-1.6 g/l in Chardara section, 1.6-2.0 g/l in Kyzylorda section, and up to 2.3 g/l in Kazalinsk section, whereas it is not higher than 0.3-0.5 g/l in upstream sections.

Hence, current hydrological and hydrochemical changes in the rivers cause new problems in the regional natural complex, in particular runoff changes in the Amudarya river became one of the causes of the Aral Sea shrinking and of the nature degradation in Southern Priaralie. At the same time, regime changes in the Syrdarya river have posed a threat of ecological instability in area adjacent to Arnasai lake system.

Environmental sustainability around the Aral Sea and in Southern Priaralie (Amudarya river delta)

Until sixties, the Aral Sea was the fourth world largest inland lake. At that time, the sea area was 68 478 km^2, and the water volume amounted to 1093 km^3 (1960) that corresponded to a water level of 53.5 m B.S.

Hydrological and hydrochemical regimes of the Aral Sea completely depend on quantity of inflow from the Amudarya and Syrdarya rivers. According to the long-term observation, the maximum inflow to the sea is 76-88 km^3 (1954-1969). Since 1950 to 1964, the total annual inflow from both rivers ranged from 40 to 76 km^3, of which 60-70 % referred to the Amudarya river.

As is well known, since 60-ties, irrevocable withdrawals have greatly increased, and, as a result, river water inflow has decreased to the Aral Sea (Fig. 6).

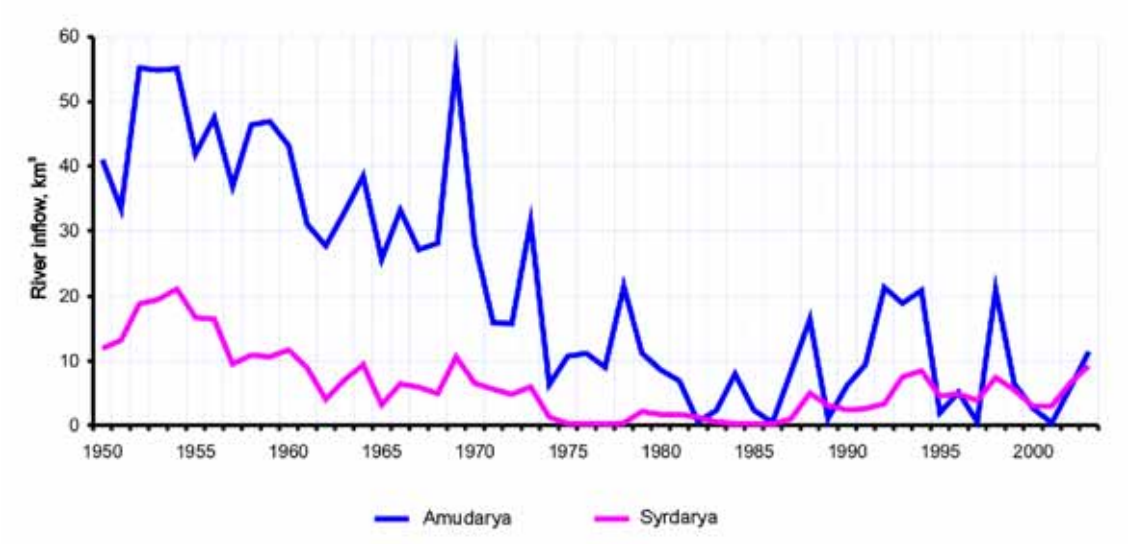

Fig. 6. Dynamics of river water inflow to the Aral Sea

Since that period, we have being observing gradual drop of the sea level, and, from 1961 to 1974, a rate of level drop was 0.12-0.45 m/year. Since 1975 to 1991, the rate increased sharply and equaled 0.54-0.84 m/year. In 1992-1995, the level drop rates decreased slightly to 0.07-0.46 m/year. However, since 1996, the rate increased again up to 1.02 m/year. As a result of low-water years 2000-2001, this rate became maximum and amounted to 1.17 m in 2002.

The level drop has led to decrease of water quantity in the sea. The mean annual water volume in the sea was about 1050 km^3 in mid-XX, while now this value is rapidly decreasing and, in 2002, fell to 110.8 km^3, i.e. decreased almost 10 times. Water area has been lowering as well and, at present, the area (Big Sea) has decreased to 28 % of the initial one (Figures 7-8).

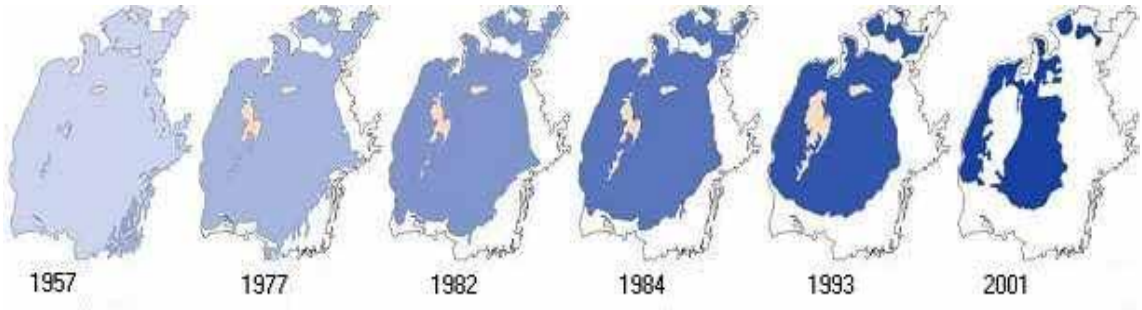

Fig. 7. Dynamics of water area of the Aral Sea
Source: GRID-Arendal

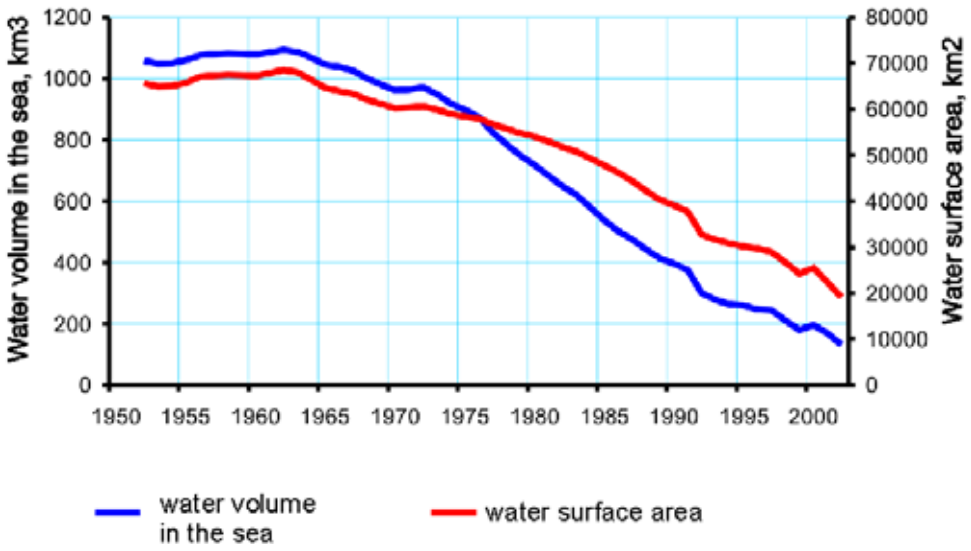

Fig. 8. Dynamics of water volume in the Aral Sea and of its area

Moreover, the sea level drop was accompanied with an intensive increase of salinity in the Aral Sea. In 1950-1965, the Aral Sea was a slightly saline water body. The salinity varied from 9.74 to 10.8 %. Until 1980, the rate of salinity increase had been low but since 1981 it speeded up and equaled 1-5 % per year and by 2002 sea salinity amounted to about 75% (Fig. 9).

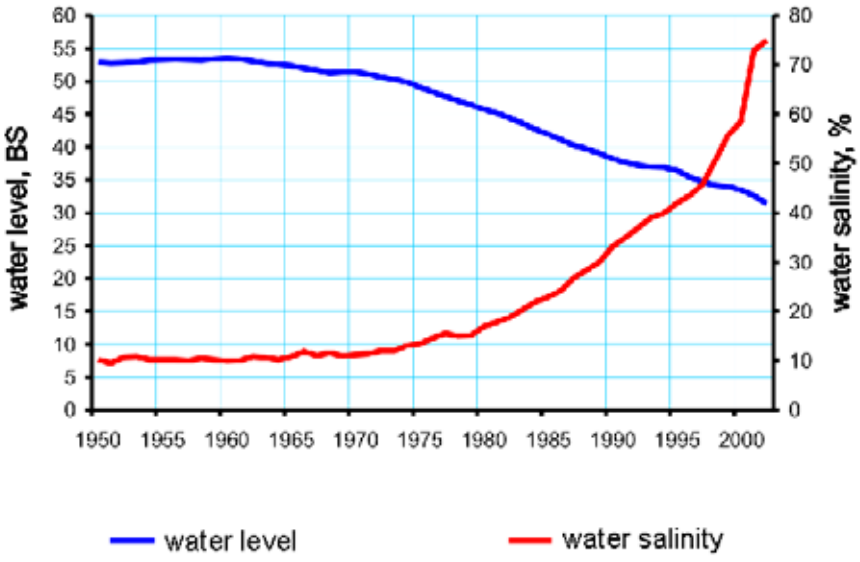

Fig. 9. Water level and salinity dynamics in the Aral Sea

The level drop has also led to occurrence of huge sandy deserts on the exposed seabed. The desertification rate varies from 162 to

2387 km^2/year. Maximum expansion of desert areas was observed in 1981-1985 (2387 km^2/year). In 1986-1995, the rates slightly decreased to about 600 km^2 a year. Since 1996, the desertification rate has increased and averaged 1787 km^2 a year in 1996-2000 (Fig. 10).

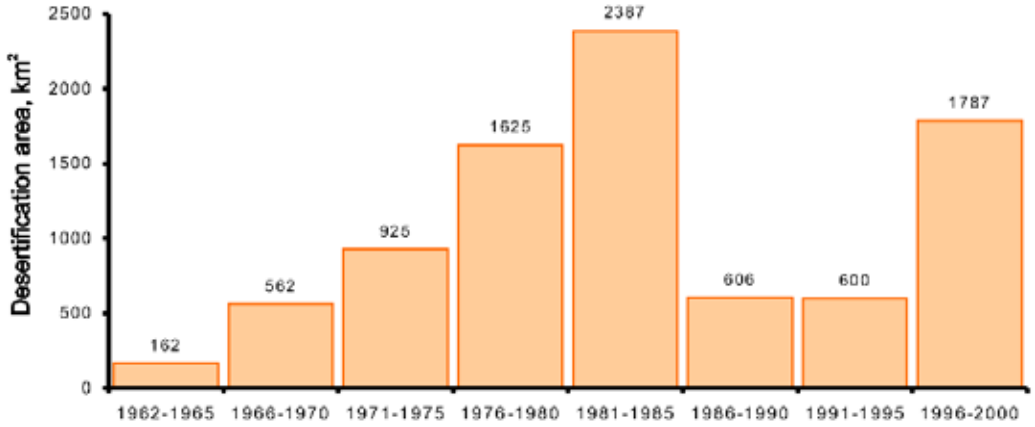

Fig. 10. Desertification rate on the exposed seabed

Nowadays, it is unreasonable to restore the former sea level at 53.0-40.0 m.

Sample calculations of SIC ICWC made for the 50-years series for the future show that, according to "Optimistic" scenario, irrigated agriculture would not suffer from shortage and inflow to the Syrdarya delta (Kazalinsk) would be 8.0 km^3/year. Inflow to Small Aral Sea is estimated to be 6.0 km^3/year, which is enough to stabilize its level at 42 m, with transferring of excess water to Big Sea (construction of dam is finished now and the Northern Sea is being filled. Inflow to delta from the Amudarya river (Samanbai station) is estimated to be 14.3 km^3/year in Optimistic scenario and it is 5.5 km^3 more than in Business as Usual scenario and 9.4 км^3 more than in National Vision scenario.

The body of the Big Aral Sea will be again divided into two components – Eastern and Western parts – with quite different bathymetric characteristics. Western part is deep, while Eastern one is shallow.

Under existing water infrastructure in Priaralie, Western part practically do not receive water and would gradually evaporate, whereas in Western part we will observe high fluctuations of the shoreline depending on inflow.

Option "Business as Usual" would maintain level at ~ 25.0 BS in Eastern part, while in Western part the level would drop to ~ 20.0 BS over the 20 years and further would continue decreasing.

"Optimistic" option leads to periodic division of the Big Sea into Eastern and Western parts, with the mean annual level at ~ 28.0 BS and dropping of water levels to ~ 25.0 BS in Eastern part and to ~ 23.0 BS in Western part.

Under such conditions it is necessary to orient towards maximum restraining of the sea level drop and to further environmental stabilization in coastal area. In other words, the first-priority measures for the near future are environmental maintenance in the area of delta lakes and bays (Fig. 11).

Analysis of long-term data shows that in 1950–1960 the total area of delta lakes, for example, of Amudarya river delta, was 300 thousand ha and salinity of these lakes was not more than 1.5–1.7 g/l. Almost all lakes were fresh, with good water quality, and, therefore, favorable environment conditions were maintained in this region.

State of aquatic ecosystems in Amudarya delta zone completely depends on quantity and quality of river water flowing to the region. In the second half of XX century, decrease of inflow to the Amudarya delta caused degradation of all water bodies in Southern Priaralie.

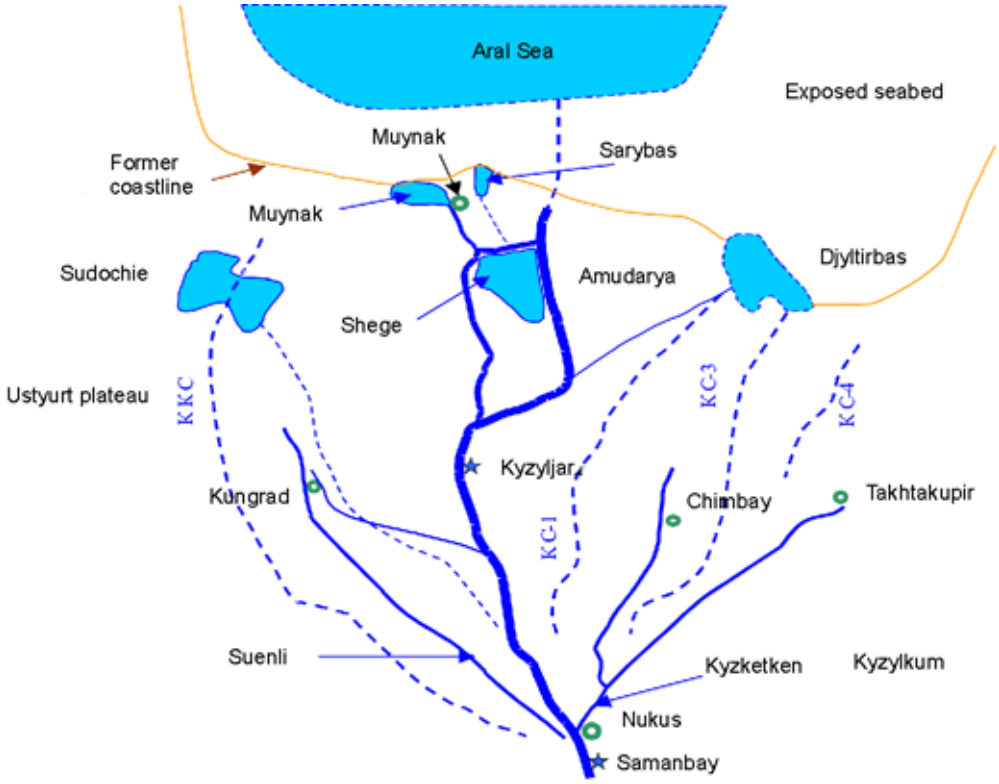

Fig. 11. Water bodies in Southern Priaralie

Previously fresh lakes Sudochie and Karateren became saline due to small inflow of fresh river water. In low-water year 2001, salinity reached 43572 mg/l in Sudochie lake. As to other delta lakes, such as

Sarybas, Muynak bay, their salinity increased to 5000–8300 mg/l. Actually, since 2002, state of the lakes has been improved. According to SANIIRI's measurements, water salinity varied from 3500 to 1200 mg/l in Mynak bay in 2004. Considerable desalination (to 1460 mg/l) was observed in Sarybas bay as well.

Table 2. Water quality changes in Amudarya delta lakes, according to salinity degree

Lake	Salinity, g/dm^3			Salinity class			Salinity range, g/dm^3
	1998	2002	2000	1998	2002	2000	
Shegekul	1.2	1.2	3.6	4	4	6	1.1-5
Muynak	5.1	4.8	3.8	7	6	6	3-18
Sarybas	1.4	1.6	1.6	4	5	5	1.1-3
Sudochie	n/a	1.9	43.6	-	5	10	1.6-40
Karateren	n/a	6	3.2	-	7	6	3-18

At present, many lakes of Amudarya delta exist mainly at expense of drainage and waste water from irrigated areas of Southern Priaralie.

Such delta lakes and former bays as Sudochie, Adjibay, Karateren, Djiltirbas and others depend on the flow from large collectors of Southern Priaralie, including KKS, GK, Ustyurt, KS-1, KS-3, KS-4. Drainage and waste flow from irrigated areas of Southern Priaralie averages about 1.5-2.0 km^3/year.

It may be noted that hydrochemical and hydrobiological regimes of delta lakes are quite unstable and depend on flow probability of the Amudarya river. Therefore, in order to ensure stability of those lakes, inflow should be kept at a level of 4.4 km^3/year irrespective of flow probability.

Environmental stabilization around Arnasai lake system (Syrdarya river basin)

Whereas natural lakes in Amudarya river delta have begun to suffer from water shortage, as a result of human impact, a lot of lakes that are fed by collector, drainage and waste waters have been occurred in natural sinks. An example of human environmental impact intensification is the occurrence of such lakes as Tuzkan, Aidarkul, and Arnasai that is called as Arnasai lake system in desert area in Uzbekistan. At the beginning of their formation, the lakes mainly served as natural ponds collecting drainage and waste waters from irrigated areas in Hunger Steppe.

Human impact on the Syrdarya river runoff has led to forced disposal of considerable winter flow quantity to Arnasai sinks, where previously small lakes such as Arnasai, Aidarkul, Tuzkan (Arnasai lakes). The area of these lakes began to increase rapidly and adjacent area, including irrigated agricultural lands became water-logged.

At present, Arnasai lake system accumulates waste water from Chardara reservoir and drainage and waste water from irrigated land of Nizhnesyrdarya basin administration for irrigation systems.

River water from Chardara reservoir is received in winter and spring. Usually, this lasts from the time of full filling of the reservoir till be beginning of intensive river water diversion for irrigation, i. e. from January to May, and depends on quantity of releases from Toktogul reservoir (Kyrgyzstan) (Fig. 12).

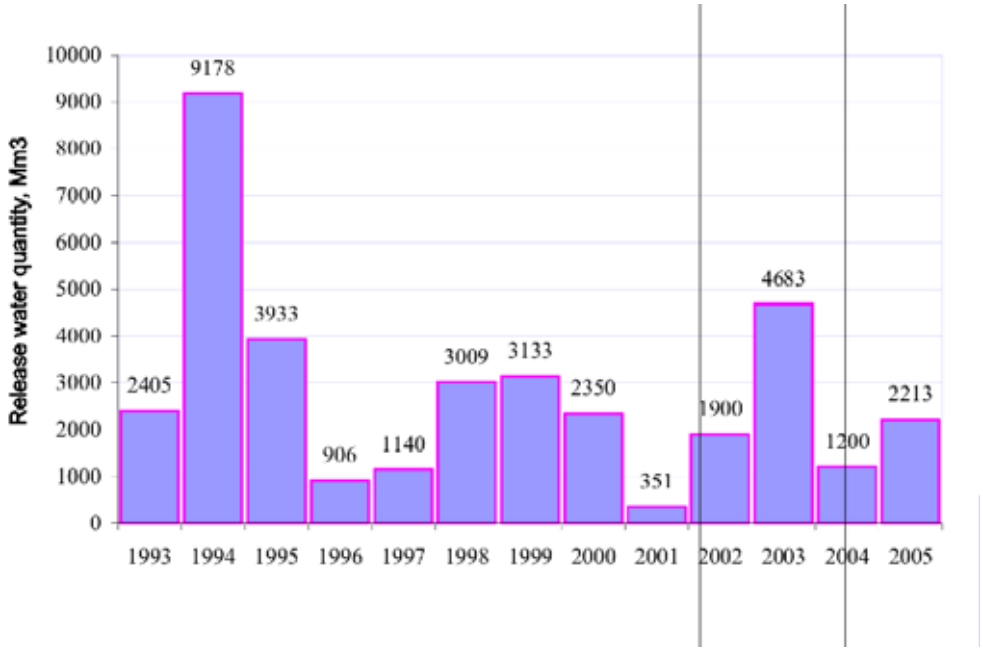

Fig. 12. Dynamics of annual river water releases from Chardara reservoir to Arnasai lake system

Drainage and wastewater inflow to Arnasai lake system, varying subject to flow probability, amounts to:

- 2.8 km^3/year in high-water years;
- 2.1 km^3/year in normal years;
- 1.5 km^3/year in low-water years;

Due to raise of water level of the lakes caused by intensive disposal of winter river flow, water quantity in the lakes and flooded area are increasing (Fig. 13).

As a result of flooding of huge areas within Arnasai lake system, Uzbekistan's economy suffers great damage. In order to prevent this phenomenon, massive efforts are needed for achievement of coordinated water policies of the riparian countries, particularly of Kyrgyzstan.

Thus, unreasoned human impact on water resources may cause more intensive desertification (which takes place in Southern Priaralie), on the one hand, and economic damage growth and biodiversity losses due to flooding of vast area (as in Arnasai lake system), on the other hand.

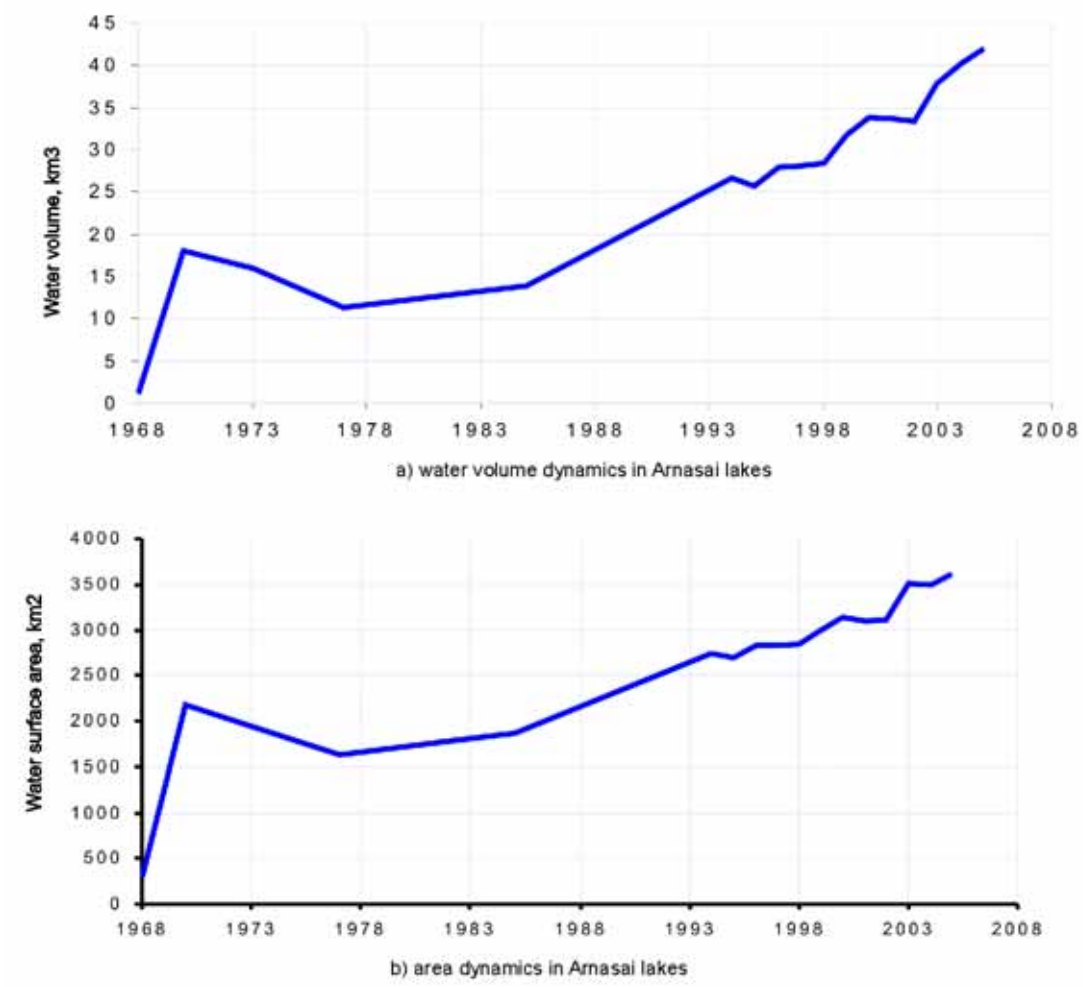

Fig. 13. Dynamics of water quantity and area of Arnasai lakes

Current mechanisms for ensuring water supply to environment and natural complex

Water resources management and allocation in Central Asia at the regional level is under jurisdiction of the Interstate Commission for Water Coordination (ICWC), while at national level this falls under responsibility of relevant Ministries, Departments and other Agencies.

Besides, at the interstate level, Basin Water Organizations (BWO) of Amudarya and Syrdarya are occupied these issues. 85 - 90 % of their activity mainly refers to management and allocation, as well as use of water resources. It is necessary to note that, at present, the interstate water institutions (ICWC, BWOs) do not sufficiently deal with such issues as provision of environmental releases, protection of water resources from pollution, etc. by the reason that these refer to national level, though By-Laws of the institutions include water protection. However, actually, these provisions are not fulfilled and remain on paper.

Environmental needs regarding water from Amudarya river and Syrdarya river are mainly determined by sanitary releases along the river channels, by limits of inflow to the river deltas and the Aral Sea (Priaralie), as well as by special releases (from Amudarya) to irrigation systems in Khorezm, Dashoguz, and Karakalpakstan.

In general, three types of releases are considered: *ecological*, *sanitary* along the river and *sanitary-ecological* to irrigation network of canals.

Ecological releases along the rivers are necessary to maintain natural and artificial aquatic ecosystems. As such ecosystems we can consider Priaralie systems. Arnasai lake system is not considered since its status has not been determined and the countries have not agreed yet upon its water requirements as of ecological system. There is no unique decision on environmental demand of Kazakhstan's part of Priaralie. Given problems needs special modeling as was made for Amudarya river delta.

Sanitary releases along the rivers are required to sustain rivers as water bodies of natural (environmental) and social importance, in particular to avoid deterioration of sanitary conditions and quality of river water.

Sanitary-ecological releases are made to irrigation systems of Khorezm, Dashoguz, and Karakalpakstan so that keep minimum volumes in canals, mainly for household and drinking water supply.

Limits (quotas) of inflow to Priaralie (including collector flow) and additional releases to irrigation systems are established for growing and

non-growing seasons at meetings of the Interstate Commission for Water Coordination (ICWC).

There exist conciliatory documents that were approved at the meetings regarding setting of necessary inflow (ecological releases) in quantity of 3,0 km^3 for delta watering. These provisions, actually, are not fulfilled, especially in low-water years.

Major positions related to water management and protection at the national level, i.e. at the level of the Republic of Uzbekistan, are regulated by the following documents:

- Constitution of the Republic of Uzbekistan, 1992;
- Water and Water Use Law, 1993;
- Nature Preservation Law, 1992;
- Decision of the Cabinet of Ministers 1992 on Adoption of Regulation regarding Water-Conservation Zones at Reservoirs and other Water Bodies, Rivers, Main Canals and Collectors, as well as at Sources of Drinking and Household Water Supply, of Health and Recreation Functions in the Republic of Uzbekistan.

According to the Constitution, Article 55, "land, the interior, water, flora and fauna and other natural resources are the national property, subject to rational use and are under the protection of the Government".

According to the Water and Water Use Law, Article 1, objectives of the national legislation are: "regulation of water relations, rational water use for social and economic needs, water protection from pollution, clogging and depletion, improvement of the state of water projects, as well as protection of business, institutions, dehkan farms, and citizens in area of water relations".

The Article 3 of this Law sets that water is the state property and the national wealth of the Republic of Uzbekistan. This refers to: rivers, lakes, reservoirs, other surface pools and water source, canals and ponds, groundwater and glaciers.

There are also regulations on maximum permissible concentrations and other criteria for assessments.

In principle, the republic has good legislative base ensuring management and protection of water resources and regulating all aspects regarding implementation.

However, in reality, until now, environmental and natural complex matter has not been raised so urgently both in Central Asia and at national level.

At least, approximate assessments of required water for the environment and natural complex did not always represent the facts, and,

finally, this has led to environmental ill-being in certain areas of Uzbekistan and, first of all, in river deltas.

The whole agricultural policy and provision of flow share for the environment depends on flow probabilities in the Amudarya and Syrdarya rivers. In high-water years, as a rule, we have excess flow which is allocated to environmental needs. The problems arise in low-water and in normal years.

In low-water years, water supply to ecological objects (inland pools, pastures and grassland, river deltas, etc.) is almost stopped. For example, in 2000-2001, Amudarya river downstream even faced the problem with drinking water supply to population.

In terms of priority and importance of keeping flow for environment, the main objective is to preserve bio-resources in Amudarya and Syrdarya deltas.

SANIIRI and Ministry of Agriculture and Water Resources estimated that to maintain good environmental conditions in Amudarya river delta, ecological flow (release) downstream of Takhiatash waterworks could be 5556.8 Mm^3/year, including 1151.1 Mm^3/year of collector waters.

Since 1991, ICWC meetings annually fix limit of sanitary-ecological releases in an amount of 650 Mm^3/year for the Amudarya downstream (within the area of Uzbekistan).

Resource-based economic approach to natural resources use, primarily of water lies in the heart of environmental and social problems in Central Asia. Under such approach, water resources (available stock, withdrawals, allocation among the states, etc.) are viewed only from the angle of supply-side. Environmental role of water resources, demands of natural landscapes and ecosystems for their preservation, as well as probable consequences of disturbance have not been considered at all. Unfortunately, such approach to water use has been dominating yet. At the same time, The Aral Sea base shows that the momentary economic benefits from extra produced rice or cotton at expense of unbalanced water use are not comparable with the ecological and social losses caused by disappearance of the sea, destruction of Prearalie infrastructure, and large-scale deterioration of people health.

This situation calls for elaboration of new reliable management mechanisms that are based on the balance of economic interests and of natural ecosystem sustainability. In this context, an essential element of any water-management activity should be ecological forecasting. This should go before development of water use projects and be based on data of regular, systematic, and reliable observations over ecosystem elements and on data from forecast models. It would be advisable to develop methods for economic assessment of the en-

vironmental component of water resources in order to consider value of aquatic ecosystems in cost-benefit analysis of water use.

National water laws and related laws should reflect water functions as a means to maintain natural ecosystems. Principle of obligatory preservation of aquatic ecosystem conditions should be laid as major provisions of such legislation.

Regional Water-Management Master Plans should be viewed as an important tool for ecosystem approach to water-related activities. Riparian countries should include ecosystem requirements both in water management plans for certain parts of watershed of transboundary water bodies and in bi- and multilateral actions plans covering the whole watersheds.

For water planning and management, the river basin should be viewed as a single complex of ecosystems since it represents a successive chain of interlinked local ecosystems from sources till estuary. This approach calls for more active and coordinated intergovernmental cooperation at all levels and for development of new effective management tools and facilities. Development of models of environmentally safe river run-off is very important. The models could be used in estimations of optimal scope of water-management activities.

The ecosystem approach to management helps to assess value and role of water resources in Central Asia in different way. First of all, this refers to flow formation zones located in Tajikistan and Kyrgyzstan, as well as to large water bodies, such as the Aral Sea, Balkhash lake, Issyk-Kul lake, Irtysh river and others. Preservation of glaciers in Kyrgyzstan and Tajikistan and rational water use in the region is a guarantee of safety and sustainable development in Central Asia and adjacent areas.

Measures undertaken for environment and natural complex conservation

Governmental agencies, such as State Committee for Nature Conservation, Ministry for Agriculture and Water Resources, and Uzbek Hydrometeorological service deal with all the issues related to environment and natural complex conservation and to aquatic ecosystems use.

State Committee for Nature Conservation is responsible for conservation of the environment and natural complex, including water resources and aquatic ecosystems, monitors water quality and sets quotas for catch of fish, muskrat and various bird species.

Ministry of Agriculture and Water Resources of Uzbekistan is responsible for observance of water use, distribution, management and protection rules. The Ministry's scope of activities extends mainly over irrigated lands.

As was mentioned above, all natural resources, including water, are under protection of the Government. The Governmental Agencies undertake great efforts at local level to ensure observance of nature and water use laws.

In order to improve environmental conditions and water management, Uzbekistan participates in development of regional and national programs supported by international donors with share contribution from the republics.

Great activity has been carried out during last decade under the World Bank's Project "Clean Water and Sanitation", with financial contribution of Uzbekistan. Since 1999 to 2002, GEF Project was implemented together with the World Bank on construction of ecological object in the Amudarya river delta – "Restoration of Sudochie Lake".

In 1999-2002, comprehensive studies of periphyton biocenoses and zoobenthos were carried out in Sudochie lake within the framework of the WB and GEF Project "Environmental Monitoring of Sudochie Lake Wetland". Number of discovered species decreased twofold over 3-year studies (critically low-water years 2000-2002) (Talskih V.N., 2003).

Among recent on-going projects, the pilot project "IWRM in Fergana Valley" implemented under support of Swiss Development and Cooperation Agency (SDC) and the ADB's Project "Water Management in Command Zone of Amu-Zang Canal", which plans rehabilitation of pumping stations and large irrigation canals in 2005-2009 are the most important.

In 2004, through a loan of the WB and share contribution of Uzbekistan, activities on reconstruction of Southern Collector in the Republic of Uzbekistan were started. The project also includes nature conservation activities and restoration of natural pastures and grassland.

Strategy for achievement of sustainable development and poverty reduction, with focus on construction of water supply and sanitation facilities, as well as on environmental sanitation is a priority direction in Actions Plan of the Republic of Uzbekistan.

The main challenge of future sustainable socio-economic development in Priaralie is achievement of agreement between the riparian countries on amount of environmental demand for water, which is to be maintained in inflow to Priaralie in different, in terms of water availability, years.

As a result of these measures, progress has been made in area of nature conservation, though there are a lot of problems still to be solved.

Conclusion

As was mentioned above, water supply and water protection in Uzbekistan are not purely national issues but, in many respects, depend on policies of other Central Asian republics. In absence of agreement and interest of all Central Asian republics, one can't solve problems of environmental and nature preservation in the region as a whole, including in Uzbekistan.

Despite available and perfect laws on environment and nature preservation at national level (particularly in Amudarya downstream zone), this issue remains unsolved due to lack of recognition by riparian states of issue importance in terms of provision of necessary water quantity. We are observing extensive environmental deterioration that, finally, lead to socio-economic ill-being.

Current challenge is how to match the increasing demand for irrigated agriculture production and impossibility to reduce irrigated areas due to particular socio-economic importance of irrigation for the region with a need to increase environmental value of water, found and allocate necessary water quantities for deltas and rivers as independent water users. A trade-off between irrigation and nature use should be found.

This could and should be based on changes in way of thinking and methods of water use so that to improve relations between society and the nature.

Water users should orient to achievement of potential water productivity both in irrigation and in other water uses. At present, actual water productivity in grain-production farms varies from 1.3 to 2 m^3/kg of grain under potential productivity of 0.8 m^3/kg. Here we have reserves of at least 35...50 % of water used to obtain the same yields. Besides, there are huge water losses due to poor management, uncoordinated water delivery at the interface between water hierarchical levels, etc. Thus, we can surely release, at least, 25-30 % for the nature. And we do not need more! If we could guarantee minimum 25-30 km^3 of water to the nature out of available 118 km^3, it would be sufficient to make our rivers clean and productive, instead of being runoff ditches, and to revive fish, muskrat, birds and riparian woodland in river deltas. What do we need in this context:

- transfer from supply-side to demand-side management;
- develop extension services for farmers to provide them with the tools of economic and rational water use;
- approve and strictly observe environmental demand at national and regional level;
- on this basis, restore deltas and provide stable inflow to the Aral Sea. Kazakhstan shows excellent example in this respect through the Project of Small Northern Sea which is close to completion and the developing Project for Syrdarya delta management and improvement. Amudarya river delta is less addressed in this respect;
- apply principles of "consumer pays" and "polluter pays" everywhere;
- organize transboundary return flow management through BWOs and in-system return flow management and use through National basin administrations;
- involve stakeholders in protection of small-rivers and water-protection zones;
- establish system of water-ecological monitoring and, most of all, water quality monitoring;
- keep the public aware about transfer to hydro-ecological water management.

In order to mitigate adverse environmental conditions connected with pollution of aquatic ecosystems, we need to make a number of decisions at regional and national levels. The major points of those decisions would be:

1. Development of a long-term, consensus strategy of Central Asian republics for ensuring water for environment and natural complexes, similar to those developed at international level.

2. Raising of role and authorities of BWO "Syrdarya" and BWO "Amudarya" regarding provision of guaranteed inflow to environment and natural complexes.