INTEGRATED WATER RESOURCES MANAGEMENT

Experience and Lessons Learned from Central Asia – towards the Fourth World Water Forum

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I would like to dedicate this book to the memory of my mentor Mr. Akop Sarkisov, who was the great ideologist and organizer of the complex land development in Central Asia. We shall celebrate His jubilee and 50-years anniversary of the Golodnaya Steppe development in 2006.

I strongly believe that success of water management system in future depends on widely implemented IWRM principles, when its concept will be accepted and understood by not only water managers but also by water users and other stakeholders in large.

Prof. Victor Dukhovny
Vice President ICID

List of Acronyms and Abbreviations

WUA	Water User Association
WMO	Water Management Organization
DB	Database
KB	Knowledge Base
GEF	The Global Environmental Facilities
GIS	The Geographic Information System
GWP	Global Water Partnership
WCC	The Water Canal Committee
IWRM	Integrated Water Resources Management
SPM	Strategic Planning and Management
NGO’s	Non-Governmental Organizations
UNDP	The United Nations Development Program
EF	Efficiency Factor
AAC	Aravan-Akbura Canal
BFC	Big Fergana Canal
BAC	Big Andijan Canal
KBC	Khodjy-Bykyrgan Canal
SFC	South Fergana Canal
CA	The Canal Administration
MIS	Management Information System
CWUU	The Canal Water Users Union
DW	Drainage water
SIC	Scientific and Information Center
ICWC	The Interstate Coordination Water Commission in Central Asia
IWRUP	Integrated Water Resources Use and Preservation
UFWC	Ultimate field water capacity
DMT (DSS)	Decision Making Tools (decision support system)
FAO	The Food and Agricultural Organization of the United Nations
ICID	International Commission on Irrigation and Drainage
NATO	The North Atlantic Treaty Organization
UN ESCAP	The Economic and Social Commission for Asia and the Pacific of the United Nations
GWP CACENA	Global Water Partnership Central Asia and Caucasus
SCADA	Supervisory Control And Data Acquisition
SDC	The Swiss Development Agency
CIDA	The Canadian International Development Agency
IWRA	The International Water Resources Association

PREFACE

Water resources management requires the deep understanding of the special value of water for human life, interaction of human beings and nature, and the social significance of water resources for national economic development. Only with the knowledge about numerous interrelations that are being formed in the water sector to ensure the equilibrium between economic activity and eco-systems as well as about the role of water for evolution processes on the Earth, can one attend to water resources management.

As known, the noosphere development potential consists of four components: the environment, human society, industrial infrastructure, and financial resources (Dukhovny V., 2004). Water is the important constituent of the potential of nature and, at the same time, it actively affects other components of the development potential and by that defines the sustainability of economic development.

The necessity of developing the holistic conception of water resources management is predetermined by the integrated role of water, its plural interrelations and impacts on eco-systems, as well as by the vital need of the population for water. Therefore, considerably earlier than water professionals began to use the term “integrated water resources management,” the tendency towards integration already underlay many activities under civilization development. The creation of man-made water ways that linked river basins many years ago for navigation and transportation of people and goods, and the impressive irrigation systems of ancient Egypt, Middle East, Mesopotamia, and Central Asia are evidence of this process.

The great integrator was God who, according to the Bible, on the third day after creating the Earth has created water not simply as a substance but as the vast complex of rivers, seas, oceans, and “lower waters.” We should be engaged in implementation of the IWRM concept because our ancestors and God bequeathed this task to us!

First of all this publication is aimed at water professionals, including water policy-makers, who make decisions that predetermine the progress and content of current reforms in the field of governance and management of water resources. It is also aimed at the wide readers – representatives of civil society interested in the proper reforming of the water sector. Our readers should understand that today their country, region or settlement face serious water problems and the use of conventional methods of water resources governance and management (that were formed during last decades) does not allow solving these problems efficiently.

CHAPTER 1. The NEW LOOKS at OLD PROBLEMS

The basis of integrated water resources management (IWRM) was developed in some countries of Europe and other continents at the beginning of the 20-th century in the process of establishing the frameworks for water resources management, in the first place in the form of Spanish Drainage Basin Authorities known as “Confederaciones Hidrograficas”, and afterwards French Water Agencies, American and Canadian Irrigation Districts.

After the 1992 Dublin Conference, a term “IWRM” and its different interpretations such as “IWRM concept”, “IWRM approaches”, “IWRM process” etc. “over-saturate” the scientific papers; and integrated water resources management is represented as the panacea for the World’s water-related ills. Most often, the scientific papers that describe the IWRM practice consider a special case of water management where at best integration is employed for two or three components of the water sector, not being the universal and genuine IWRM system.

According to the most authoritative ideologists and authors, IWRM is the <u>process</u> of coordinated development and management of water resources that is defined by the following:

- Transition from water management within administrative units towards water management within the limits of drainage basins or irrigation systems (hydrological boundaries);
- Moving from sectoral water management towards integrated cross-sectoral one;
- Transition from the authoritarian one-way principle of water management “top-down” towards the more democratic two-way principle – “bottom-up” (forming water requirements and participation of water users in decision making) and “top-down” (establishing of water use limits (quotas) and support of water users);
- Transition from the command-administrative method of water management towards the corporative water management with participation of water users and other stakeholders in decision making; and
- Moving from water resources management towards water demand management;
- Transition from sectoral water management by water professionals towards public water management with participation of water users and other stakeholders;

Agreeing with abovementioned understanding of IWRM in principle, we propose to consider IWRM as a management system rather than a process. This management system should be based on the coordinated development and use of all available water (surface water, groundwater, and return water), land, and related resources within the hydrological units. In addition, it has to co-ordinate all interests of different economic sectors and hierarchical levels of water and nature management involving all stakeholders in decision making, planning, financing, preserving and developing water resources for the sake of sustainable development of civil society and conservancy.

Why should IWRM be considered as “<u>management system</u>” rather than “<u>process</u>”? Because the management system provides a sustainable environment for self-organization of driving forces aimed at implementing specific tasks that include forming and developing mechanisms taking into account dynamics of all transition processes and especially a capability of the system to adapt to new conditions. From the very outset, the management system provides for firmness of an ultimate aim and basic principles, but at the same time, it may adapt to varying conditions and withstand destabilizing factors owing to its ability for self-perfection.

Considering the practical experience presented in Version 2 of the IWRM ToolBox (The Global Water Partnership {GWP}, 2002; translated into Russian in 2003) shows that only three case studies out of 64 are actual examples of implementing the IWRM concept as a whole. In the recent paper published by Torkil Jonch-Clausen (TEC Background Paper No 10) only one pilot project out of 5, the same those described in the IWRM ToolBox – Australia: The Murray-Darling Basin Commission, is an example of real IWRM. Analysis of 35 projects (the World Wildlife Fund, 2004) has shown that most of them contain only planning IWRM or the working program, and just three projects actually provide putting the IWRM principles into practice in the form of the advanced system of water management. Among them, it may be mentioned once more the water management practice in river basins Murray-Darling and in region Siene-Normand (France), as well as the “Eurogladies” Water Rehabilitation Project in Florida.

Of course, the popularization of a term “IWRM” has positive implications from the point of view of attracting attention to the integration of water management processes. However, it often results in replacing the integrated system of water management by its fragments or even by slogans. We deal with the strange situation when the IWRM concept is struggling against the sectoral fragmentation but at the same time creates disintegration in the process of its implementation. It is not accidentally that there are many recent documents containing the criticism concerning interpretation and understanding of IWRM (Asit Biswas, the Water International, July 2004, abovementioned document of the World Wildlife Fund, 2004; Frank Jaspers, 2003 etc.).

Giving credit for the tremendous GWP’s activity related to the introduction of IWRM and completely supporting development of National IWRM Plans in some countries we want to mention that the interpretation of IWRM as “a process” created the uncertainty in understanding the IWRM concept (TAC Background Paper No 4, 2000). Such an interpretation distorts the IWRM core, and to some extent damages the main idea to reform the existing water management into the system aimed at high-efficient water resources use from all natural sources and achieving maximum (potentially possible) water productivity under all uses.

Only such an approach enables us to integrate requirements of the environment and society, eco-systems and industrial infrastructure, the needs of people and gigantic economic “devil” with its ulterior and evident trends, because each component of the noosphere either is related to water use or depends on a water factor.

Presenting IWRM in the form of “process” is an intermixing of two approaches. On the one hand, it is based on the interpretation of the method of integrated development planning (IDP) that according to Latin-American specialists (Biswas A., 2003, and others) is “the permanent process aimed at planning and developing the water sector in conformity with specific requirements.” On the other hand, it is based on the interpretation of IWRM as “the management system that meets specific criteria and operational characteristics.” A. Biswas describes division into IPWRB and IWRM in detail (Biswas A., 2003, and others). This author differentiates two kinds of the integration of water management activities, but at the same time, points to their interrelations. These interrelations are based on some general approaches: (i) activity within hydrological units (a river basin is the main unit for water management planning); (ii) use of all kinds of water resources (surface water, groundwater, and return water); (iii) taking into account all kinds of water uses; (iv) a priority of water requirements of eco-systems; (v) joint use of water, land, and related resources; (vi) public participation in decision making at all levels of the water management hierarchy; and others. It is necessary to note that division of IWRM approaches into “coordinated development” and “water governance” is described in a new handbook of the GWP (Catalyzing Change, 2004).

At the same time, IWRM includes the planned set of measures for each phase of development that are aimed at providing the specific level of water use and conservation as a result of applying this management system, and development of a flexible strategy that employs such tools as the forecasting system and development models, which take into consideration various options and possible scenarios of adverse impacts. Moreover, the selection and introduction of integrated measures should be implemented in such a way that allows to withstand adverse impacts and to facilitate achievement of the Millennium Development Goals. Thus, IWRM is the management system going through specific development phases with clear-cut specified parameters and perspectives rather than the process with its intrinsic instability that is typical for a dynamically transforming framework and activity affected by destabilizing factors. It is clear that an environment will change, however the IWRM system employs a set of tools that can provide the sustainable water and nature management based on adaptation to changes and ensure achievement of selected goals.

As Emilio Gabbrielli, Executive Secretary of the GWP, stressed in the Foreword to IWRM ToolBox Version 2, introducing IWRM, first of all, does require the joint effort of all stakeholders who, in most cases, have generally acted in isolation of each other, or even consciously or unconsciously fighting against each other. Based on IWRM principles it is necessary to provide beneficial positions for all stakeholders within the framework of water resources management. In this case, with complete awareness they should reject a selfish approach and assimilate an integrated approach and results of its application.

It is necessary to note that the pre-revolutionary practice in Russia, and later in the USSR, was aimed at integrated water resources development drafting the Integrated Water Resources Use Plans in different river basins (the Syr Darya, Amu Darya, Volga and other rivers, 1956, 1972 to 1987) and water management within hydrological units (Zerdolvodkhoz, 1926; UPRADIC, 1927).

Deep understanding of the need in integrated water resources management was inherent to the outstanding Russian scientist and water professional professor G. Rizenkampf (1930) who at the beginning of the last century in his book “The

Golodnay Steppe Irrigation Project" has written: "The irrigation scheme is, as it were, a canvas over which the future life will be "embroidered"; and during this process it is necessary to fancy clearly the entire image of the future life. Construction of the irrigation scheme should not be a self-sufficing goal, this is integrated part of the whole – revival of a desert …. The main requirement is the most rational organization of all life and not just construction of the irrigation scheme; achieving the maximum effect as a whole and not just in details. It is necessary to meet those technical and economic requirements that will result in the better organization of the life as a whole. One needs not only to draft the irrigation project, but also to develop the action plan for developing the whole region under consideration including roads, industrial and market centers, the most rational power sources for plants, factories etc. In addition, it is necessary to prove that the designed irrigation scheme is inherently related to the future organization of the life and is a correctly designed part of the whole."

Just such an approach has predetermined development of virgin lands in Central Asia (the Golodnay Steppe, 1956; the Karshi Steppe, 1964 etc.) which, in fact, are unique examples of integrated development of large-scale irrigation districts. Although these approaches suffered from the lack of public participation, in all other respects they have completely met modern requirements of the IWRM concept. For instance, development of virgin lands in the Golodnay Steppe based on irrigation has included the following components:

- Irrigation and agricultural development of virgin lands;
- Drainage to control land salinization;
- Construction of a residential area on new-developed lands;
- Water saving at all levels of water management hierarchy;
- Construction of water and engineering infrastructure (water supply pipelines, roads, power transmission facilities, communication lines, gas pipelines etc.); and
- Establishing the O&M framework both for irrigation systems and other engineering infrastructure;

Therefore, in the 1960s to 1980s, sufficiently high indicators of water management were achieved in the Golodnay Steppe Irrigation Scheme covering the area of 320,000 hectares (an efficiency factor of the irrigation system is 0.78; a head water withdrawal is over the range of 8,500 to 10,000 m3/ha under an average crop yield of 2.8 to 3.2 ton/ha).

The integrated water development projects have the long-term history in Central Asia. Since the 1950s, the Master Plan for Integrated Water Use and Conservation in the Aral Sea Basin and Master Plans for Integrated Water Use and Conservation in the Amu Darya and Syr Darya River Basins have become the basis for international water sharing in the region. They were developed based on the following components: (i) forecast of water resources availability; (ii) predicting water demand; (iii) water balances; (iv) cross-sectoral water demand; (v) flood control measures; (vi) hydropower generation; and (vii) the irrigation development strategy including milestones and timeframes. At the same time, these plans did not include legal and institutional components and paid insufficient attention to ecological problems and measures to provide planned time frames. Although these plans were coordinated with the Governments of all five countries, they were not accompanied by the wide public awareness campaigns and particularly by public participation in the decision making process.

From the position of current approaches, it is clear that IWRM is the long-term process. ***Its introducing and establishing the well-functioning management system are the long-term action*** since it is required not only to plan the water supply and distribution, but also to form the specific political environment (in the foreign publications it is defined by the term “governance”). An enabling environment is the basis for introducing IWRM, and its ultimate aim may be achieved only in case of there are political will and commitments (“governance” is imbued with the need to develop the sustainable water management system).

The main theses of this publication are based on outcomes of long-term activity of Professor V. Dukhovny in the field of the irrigation schemes management in Central Asia, and on data of IWRM development projects implemented by the SIC ICWC in collaboration with other organizations. In particular, information and data of the following projects were employed: “The Principal Provisions of the Regional Water Strategy for the Aral Sea Basin” (1996 to 1997); “IWRM in the Amu Darya Delta” (1999 to 2003); “The Strategic IWRM Planning” (2002 to 2004); and “IWRM for Lower Reaches of the Amu Darya and Syr Darya Rivers” (2004 to 2005).

Authors have managed to adapt main provisions of the IWRM concept to improving active irrigation systems within the framework of the most ambitious and fruitful project “Integrated Water Resources Management in the Fergana Valley” (the IWRM-Fergana Project) funded by the Swiss Agency for Development and Cooperation (SDC). During the period since September 1, 2001 until February 28, 2002 the initial phase of the project was implemented, and since May 1,2002 until April 30, 2005 the implementation phase was in progress. The project is implemented by the consortium consisting of two institutes – the International Water Management Institute (IWMI) and the Scientific-Information Center of the Interstate Coordination Water Commission (SIC ICWC)

The project covers four provinces in the Fergana Valley: Andijan and Fergana Provinces in Uzbekistan; Osh Province in the Republic of Kyrgyz Republic; and Sogd Province in Tajikistan. Project activities are mainly carried out within the command areas of three main irrigation canals – by one in each participant country: the South Fergana Canal in Uzbekistan that is simultaneously the inter-state, inter-provincial, and inter-district canal (SFC); the Aravan-Akburyn Canal (AAC) in the Republic of Kyrgyz Republic that is also the inter-district canal; and the Inter-District Khodja-Bakirgan Canal (KBC) in Tajikistan (the former Gulakandoz Canal). The general goal of the project is “to contribute into social and environment safety, and to support the rural restructuring in Central Asian countries by means of improving the efficiency of water resources management by the example of interventions in the Fergana Valley” At present (since May of 2005), the Phase III of the IWRM-Fergana Project is in progress.

CHAPTER 2. WHY IWRM?

IWRM has arisen as distinct from narrow-departmental water use, which results in inefficient water management. IWRM is something another one, i.e. this is the instrument aimed at sustainable development and is to be applied to water management. Therefore, IWRM should mitigate impacts of the economic development on a catchment area by means of the more advanced practice of land and water use and improving the political, economic, and social environment.

IWRM has to provide for conditions to use jointly land and water resources. Deforestation changes natural surface runoff; intensive cattle breeding causes often groundwater pollution including by such pollutants as coli bacillus and nitrites. Increasing water use for hydropower generation reduces the water availability for irrigation and other agricultural uses. Introducing IWRM requires in the more extent of institutional and social reforms rather than engineering ones, although the engineering measures are the important component and can be applied without large expenses and increasing in water services prices in all economic sectors. There are many examples when IWRM considerably reduces capital investments and power consumption (see Box 1 and Box 2).

Box 1. IWRM aimed at increase in water availability for agriculture

In 1858, Henry Haynd proposed to build a dam across the South Saskatchewan River to link this river with the Qu' Appelle River creating a waterway from Lake Winnipeg to foothills of the Rocky Mountains in Canada. This project was implemented in 1967, when construction of the Gardiner Dam was completed and Lake Diefenbaker (the water reservoir) was created. The aim was to provide the surface water storage for multipurpose use, mainly for irrigation in the agricultural sector, rather than for water transfer. Canadian society united to find general and secondary benefits resulted from the project including hydropower generation, recreation, and water supply to 45 percent of the population in the Saskatchewan Province. The obvious secondary benefit of the project was the creation of natural habitats for waterfowl including endangered species such as song-plover and another wildlife. Other secondary benefits include the diversity of regional agriculture and the economy of the Saskatchewan Province as a whole owing to sustainable water supply for irrigation, intensive recharging groundwater, and even the changes in regional climate – the lake is large enough, and evaporation from its surface increased precipitations in arid districts along a wind direction.

It is possible to give many other examples of the successful, but only partial yet, introduction of the IWRM principles. The municipal water authorities use IWRM as the planning method, when upstream water use threatens water quality and by the growing physical and environmental water scarcity. During the second half of last century, conventional technological approaches aimed at large-scale irrigation, hydropower generation, and runoff control resulted in risks for sustainable water supply. According to data of the IWMI, 65 percent of irrigated lands in the world are located in the zones of persistent risk related to water scarcity, 20 percent of the population has not access to adequate water supply and sanitation. Most of aquatic ecosystems has degraded: millions of hectares of wetlands, thousands of kilometers of river channels, thousands of square kilometers of lakes disappeared or were polluted. All this is a result of the technocratic approach and departmental planning.

The IWRM concept, as the advanced approach, is being included in curricula of colleges and universities in increasing volumes all over the world. At the same time, this concept meets increasingly understanding of planners, managers, and politicians, and facilitates optimization and settling social, economic, and ecological problems and in that way promotes putting the sustainable development principles into practice. The Action Plan and the Millennium Development Goals adopted at the World Summit on Sustainable Development in 2002 in Johannesburg gave incentive for accepting the IWRM concept as the unique approach.

Box 2 IWRM aimed at supplying the safe potable water: New York City

Faced the water quality deterioration, the New York City's administration had to make decision either to build new water treatment facilities with investments of about US$ 6 billion or to improve water quality in sources with their following protection. The IWRM method allowed them to solve the problem with only US$ 1.6 billion. The New York City's administration has used the integrated approach that included the following: (i) purchase of the control packet of shares of farmers' lands on a voluntary basis (more than 130 square kilometers of lands were purchased by 2002); (ii) subsidies for application of advanced methods in farming, forest management, and other economic activities and grants for improving upstream waste treatment facilities; (iii) direct payments to communities in the basin in order to compensate their expenses for measures related to water saving. The results were impressive: reduce in the content of coli bacteria, phosphorus, and other basic pollutants on more than 50 percent. This provides safe water supply in the city and additional services of eco-systems in the basin.

What does resources management mean in general? This is the process of achieving targets and solving specific tasks by the most economically feasible and efficient method using limited resources and a set of regulated or routine procedures that include planning, organizational management, and training of personnel, monitoring works, and resources consumption. In contrast to the project management that is aimed at producing final product or object during the limited time horizon, management of ecosystems or operational activity should support <u>the clear-cut order of the reiterative processes, rules, regulations and interacting of components</u> that provide the stable and safe status of controlled objects, even under emergency, in order to produce necessary output or to meet the specific requirements.

Water resources management based on the above definition may be presented as delivering water to specific entities interested in its use. Better to say, the goal of water resources management can be formulated as <u>supporting the permanent balance between available water resources and the need of society and ecosystems in necessary water volumes with acceptable quality at the proper place and in proper time.</u>

Actually, our planet that looks like a blue ball from the outer space is not rich in fresh water resources that are needed for both human society and nature. It should be stressed just for nature in order to enable nature maintaining its quality during many centuries. As clearly shown in Figure 1, after satisfying all needs of nature including sanitary and ecological water releases through rivers and deltas only 4,200 cubic kilometers, 90 percent of which is already used, remain at the disposal of human society.

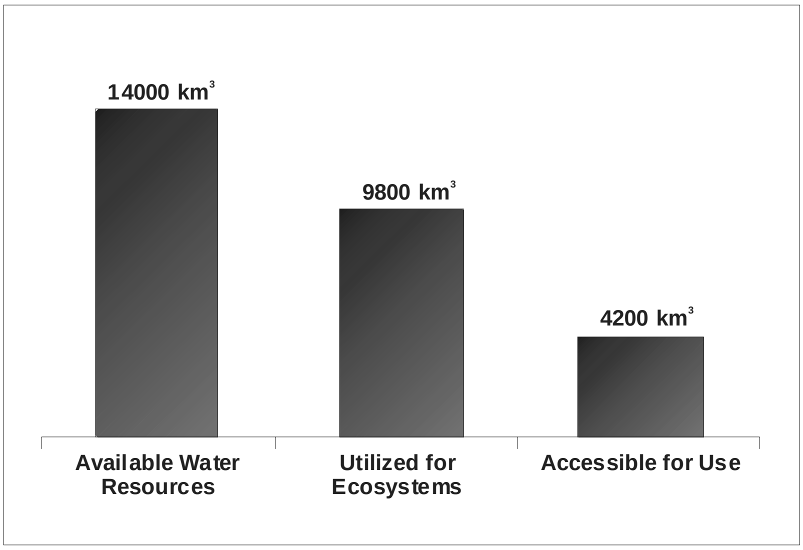


Figure 1. Global Fresh Water Availability and its Use (Shiklomanov I.A., 1997)

It means that only 700 cubic m per year remain to each person out of 6 billions living on the Earth for satisfaction of all the needs (potable water supply, industrial use, irrigation, hydropower generation etc.). Assuming equal water requirements all over the world the following approximate distribution of this water amount may be presented:

- Water supply to the population (150 l/day per capita) 56 m^3/year;
- Industrial water use 161 m^3/year;
- Irrigation 483 m^3/year;

It is necessary to note that such countries as Israel and Jordan successfully keep themselves within these limitations. Undoubtedly, the proper water management system and intensive state investments possible with the national income per capita more than US$ 15,000 a year help them to achieve these results. However, countries with the national income per capita about US$ 1000 a year and predominant development of the agrarian sector also are close to this average indicator, for example, Egypt maintain water consumption at the level of 900 cubic meter per capita per year. This is provided based on the following: (i) use of all available water resources (surface water, groundwater, and return water); (ii) the clear-cut system of water use limits, water distribution, and keeping records; (iii) participation of all stakeholders in decision-making; and (iv) permanent state supporting. The basis of this progress is "management and governance" or most likely vice versa "governance and management" that should supplement each other.

Is it easy to coordinate available resources with their demand? At first glance, – yes, it is, it seems the engineering task related to providing the proper balance (see Figure 2, the central fragment). On the one hand, it is necessary to estimate available water resources such as precipitation, surface runoff, groundwater storage, return water, and on the other hand, water demand of different economic sectors such as municipal water supply, irrigation, industry, hydropower generation, recreation, navigation, fishery, and of ecosystems. However, each component of the water balance is related to both the social situation and economic and political conditions. Diverse water sources, their interrelations, different departmental interests, different impacts and their consequences, various management tools and mechanisms, and complicated water infrastructure – all these components transform the simple task into the very complicated co-ordination of interactions of different blocks and providing the balance within this system. If we want to provide the balance of different interests, current and long-term goals, economic development and conservancy etc, then it is necessary to employ a holistic approach for solving this task.

Let us consider the pattern of interactions of different spheres and driving forces within the IWRM system in more detail. In the process of drawing up the water balance all water resources, so-called available water resources that include estimated river runoff and approved groundwater supply after deducting physical water losses related to seepage and evaporation from river channels and reservoirs and so-called sanitary water releases, are taken into account. It is very often return water formed due to irrigation, industrial or municipal uses, independently from its quality and time of formation is added to available water resources. Such an approach was employed, for example, in the Master Plan of Integrated Water Resources Use and Conservation (MPWRUC) for Amu Darya and Syr Darya basins. At the same time, ecological requirements of rivers, their deltas, and the Aral Sea itself were met according to the residual principle. Such a practice resulted in complete degradation of many our rivers and water bodies.

IWRM accepting as one of goals to meet, first of all, water requirements of ecosystems and then the needs of human society should be based on use of <u>water resources that are acceptable from the environment point of view</u>. It means that water resources that meet requirements of ecosystems (in river channels themselves in order to be the real river environment, and in deltas to provide fishery and to be the habitat for migratory and nested birds) should be subtracted from total available water resources. Under conditions existing in the Aral Sea basin, available water resources amount to 78 cubic km per a year rather than 126 cubic km per a year as estimated in the MPWRUC (see also Section 4.6).

In case of accepting an amount of 78 cubic km per a year in the Master Plans for the Aral Sea basin, even with the population of 50 million people instead of today's 36 million people it would be possible to limit the specific water withdrawal up to 1600 m3/year per capita. This amount is insufficient under the former water use system, but it becomes practical one if the water use practice is aimed at the potential water productivity. It is important to note that water use limits would encourage all water users to economically sound and rational water consumption rather than to its conspicuous consumption (at present, on average, about 2,500 m3 a year per capita). However, such a strategy requires the firm political will, and here we face the first impact of "politically enabling environment" on IWRM – setting priorities of ecosystems' water requirements.

Further, another factor of "water governance" takes place: if water will be used within limits of environmentally permissible water withdrawal from rivers then policy-makers should immediately accept providing of economically sound water use, managing of water demand, and ensuring of water-saving everywhere as a main principle of their policy. Such an approach requires developing adequate legal, financial, and organizational frameworks and regulatory instruments that have to be applied within IWRM. Here, it is necessary to distribute properly the roles within the political "superstructure" (between political, legislative, and regulative bodies) that in a foreign scientific literature is mentioned as "governance" and within the management system, which is subdivided into sub-systems responsible for water allocation, water use, conservancy, and emergency management. A the same time, "governance" specifies rules of game and provides encouraging (regulative) mechanisms, and managers are in charging for their implementation, detailed elaboration, and applying the established principles of water allocation, conservation, and monitoring while water users are responsible for rational water use in their practice. Interrelations related to water resources management and use between water management organizations and water users are included into the IWRM system, and the political "superstructure" provides establishing the mechanism of "governance."

Why does it need? If look aside the flow-chart in Figure 2, then it becomes obvious that each water management organization acting in the interests of either water supply of the settlements, city and district or irrigation should satisfy the requirements of its clients in sustainable, equitable, and high-quality manner. From this point of view, it seems practical that water supplier should have more water than it may be necessary for consumers in order to satisfy them under any changes in their water demands. French water professionals even have put the rule "water supply according to any demand" into practice considering that the extent of automation and technical capability of their systems is so high that they are always able to supply required water volumes (Plusquellec, 2004). However, such a management assumes the excess in resources either in water withdrawal or in expenses for water delivery with following consequences that go beyond limits of single supporting the balance "demand-and-supply", and are related to abovementioned institutes and management spheres.

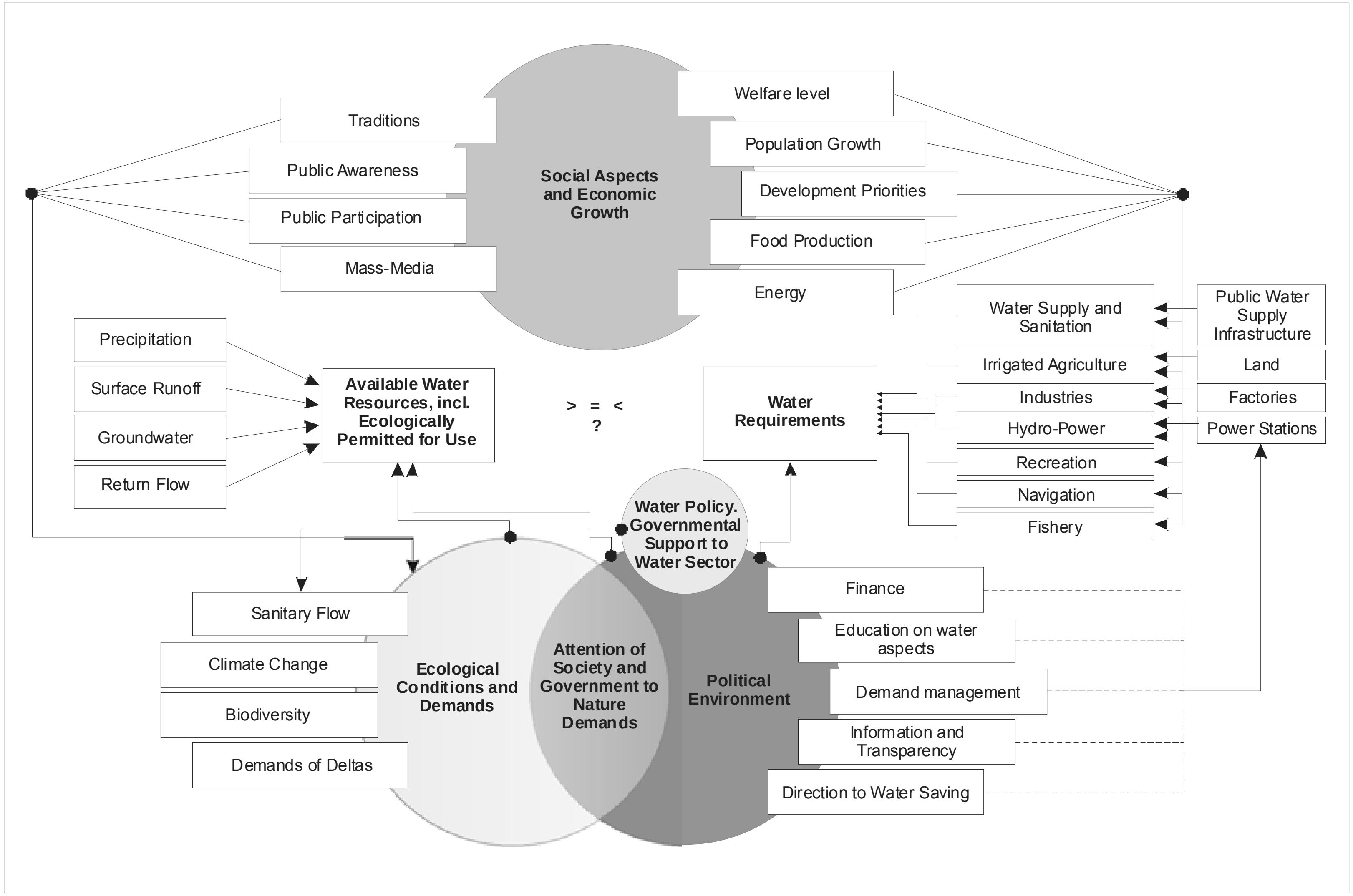


Figure 2. Flow-chart of Interacting Factors within the IWRM Framework

Again, the role of the Government is important, and the State shall define those frames, within which water management organizations should operate in the interests of all economic sectors and water users. The management system (IWRM) should provide <u>conditions for achieving (or approaching to) the maximum water productivity by all water users</u> (in irrigated farming, industry, and domestic water supply) and for successful surviving. It means that for producing unit output the minimum water volume will be used that is close to biological or technologically needed water consumption under minimum water losses over all the technological cycle including water intake, water conveyance, water supply, and water use (so-called potential water productivity). Such an approach needs in the clear-cut co-ordination of all technological processes as well as the observance of other technological requirements (non-related with water resources).

For instance, in irrigated farming it means the need to follow all procedures of land reclamation, soil treatment, soil fertility conservation, selection of crop variety etc; correspondingly in the water supply sector - the rules and regulations of sanitation, combination of wastewater treatment and use etc; and in industry – introducing the advanced production technologies, regeneration (cyclical) water use, wastewater disposal and recycling etc. Thus, activity within IWRM often goes beyond “pure” water resources use and conservation, and includes all water-related spheres as the main limiting factor. Just such an experience should be taken from integrated development and management of the territorial-and-economic complexes established on developed desert lands, which have been applied in the Golodnaya and Karshi steppes and at that time have provided the high specific productivity of water and land resources in the Central Asian region. The examples of managing the territorial-and-economic complexes within river basins that take place in such developed countries as the USA, the Netherlands, Switzerland, Austria, and others recommend application of this approach. Therefore, the sphere of applying IWRM should go beyond the limits of conventional water resources management in some zones with water scarcity and intrude into the spheres of social and environmental management providing their coherent development under the leading role of “water governance.”

Let us look once more at Figure 2. It is obvious that the political environment using specific financial instruments (incentive-stepped tariffs for water and the system of penalty sanctions and incentives) is encouraging all water users to reduce their water demand. At the same time, “governance” encourages the use of social instruments – traditional methods of economically sound water use, and public participation in decision-making related to water sector development and management. Under clear-cut defined rules of play, the IWRM system may be adapted to conditions of each river basin on the basis of general principles of “governance” taking into consideration the limiting management factors and the balance of water resources and demand.

Almost ubiquitous water scarcity (temporary or permanent; on-going or future) does not allow surplus water consumption. Another limitation for water use is the hydrological connection between surface water and groundwater along streams as well as the non-uniformity of distribution of water users and natural “consumers” over the basin territory.

The spatial and temporal non-uniformity of water use promotes conflicts of interests regarding water volumes (the upstream water use is reducing inflows to downstream areas), water supply schedule (the schedule of water use for the hydropower generation conflicts with the schedule of water use in the irrigation sector and environment requirements), and water quality (return water disposal at upstream sections of the river basin is polluting the water used in downstream areas). Another problem is insufficient financing water infrastructure development, operation, and maintenance that in the certain extent is related to different water productivity and efficiency in different economic sectors. As a result of such contradictive trends, the environment for "hydroegoism" is created, and it can be overcome only owing to very balanced and rational governance of the water sector and the integrated management that requires not only technical knowledge, management skill, but also the system approach.

It is important to note that in the process of IWRM implementation, there is not any need to seek universal and stereotyped approaches that are acceptable for all (this principle is clearly stated in the IWRM ToolBox Version 2, 2003) however, at the same time, more or less general rules regarding the institutional framework should be formulated. However, reforming the legislative base is possible in the less extent, and extremely limited possibilities exist for reforming financial-economic structures because they much more depend on the specific character of political and economical conditions, economical potential of the State and water users, the environment status as well as on the need to develop and to support national culture, education, traditions, social pattern of land use etc.

In the large extent, this can be referred to management rules that are the most vulnerable part of the modern management system, and require paying the most attention of all specialists of the water sector because each basin, each sub-basin, and each water management or irrigation system, as each man, has its own features. This is predetermined not only by specific landscape, configuration and lithology of a watershed, but also by conditions of water withdrawal and distribution (surface water sources or groundwater; regulated or unregulated flow), parameters of water distribution system; the combination of hierarchical water management levels, composition of operational works and conditions at different levels of the water management hierarchy.

Therefore, the mechanism of water management and distribution has to use not only the sectoral rules, but also to provide the possibility for formulating adequate regulations in case of changeable conditions. For their development, the active interaction of high-skill international expert, scientists, and water professionals with national water professionals and water users engaged in organizations that put the IWRM principles into practice is needed.

At the same time, water resources management becomes not only the professional activity, but also an art. The specific system of organizations of active stakeholders, aimed at solution of specific tasks and achieving necessary results, which provides forming, maintaining, and developing management mechanisms that are needed to be responsive to impacts of the transition processes, and is capable for self-perfection. It is especially important that purposes, basic provisions, and principles specified for the management system remain in force during the long-term period, and mechanisms of adaptation and self-perfection will being adjusted to changes in the internal and external environment. Thus, such an approach and methods of its implementation are the basis for the sustainable balance of many components and integrated water resources management. Let us look again at the above-mentioned formulation of IWRM, which in our interpretation is defined as follows:

“IWRM is the management system based on consideration of all kinds of water resources (surface water, groundwater, and return water) within hydrological units that coordinates interests of different economic sectors and hierarchical levels of water use, involves all stakeholders into decision-making, and promotes efficient use of water, land and other natural resources for the sake of sustainable satisfying water requirements of eco-systems and human society”

IWRM is based on the following key principles that define its practical backbone:

- Water resources management is implemented within hydrological units in concordance with geomorphology of the drainage basin under consideration;
- Management takes into consideration assessment and use of all kinds of water resources (surface water, ground water, and return water) taking into account the climatic characteristics of the region;
- Close co-ordination of all kinds of water uses and organizations involved into water resources management including cross-sectoral (horizontal) co-ordination and co-ordination of hierarchical levels of water governance (basin, sub-basin, irrigation system, WUAs, and farm);
- Public participation not only in the water management process, but also in financing, planning, maintaining and developing water infrastructure;
- Setting the priorities of water requirements of eco-systems into the practice of water management bodies;
- Water saving and unproductive water losses control by water management organization and water users as well as water demand management;
- Information exchange, openness and transparency of the water resources management system; and
- Economic and financial sustainability of water management organizations;

In the process of putting the IWRM principles into practice, it is necessary to consider the following:

- <u>The political environment (“governance”)</u>: laws, international agreements, political climate, social conditions and priorities, commitments related to public participation; economic status, political will and priorities, the state participation in financing etc. Just governance should accept and promote abovementioned IWRM principles by transforming them into approved regulations and establishing necessary management mechanisms;
- <u>Control objects</u>: all kinds of water resources, hydraulic structures for water supply control and monitoring, land resources including irrigated areas, eco-systems, and irrigation systems;

- <u>Participants of water management</u>: water management organizations and their personnel, governmental and non-governmental organizations, all social groups, beneficiaries of the projects, the private sector, and municipal bodies;
- <u>Management mechanisms</u>: different projects; legislative and institutional tools, regulatory tools, economic tools (methods of water charging, tariffs, penalty provisions, licensing, and financial incentives), modeling, principles of management "top-down" and "bottom-up", standards, automation of water control systems, etc.; and
- <u>Natural conditions</u>: climatic, geo-morphological, geological, hydrogeological, soil, and biological;

It is necessary to take into consideration one more important circumstance and namely building up the IWRM system should be based on the combination of the IWRM strategy that aims at the Millennium Development Goals formulated by the UN (details are provided in the GWP publication "Catalyzing Change: A handbook for developing integrated water resources management (IWRM) and water efficiency strategies") and IWRM tools. The IWRM tools include the following: (i) water resources distribution management mechanisms; (ii) water demand and use management mechanisms; (iii) nature management mechanisms including water quality control, and (iv) emergency control mechanisms. Each mechanism is a set of tools that will be described in more detail in Chapter 6.

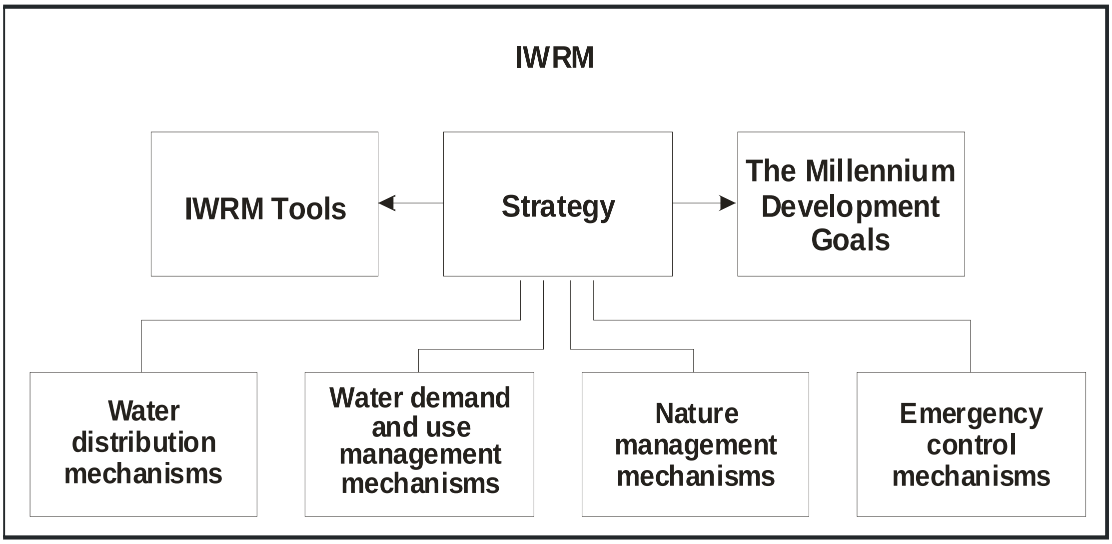


Figure 3. The System for IWRM Implementation and Development

Here, it needs once more come back to the notion of IWRM – "system" or "process." After comprehending the principles, parameters, and time horizons of the today's stage of water resources management, "governance" identifies a body or the group of organizations that with participation of water users have to develop the flexible development strategy and implementation mechanisms including forecast and development models that are capable to take into account different options and possible negative trends and to propose measures for withstanding destabilizing factors and facilitating implementation of the Millennium Development Goals.

Based on this strategy it is necessary to prepare the Terms of Reference to the design and scientific institutions for developing the Iterative Water Resources Development Plan (IWRDP), which should provide for the permanent process of elaborating essential measures for transition to the new stage of the scientific and technological advance and water resources development that should be adequate to the new status of the environment and human society. Thereafter, the set of mechanisms will be improved or changed at each new stage. On the one hand, such an approach provides the completeness of IWRM at each stage and, on the other hand, the on-going improvement of water management in the process of moving from one stage to another one. The role of "governance" consists in monitoring and promoting the introduction of IWRM at the current stage and preparation of the IWRDP for the outlook.

Summarizing the abovementioned in his chapter, we would like to stress the following:

At the modern stage, under conditions of global economic changes, unpredictable dynamics of prices on agricultural output and energy resources, of currency exchange rates and market relations, the absolute <u>uncertainty</u> related to both the lack of holistic information and the deficiency of our knowledge on natural and economic processes <u>takes place even in developed countries</u>. In such an environment, water resources management, with its inherent multilateral relations and under poorly predictable hydrological and other natural processes, imposes additional problems for the national economic development and the existence of human society generally.

It is clear that under such conditions, the sectoral approach in water resources management strengthens the complexity in coordinating different interests, and therefore, IWRM is the natural response to the world processes and the lack of our knowledge about multilateral relations of water with the economy and the environment (not in the sense of water as "natural substance", but regarding implications of its use and management). This is one of reasons why IWRM is being presented as the panacea from all ills of the water sector including existing uncertainties and the complexity in identifying causes and effects of different events, which affect water resources management, use, and development as well as interrelations with the economy, ecosystems, and social structures.

According to the Dublin Principles and provisions of the Agenda 21 of UN Conference on Environment and Development (1992), IWRM is defined as the holistic and integrated approach based on involving all stakeholders and their partnership, the look at water as economic good etc.

The holistic and system-oriented approach considering three spheres affected by water use and relations (socio-economic, environmental, and political) should include both the integration of different components and the subdivision of complicated systems to simplify their analysis.

Some components of these spheres refer to "governance system" while others to "management system." The role of "governance" that takes place mainly in the political sphere and partially in social and economic spheres consists in creating the enabling environment for IWRM, in which managers and stakeholders could successfully interact and be integrated. Therefore, one cannot confuse these interrelated systems since their roles are different.

Governance by means of political, legal, social, economic and administrative methods creates infrastructure, laws, the system of political, financial and social regulation and economic stability – a set of rules and limitations that should be used by managers and for their orientation.

On this base, IWRM develops the system of technical, economic, financial and organizational tools that provide the multilateral integration in the process of water resources management.

Thus, governance includes the following:

- The legislative base for forming the water sector, water relations, and water use limitations;
- Developing water rights and the water market;
- Acceptance of IWRM and its basic principles as the major direction of national economic development;
- Developing specific organizational frameworks and regulations that co-ordinate the role of the State and stakeholders;
- The policy of water prices, encouraging actions of the State and local water management bodies;
- Distribution of role and responsibilities across levels of government;
- Commitments of the State regarding the natural value of water;
- Enhancing public commitments regarding water resources through purposeful education; and
- The way of involving stakeholders into water resources planning and management; the possibility for decentralization and transfer to them a part of rights in water management;

At the same time, IWRM is based on the following:

- Recognition of basins, sub-basins, and irrigation systems as the units for planning and operation, and the hydrological cycle as the basis for the assessing all kinds of water resources regarding their amount and quality;
- Integration of information on water and land resources within the catchment area into the joint information database that should be related to dynamics of streams (surface water and groundwater; natural and anthropogenic streams) over the catchment area taking into consideration not only hydrological boundaries of the watershed, but also the runoff distribution zone, especially in the irrigation districts;
- Achieving the potential water productivity under all water uses;
- Co-ordination of irrigation and drainage within the watersheds and irrigation systems;

- Co-ordination of the water requirements of national economic development and eco-systems; provision of sustainable development under conditions of dynamic water demands and variations in water availability;
- Integration of water demands and management requirements based on planning to achieve the potential productivity of water and land resources;
- Integration of opinions, resources and knowledge of stakeholders in order to provide the consensus as the instrument overcoming the uncertainty and conflicts;
- Integrating professional knowledge of scientists for the purpose of well-oriented management in spite of the natural segregation in scientific and professional aims;
- Integration and assessment of information received from all levels of the water management hierarchy related to water demands of stakeholders for enhancing integration processes; and
- Integrating national, regional and local interests and their consideration in IWRM;
- Co-ordination of different levels of the water management hierarchy.

CHAPTER 3. THE CURRENT STATUS OF WATER MANAGEMENT IN CENTRAL ASIAN COUNTRIES

The present-day water management system in the region functions under very complicated conditions due to variations in water resources availability (dynamic runoff modes in rivers that predetermine fluctuations of water withdrawals and the need to adjust water allocation) and unstable water demand defined by a number of objective and subjective causes.

During the Soviet period in all republics of Central Asia, there was the strong management system with water sharing according to the principle “up-down” based on the water limits and operational modes approved by the All-Union Ministry of Water Resources and further by republican water bodies. The centralized water management system extended as far as farms’ boundaries, and further its influence was decreasing. The efficiency of water management in farms depended on the experience and professional skill of their personnel and available equipment. At that time, in Central Asia there were the irrigation systems with the efficiency factor of 0.78 and specific water consumption of 10,000 m^3/ha. However, there were also the irrigation systems with the efficiency factor of 0.55 and specific water consumption up to 20,000 m^3/ha.

At present, the situation has considerably changed owing to collapse of the state system of water allocation among water users – the all-union (national) system has transformed into the international one. The number of water users has drastically increased at all levels of the water management hierarchy, especially during the period when administrative bodies, following their discretion, established offtakes at different irrigation canals without the co-ordination with water management organizations. Disintegration of large collective farms and state farms and restructuring the agricultural sector have also resulted in increasing the number of water users at the former on-farm level (a hundred times greater).

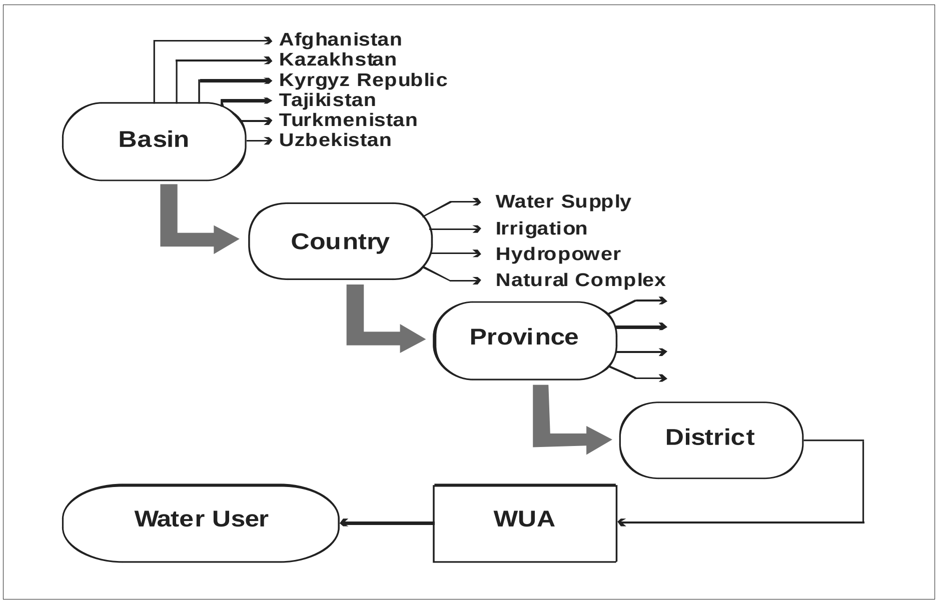


Figure 4. The Hierarchical Levels of Water Management

The following hierarchical levels of water management provide water delivery from a source to a consumer: the basin, sub-basin, irrigation system, secondary distribution canal, WUA (Water Users Association), water users group, farmer, and finally a field (Figure 4). There are typical factors at each hierarchical level that in different extent affect the reliability of water supply. In the Aral Sea basin, where all main water sources are international ones, the upper hierarchical level (the basin) is represented by six countries (at least, four countries are located in the basin of each main river). If under sufficient water availability (or close to it) in the course of average years, it is possible to establish equitable water distribution between countries, then the situation abruptly changes during droughts. For example, during the droughts of 2000 to 2001 a water deficit, on average, along the river, amounted to 23 to 25 percent of a mean annual runoff; however, water users of the middle reach of the river received less water on 15 to 17 percent and at the same time, downstream water users received less water on **36 to 55** percent (Table 1).

Table 1. Distribution of Water Supply Deficit over the Amu Darya Basin in the 2000 dry year.

Country, river reach, province	Deficit, km3	Deficit, % of water limit
Tajikistan	**0.7**	**11**
Turkmenistan		
Middle river reach	**1.8**	**17**
Lower river reach	**2.8**	**55**
Total over the country	**4.6**	**30**
Uzbekistan		
Middle river reach	**0.8**	**15**
Khorezm Province	**1.2**	**36**
Karakalpakstan	**3.8**	**59**
Total over the country	**5.8**	**37**
Total over the basin	**11.0**	**30**

What stability of water supply at lower levels of water management hierarchy can be speaking about? One can see how it is difficult for the staff consisting of 20 water managers to ensure stable water supply in the WUA “Japalyk” in Osh Province of the Kyrgyz Republic, in which there are 11 irrigation canals and about 5,000 water users. At the same time, it is necessary to take into account fluctuations of flow rates in the river and the main canals.

Variability of water supply and its equability at the level of the main canal, WUAs, and farm accordingly that was observed in 2003 on the irrigation systems where the introduction of IWRM was commenced (the South Fergana Canal (SFC) in the Uzbek part and the Aravan-Akbura Canal (AAC) in the Kyrgyz part of the Fergana Valley) is shown in Figures 5 and 6.

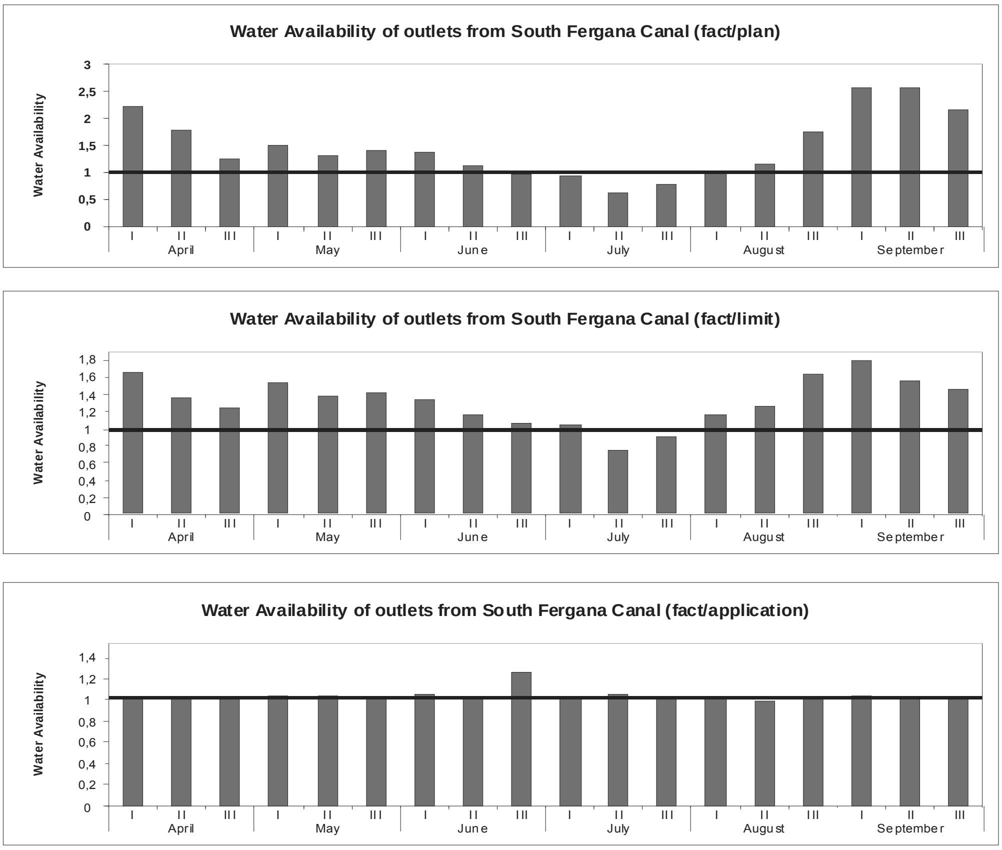


Figure 5. Water supply to branches of the SFC located at head/tail sections (actual water supply/planned; water supply/established limit, and actual water supply/ applied by user) in 2003

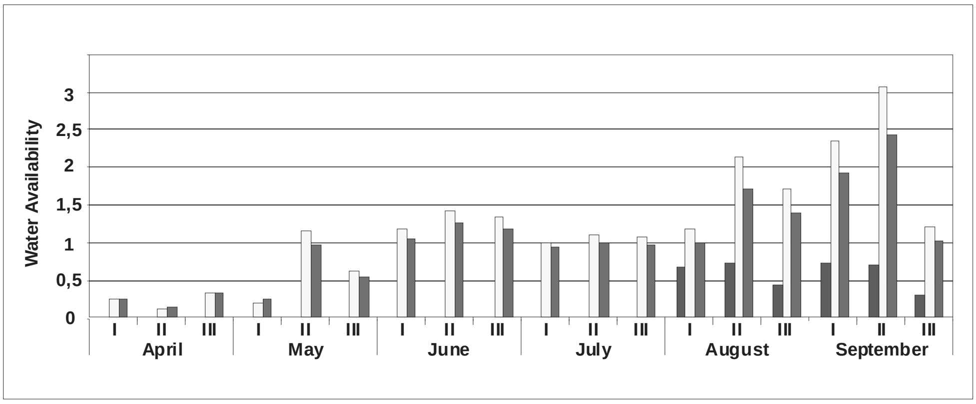


Figure 6. Water supply per water balance sections of AAC in 2003 (actual water supply/ planned water supply)

Still more fluctuations in water supply may be observed at some secondary canals within WUAs' area (Figure 7). If the ratio of actual water supply to planned water supply along the Khojabakirgan Canal fluctuates at the range of 0.25 to 2.0, then the fluctuation of water supply along its branches is more considerable.

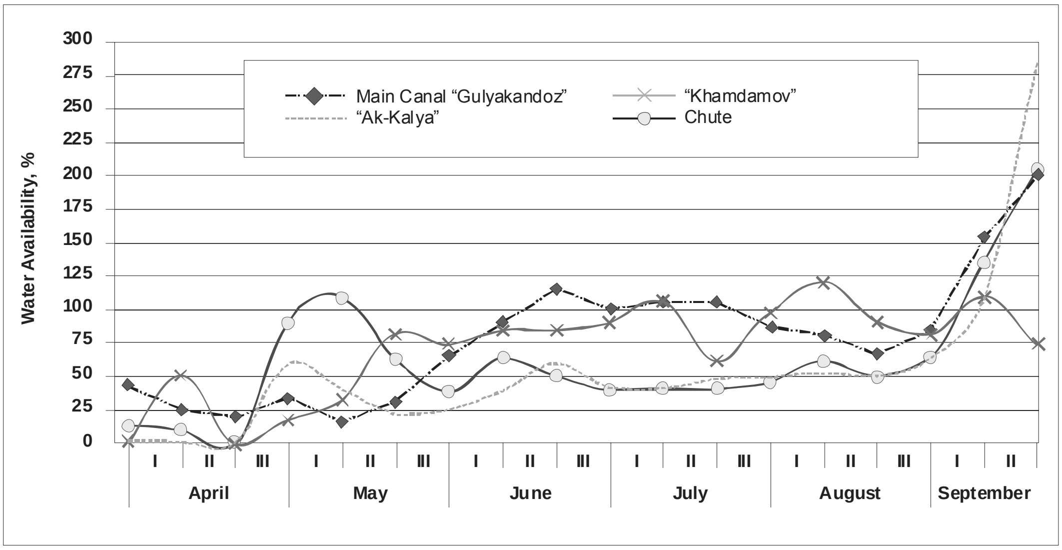


Figure 7. Variability of water supply along the canals within WUA "Zaravshan" in Tajikistan during vegetation period 2003.

Current problems in the water sector of Central Asia are related to poor management of irrigation and drainage systems. One can note that maintaining of drainage systems is not practically mentioned as a priority activity of water management organizations in most of countries. Owing to that practice, rational water use is problematical, and deteriorating of land reclamation conditions are in progress. About deteriorating physical conditions of drainage systems was clearly stated in final decisions and the proceedings of the conference held in March 2004 in Tashkent, and in the minutes of the workshop held within the framework of the special project on analyses of interrelations of drainage and water use in some regions of five countries (SIC ICWC, 2005).

As before, the situation related to water use is causing serious anxiety. Analysis of actual data shows that water management organizations mainly mobilize their efforts to withdraw water from its sources as much as possible by means of either by gravity or by pumping. As a result, an amount of water diverted into irrigation systems considerably exceeds actual water demand creating reserves for water managers facilitating their relationships with water users. At the same time, this practice results in increasing operational costs and in damaging the environment and interests of downstream water users. The introduction of payment for water services in Kazakhstan, Kyrgyz Republic, and Tajikistan has played its role in some decreasing water withdrawals, however, water saving is not an ordinary practice of water management organizations yet.

As the main irrigation method in our region, surface irrigation in itself predetermines large unproductive water losses. The water losses may be increased due to the lack of the proper co-ordination at all levels of the water management hierarchy. At present, activity at each level of the water management hierarchy (the basin, irrigation system, and WUAs) is implemented according to their own goals and tasks with a little care for end water user – a field where farmers and irrigators try to receive the maximum crop yield. As known, the maximum and economically-efficient crop yield is provided by means of controlling the provision of water to plants, and for this purpose, soil moisture within the root zone is maintained at the optimal level that amounts to 65 percent of the ultimate field water capacity (UFWC) over the range of so-called “available moisture” (from wilting moisture to the UFWC). Untimely or excessive irrigation results in decreasing a crop yield and prolongs the vegetation period since a plant “comes to a standstill” in stress situations (Figure 8).

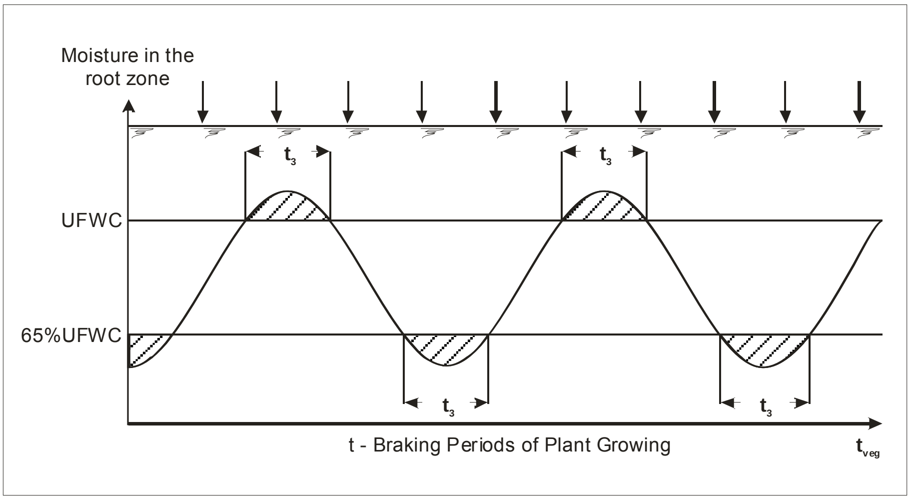


Figure 8. The chart of assimilation of soil moisture by crops in the growing season

Both over-moistening and under-moistening soils (i.e. non-optimal soil moisture in the root zone; crosshatched areas) retard the process of photosynthesis, at that time, plant does not build up practically their biomass, and even fruit cast takes place. At the same time, one of water management tasks is to provide optimal soil moisture during an entire growing season. The productivity of water and land resources in irrigated farming depends on timely water supply to a farmer (in required volumes) to meet the requirements of plants. Just a failure of this condition is a so-called “water factor” of crop yield shortage that at present is observed actually everywhere in the region.

Let us consider the following chain of water requirements “a Field – a Farm – WUAs – the Canal Administration – a Basin.” Even in the Fergana Valley, where water supply is enough sustainable at the basin level, going along this chain it is necessary to overcome a number of technical obstacles, let alone organizational contradictions.

Water requirements at the field level depend on a crop pattern, terms of farm operations (sowing, sprouting, and tillage operations) as well as on climatic, hydrogeological, and soil conditions. The water applications schedule based on the existing standards or on simulating by means of computer models (CROPWAT, ISAREG etc.) is presented by a sufficiently irregular chart that is not coordinated with a carrying capacity of irrigation canals (as shown in Figure 9a). Its co-ordination with characteristics of irrigation canals is based on the method of so-called “chart smoothing” by means of shifting water applications on some fields within the limits of feasible deviations ((± 3 to 5 days for cotton; and ± 5 … 8 days for grain). At the same time, it needs to adjust it to surface irrigation methods on a field (furrow irrigation, border irrigation, basin irrigation etc.) in order to minimize water losses at the field level. Therefore, a time of water application, flow rates of field canals and the number of simultaneously irrigated plots (for example, the number of furrows) should be clear-cut limited. As a result of such an adjustment, the water applications schedule has taken the form shown in Figure 9b.

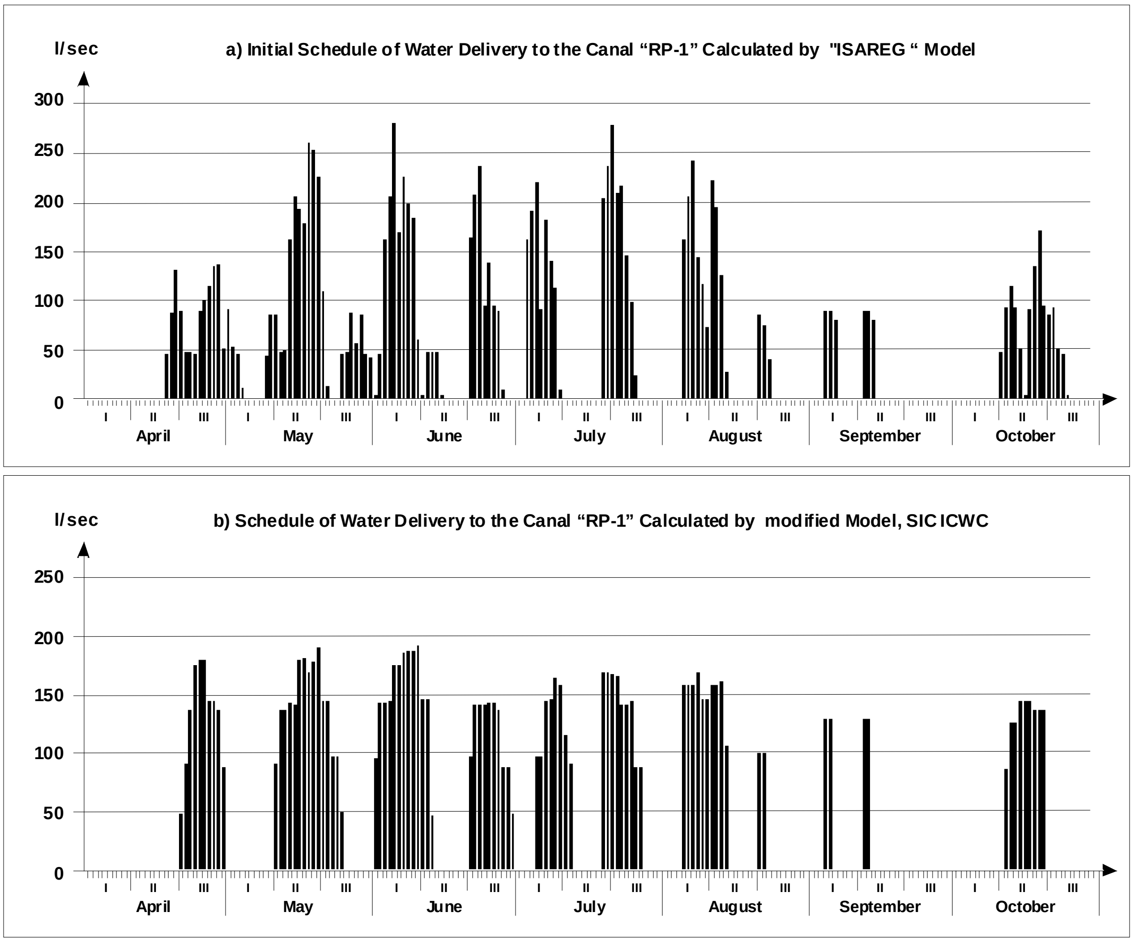


Figure 9. Results of successive smoothing the water supply chart made by means of modeling (the software ISAREG modified by the SIC ICWC)

Then, the following phase of the co-ordination is necessary – within WUAs depending on water supply to water users by a permanent flow or according to a water rotation schedule. In this case, water management planning requires not only the co-ordination of water supply at the field level, but also the co-ordination within a farm based on specifying a sequence of fields' irrigation and establishing water user groups on the secondary canal under monitoring the strict observance of the water rotation principles (an order of priority, time and volume of water supply) by water users themselves.

Stability of water supply at the WUA level is based on stability of main canal operation that depends on proper activities of operational staff, the level of dispatching and information exchange. As a whole, this system of co-ordination and monitoring predetermines timely and equitable water supply and an amount of nonproductive water losses over the irrigation system. This may be illustrated by the ratio of total water supply in the head of the irrigation system to total evapotranspiration over all fields under crops within the command area. Values of this indicator varies from 1.65…1.72 within command areas of the SFC and the Aravan-Akburyn Canal to 2.0 and more within the command area of the Khojabakirgan Canal in Tajikistan (Table 2). It is obvious that total water losses vary over the range of 50 to 100 percent of useful water demand for crop growing. Taking into account that the average level of physical water losses (seepage and evaporation) amount to 25…30 percent one can say that today organizational losses due to the lack of proper co-ordination at all hierarchical levels of water management exceed this value. Considerable potential to increase water productivity was determined in the process of analyzing operating data of the pilot fields established by the project within command areas of these irrigation canals. In 2002, surveys of farm fields and drafting their agronomical passports according to the specially developed method and format were implemented within the framework of the IWRM-Fergana Project. On the basis of these activities were prepared the recommendations to farmers that enabled them to decrease water withdrawal and to increase a crop yield, and as a result, water productivity on these fields has been considerably increased (Figure 10).

Table 2 Operational indicators of the pilot irrigation canals

No	Indicator	Units	SFC	AAC	KHC
1	Head water withdrawal (taking into account water transit and inflow)	mln. m^3	1,049.78	116.26	129.42
2	Specific water withdrawal	000’ m^3/ha	12.50	12.57	16.00
3	Water supply factor (at offtakes from canal) during a growing season:				
	minimum		0.63	0.15	0.17
	average		1.01	0.99	0.82
	maximum		2.58	2.42	1.77
4	Operational efficiency factor of the canal during a growing season (taking into account water inflow along the canal):				
	minimum		0.82	0.66*	0.44
	average		0.88	0.74*	0.80
	maximum		1.07**	0.77*	0.87
5	The ratio of total water withdrawal to evapotranspiration		1.72	1.65	2,00
6	Evapotranspiration	000’ m^3/ha	7.26	7.58	7.73

*) planned indicators
**) owing to inflow into the canal

These indicators show that in the process of putting IWRM into practice it is necessary to develop specific mechanisms providing the joint interested motives for water users and water management organizations in increasing the water productivity, and at the same time to assist them in achieving this goal. These mechanisms should take into account specific factors causing unproductive water losses, instability in water supply, and unevenness of water distribution. As a whole, the ranking of causes of water productivity reduction that arise within the irrigation system promotes the development of practical measures for achieving the basic criterion of IWRM – provision of “potential productivity” of the water by all water users or, at least, approaching to it (Table 3).

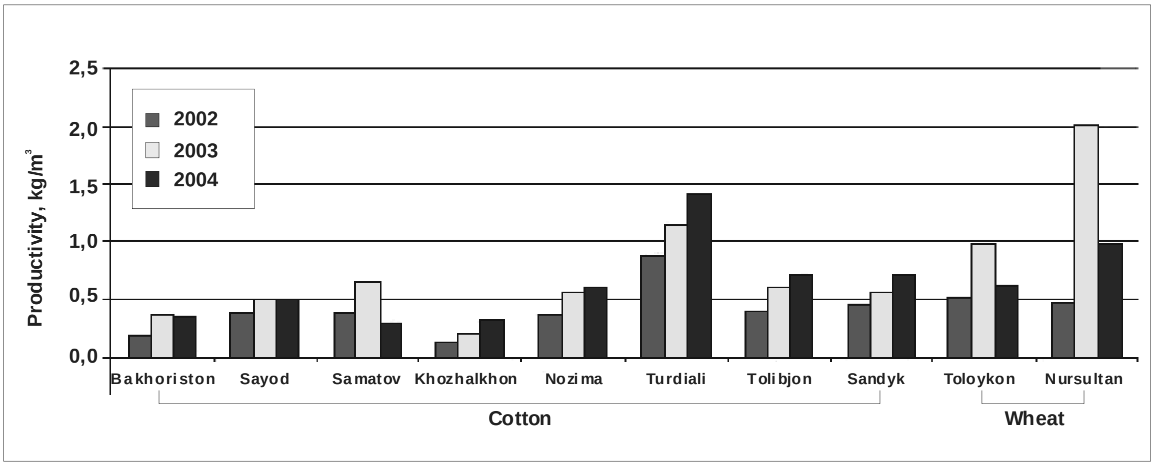


Figure 10. Irrigation water productivity in pilot farms under the IWRM-Fergana Project (kg/m^3)

As shown in Table 3, most of approaches to improve the water productivity are based on the engineering measures and IWRM tools in combination with organizational, legal, and financial measures. To implement these measures in the first place it is necessary to combine efforts of all participants of the multistage water supply process within water management organizations and WUAs, and farmers themselves. Such joint efforts are needed to use agreed procedures and methods for stabilizing water supply, providing equitable water distribution, and establishing the proper public control by water users themselves. At the same time, the technical and financial assistance of the State and local governments is necessary. Finally, it is important to gain a general understanding of the importance of the co-ordination at all levels of water management hierarchy, and of the input of each participant into integrating water resources management.

Table 3. Causes for water productivity loss within irrigation systems and mitigation measures

Hierarchical level	Type of cause	Mitigation measures	
		Type	Brief description
Basin	Instability of head intake and water disposal due to the following causes:		
	• Political tensions;	legal	Agreements
	• Breach of the water supply schedule;	organizational	Establishing a management body or developing the regulations
	• Excessive water diversion at upstream intakes;	legal technical	Agreements and fines Distribution accuracy due to applying SCADA
	• Underestimate of water losses at upstream river sections	technical	Monitoring and evaluation of flow rates and water losses
	• Unstable flow modes in rivers	technical	Runoff control, use of drainage water
	• Uncontrolled water distribution	technical	Improving the water management system
Irrigation system	• Lack of the system of water resources planning, distribution and dispatching	technical	• Developing and putting operational rules into practice • Drafting the plan and its adjustments
	• Lack of water distribution discipline	technical	• Regulations for water monitoring and records • Introduction of the GIS and water use plans
	• Water over-diversion against schedule	organizational, economic	• Applying of penalty provisions
	• Lack of water keeping records	technical	• Improving the water monitoring system • Introduction of the SCADA • Establishing the management information system
	• Lack of the proper water distribution procedures	technical	• Introduction of water rotation • Use of all types of water resources
WUA	• stochastic and disordered water supply requirements	technical	• The water use plan • Procedures of water distribution among water users groups, and • Water rotation (the warabandi method etc.)
	• Lack of the water supply monitoring and evaluation system	technical	• Establishing the monitoring system • Management information system • Dispatching
	• Incentives for water saving	financial	• A warding bonuses to WUA's workers for water saving • Fines and privileges • Financial incentives for WMOs
	• Lack of the proper water application schedule	technical	• Water supply planning and adjustments • Forecast of water demand
Farm	• Lack of the water use plan	technical	• Water use planning and training
	• Improper irrigation methods	technical	• Recommendations on irrigation technique and methods
	• Lack of adjustments in accordance with weather conditions	technical	• Extension services

CHAPTER 4. THE IWRM PRINCIPLES

In a general way, the key IWRM principles were mentioned in Chapter 2. Now we describe a chief matter of each principle because it is important for understanding what measures are necessary for their practical application.

4.1. Why Water Management Based on Hydrological Principles?

As is well known, water does not recognize any administrative boundaries. According to the laws of physics, water goes through the complicated hydrological cycle – water falls to the Earth in the form of precipitation, forming streams (rivers) from which water can be withdrawn for the needs of a human being, evaporates and enters the atmosphere, transforming into precipitation again.

Water from precipitation partly seeps into the ground forming bodies of ground water, which are, nevertheless, in close interrelation with surface streams. The area, where a surface stream is formed and the complete water cycle takes place, is called the watershed area (a drainage basin). Water within the drainage basin circulates regularly, and naturally crosses administrative boundaries, which are delineated by people on the basis of geopolitical considerations. It is obvious for controlling all possible factors affecting the hydrological cycle a drainage basin as a whole should be under the jurisdiction of a single water agency or a consortium of closely interacting organizations responsible for water resources management. Any institutional framework within administrative boundaries, not coincident with drainage basin limits, results in loss of controllability of some components of the hydrological cycle and finally affects stability of water supply and equability of water distribution, i.e. implementation of main objective of water resources management.

It should be noted that most of water professionals consider that according to Article II of the Helsinki rules on the uses of the waters of international rivers (1996), boundaries of a drainage basin should coincide with the watershed limits of the system of waters, including surface and underground water, flowing into a common terminus. In our view, especially in case of pumping irrigation, a domain of influence of irrigation systems very often oversteps the limits of a watershed. For example, the command area of the Amu-Bukhara Main Canal with diversion from the Amu Darya encompasses practically the entire basin of another river (the Zarafshan River Basin). The same situation is observed in command areas of the Karshi Main Canal and Karakum Main Canal that encompass the basins of several rivers etc.

At present, the original conditions for forming, transforming and cycling of natural waters remain on a negligible part of our planet - somewhere in tropics, virgin forests of Canada, and out-of-the-way desert places.

Water infrastructure for runoff control, which is especially grandiose in the hydropower sector; branchy and complicated infrastructure in the irrigation sector; and rather complex infrastructure in the water supply sector together with waste and drainage water disposal infrastructure (with its complicated hierarchical tree including main, inter-farm, and on-farm drains) form the quite complicated anthropogenic morphology of water-management systems within the entire drainage basin or its separate parts.

Interrelations of these components create the complicated system for integrated water resources management, use, conservation and development that should be governed according to the IWRM principles. It encompasses not only water resources themselves and water infrastructure but also related land and other resources both within a watershed and in the zone intensively affected by water management. It is absolutely not necessary and often impossible to manage the entire basin area by a single water management organization. Water resources of the entire basin or its portion can be managed by the water and ecological association or the Water Council. A good example of such an approach is the experience of French colleagues in establishing participatory water management within the framework of the Basin Agency that interacts accordingly with similar public water management organizations at the level of sub-basins.

Thus, water management based on hydrological principles can be established in the form of the uniform organizational framework within one country, but more often, it should link the complicated institutional hierarchy top-down, and this approach is described below. The basic instrument in water resources management based on hydrological principles is organizational frameworks built up in accordance with the hierarchy of water streams (first of all, of natural streams and then of man-made ones).

To ensure eco-systems sustainability a system for developing adequate restrictions and requirements in accordance with the basin morphology needs to be developed. At the same time, this system should include sub-systems for monitoring and drawing up water balances for the basin as a whole and sub-basins and their co-ordination using institutional, economic, technological, and managerial tools under participation of stakeholders (water users). Such a system was developed and now it is put into practice in the Aral Sea basin. It includes the following levels:

- A international drainage basin managed by the Basin Water Organization (BWO) established on the equitable basis by basin States[1] (the inter-governmental level);
- A canal system managed by the relevant administration (an organization at the inter-provincial or inter-district level); and
- Irrigation systems within WUAs (see Section 4.4) or a water distribution system within WUOs in case of water supply.

In the process of institutional development it is very important to consider all or interdependent levels of the hierarchy. For instance, within the IWRM-Fergana project we studied activities at the following levels: the irrigation system (canal), WUA, and farm without consideration of the basin because selected pilot systems had not water intakes at the basin level. At the same time, the Feasibility Study for the IWRM Implementation in Amu Darya and Syr Darya Lower Reaches Project includes the fourth component (the basin level); and it is a determinant for water

[1] According to the Helsinki Rules a “basin State” is a State the territory of which includes a portion of an international drainage basin

management stability at lower levels of the hierarchy. In addition, the following two-way co-ordination should be established (Figure 11):

- Providing potential water productivity at all levels of water management hierarchy from a farm to the basin (bottom-up); and
- Decreasing in specific water losses in irrigation systems “top-down” from the basin level to a field.

Another aspect of water management on the basis of the hydrological approach is related to developing individual solutions for each drainage basin, irrigation system or WUA, because the morphology of basins, hydro-geological and land reclamation conditions, not to mention institutional and economic relationships of water suppliers and consumers, are extremely diverse. Therefore, it is necessary to develop only the general principles of IWRM implementation without searching templates or standard solutions for different systems!

4.2. Water Record-Keeping and Integrated Management Involving All Water Resources

Water within the drainage basin are withdrawn from available surface and underground water sources. The current problem is that different departments keep records of these sources, but the main issue is that different departments without the proper co-ordination also manage their utilization. This results in an information disorder concerning the water resources status and certain anarchy in water use. As a result, unproductive water losses are increasing, while water supply irregularity and an artificial water shortage occur in some areas of the basin. This problem is especially obvious in dry years.

Most part of the naturally renewable water resources is formed on the drainage basin surface and flows down into the river network. The Hydrometeorological Services are keeping records of runoff formation and transformation along the rivers. Water management organizations are responsible for water withdrawal from rivers and its delivery to water users. Small water sources are under the jurisdiction of local authorities

Another component of the renewable water resources is ground water, which according to its genesis can be subdivided into two groups: ground water naturally formed in the mountains and over the catchment area, and ground water formed due to deep percolation in the irrigated areas. Available ground water resources in the basin area are usually estimated based on the hydrogeological survey, following which aquifer storage available for usage is approved. Assessing storage and use of aquifer are carried out by the Departments of Geology without precise co-ordination with Ministries of Water Resources.

Return water, i.e. water that returned to the natural system after use of natural runoff, is a part of the available water resources within the drainage basin. Return water can form due to both surface water releases and underground inflows. Owing to its higher salinity, this water is the main source of pollution of water bodies and the environment as a whole. Under current conditions in drainage basins with arid climate, drainage water of the irrigated areas forms about 90 percent of the total return water volume, and the rest is sewage water released by industrial plants and public utility companies. The water management organizations and hydrometeorological services are mainly keeping records of return water. For practical purposes, nobody controls the re-use of return water. Although, many research and promotional works were carried out to assess the scope of return water use, but there are not the precise normative documents and regulations in any country. As a result of unsystematic application of this water for irrigation, land salinization takes place and land productivity drops considerably in some areas.

Moreover, it is necessary to bear in mind that return/drainage water within an irrigated area is a by-product of irrigation; and in the process of improving or changing management methods its volumes can be reduced and at the same time, water salinity would increase.

On the one hand, considering of all water sources is very important to meet requirements of water distribution in equitable manner but, on the other hand, from the point of view of water quality control, return water management has great implications since return water formed in the process of water use by any economic sector is the major source of polluting natural waters. At the basin level, management tools of groundwater and return water are the following:

- Keeping records of renewable groundwater in co-ordination with the zones of their replenishment and estimating allowable amounts for their use as well as quotas (limits) of water withdrawal depending on annual water availability; at the same time it is very important to apply artificial groundwater recharge in wet years in order to use water reserves during dry years. During devastating droughts in 1974 and in 1975, in the Fergana Valley more than 1,000 water wells that struck deep into shallow freshwater aquifers were drilled in order to decrease water scarcity in this zone. A groundwater table steeply dropped, and underground inflow into the river decreased but in subsequent years, when water wells were put out of operation, the regular groundwater condition has rehabilitated;
- Regulations on drainage and waste water disposal into international and national rivers and sinks including restrictions for releases of pollutants based on water availability in water bodies; and
- Regulating drainage water quality including aspects of its intra-system use (the utmost permissible salinity of drainage water may be an indicator to specify the rationality of its use for crop irrigation).

It is very important properly to select planning and management tools at the irrigation system level. Based on applying the GIS, areas of possible using of groundwater (water withdrawn from water wells and drainage tube-wells) and drainage water need to be specified for each irrigation system taking into account a texture of soils and water salinity. In order to define additional water sources, overlapping of thematic maps with a water demand map has to be performed. Findings are used in the process of drawing up a plan of water use ensuring the more equitable water allocation. Especially favorable conditions for return water use at the level of farm, WUAs or main irrigation canals are formed in intermountain valleys with a cascade location of irrigated areas when return water from upstream-irrigated areas can be delivered into canals of downstream irrigation systems by gravity.

Israel, where each cubic meter of water is under consideration, serves as an excellent example for others in management of return water. Out of 2.2 km^3 available water resources, sewage amounts to 20 per cent. It is treated at sewage disposal plants providing the standard parameters that enable using this water for irrigation of technical crops. After treatment, water is transported through special water pipelines to the Negev Desert for land irrigation. Usage of industrial sewage for needs not requiring a high-qualitative treatment is the efficient method of water re-use. In the irrigation sub-sector, this approach is applied in Australia for cascade irrigation of salt-tolerant crops, where drainage water formed after irrigation of grain and forage crops then is used to irrigate firstly sunflower, and finally plantations of trees and bushes.

4.3. Cross-Sectoral Integration

From the point of view cross-sectoral (horizontal) integration, water management agencies should take into consideration interests of all water users in any economic sectors equally and provide a priority for water saving and eco-system safety within one hydrological unit. The problem is that different departments manage the use of different waters. For example, surface water use is managed by the Ministry of Water Resources in the interests of irrigated farming and at the same time by the Department of Energy in the interests of power generation. Departments of Geology usually co-ordinate groundwater uses. Drinking water supply is the responsibility of municipal services or local governments. The respective industrial departments control industrial water use. At the same time, not all the above-mentioned public departments and ministries, as a rule, do co-ordinate their activity with each other. If during the Soviet period, there were statistics on water use in all sectors (in the format “2-TP Vodkhoz”) currently nobody has even general information.

Gathering all economic sectors under “a single organizational roof” is not needed at all. Furthermore, according to Roberto Lenton (“Catalyzing Change” GWP, 2004), this approach can be even harmful since a sectoral professional specialization is important for an efficient activity of specific sectors. However, the main basis for inter-sectoral integration is the co-ordination of sectoral interests in the process of joint use of available water resources according to agreed schedules, and use of wastewater derived in one sector by other sectors. At the same time, the mechanisms for conflicts settling should be developed to integrate contradictive interests. It may be achieved by participation of representatives from different sectors in public bodies at any level of the water management hierarchy. The public bodies established on an equal footing should provide consensus based on mutually acceptable regulations. There are the following instruments for co-ordination:

- Integrated planning and co-ordination of water resources use;
- Co-ordination of the economic growth of sectors;
- Data exchange; and
- Participation in material and financial inputs that are of mutual interest.

Relevant public bodies play the positive role in such a co-ordination (the participation of representatives of such sectors as hydropower engineering, nature management, agriculture, and water supply in the Basin Water Councils, and correspondingly the participation of representatives of administrative districts and big water users in the Irrigation System Council as well as water users in the WUA board). In many countries, the National Water Councils are established under the direction of Prime Ministers of these countries and with the participation of leaders of all sectors interested in use of water resources as well as leading scientists and water professionals.

4.4. The co-ordination at different levels of the water management hierarchy

As shown above (Figure 4), any present-day management system, especially in the irrigation sub-sector, is a multilevel tree of water supply and distribution from a basin, mains, secondary and tertiary canals, irrigation network within water users' associations (WUAs) to irrigated plots of farmers (or the water distribution network of utilities and industrial water users). Basic water losses and water supply irregularities take place owing to the lack of co-ordination between different hierarchical levels of water management, and result in an inefficiency of water management system as a whole. We suffer losses owing to the poor water management rather than water scarcity. Therefore, one of the main tasks of IWRM is the proper co-ordination of activities at different hierarchical level of water management. The situation when each water agency develops its own criteria and approaches that do not answer the general purpose of IWRM (to reach the maximum water productivity) needs to be obviated. Provincial and basin water agencies hold an interest in supplying water to consumers as much as possible, and in turn, water users hold an interest in reducing their water consumption down to the limit (if they pay money for water).

Each level of state water hierarchy holds an interest in withdrawal of maximum possible water volumes from a water source and in allocation of these water resources to those persons who is "more desired" or according to instructions of bosses. At the same time, water agencies insufficiently take care of maintaining a high efficiency factor of irrigation systems and of preventing operational water losses. In addition, having excessive water reserves, they often dispose unused water (the considerable financial resources are spent for water delivery, especially under pumping irrigation) into the drainage system.

A basic tool to co-ordinate activities of different levels of the water management hierarchy (both according to horizontal and vertical links) is public participation in operation of a <u>properly established institutional framework</u>. The organizational chart of a water management organization that operates based on the hydrological principles is shown in Figure 11. There are the following levels of water management: the upper level – a basin that can be divided into sub-basins; the next level – irrigation systems (in the presence of the joint water intake and the main drainage network) or an administration of single main canal; further the level of WUAs (in the sub-sector of irrigation) or WUOs (in case of other water consumers); and finally water users (farmer, enterprise, residential district etc.).

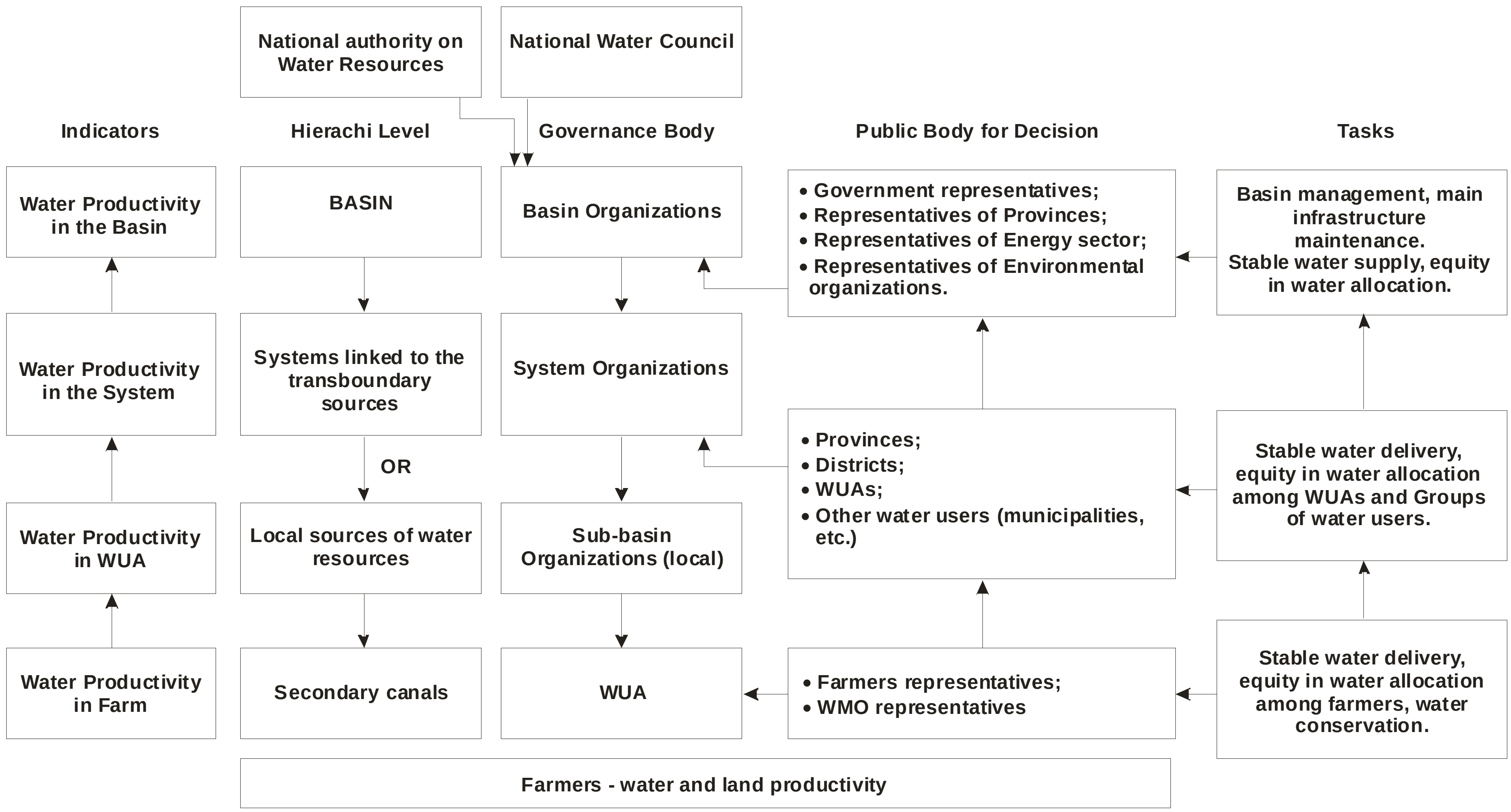


Figure 11. IWRM Hierarchical Levels and their Links

In case of a inland drainage basin, a basin water organization (BWO) that is usually established within the framework of the National Ministry of Water Resources and can consist of territorial water management agencies is responsible for water management of the basin and sub-basins according to the regulations of the BWO (similar to BWOs in international basins). Irrigation systems that divert water from the basin water sources are managed by an organization of the next hierarchical level, which may be subordinated to the BWO or may be a corporative public-and-governmental organization. WUAs with their own administrative staff and public participation mechanisms are the next level of the water management hierarchy.

All these water management levels are coordinated based on considering the applications for water supply that are formed according to the principle “bottom-up” and on establishing restrictions in the form of water limits and relevant water supply schedules that are formed according to the principle “up-down” and are supported by contractual relationship between BWOs and irrigation system administrations or between the last ones and WUAs.

When the irrigation administration is the subdivision of BWO, the contractual relationship is formed only between the BWO and WUAs. In parallel with management according to the principle “bottom-up,” the public water management by water users is formed in the following succession: WUA – the Canal Committee (or the Irrigation System Committee) – the Public Basin Council. Apart from institutional tools of the co-ordination, there are also management, legal, and financial tools.

Management tools:

- Keeping records of water on the way from the basin to a farm; strict water demand rationing;
- Drafting the coordinated plans of water allocation and use at all hierarchical levels of water management that include organizational water losses control;
- Reporting that shall provide not only annual and quarterly reports but also an operational reports containing specified criteria and indicators for timely adjustment of water supply;
- Improving the dispatcher control to ensure equitable and sustainable water supply upholding the priorities of eco-systems and municipal and industrial water users as well as the observance of limits related to water infrastructure safety; and
- Adjustment of water use plans based on tailor-made computer models in case of changes in hydrologic, climatic, economic, and other conditions.

At the same time, abovementioned tools are the integral part of the management information system (MIS) that is more comprehensively described in Chapter 6, and is an important component facilitating the introduction of IWRM principles.

Legal and economic tools are closely interrelated and mutually complementary. The principle tools are listed below (they are described in Chapter 5 in detail):

- Water rights and their protection by the State;

- Contractual relationship between water users and water agencies, and also between water agencies operating at different hierarchical levels of water management;
- The law on a liability for infringing water rights and contractual relationships
- Payment for water supply and other servicing of water users (it has to be differentiated depending on water services' quality);
- Penalties for water pollution;
- Fee for water as resource;
- Government control of rights and duties of water management organizations and water users, as well as state liability regarding a support of both parties;
- Providing incentive and preferential terms both for water users and water management organizations under rational water use; and
- Fines for surplus water withdrawal from the water supply system.

It needs to keep in mind that public participation was, is, and will be the main tool for coordinating water users both according to horizontal and vertical links.

4.5. Public Participation in Water Resources Management

An extremely important component of putting IWRM principles into practice is broad involvement of public organizations in the management process itself. Water management issues need to be considered in the context of interactions between a civil society and the State.

Public participation has to create an environment of *transparency* and *openness,* under which the likelihood of decisions not corresponding with public interests are decreased. The more intensive the public participation, the less favorable conditions for corruption and ignoring of public interests. This is a platform for making equitable and well-thought-out decisions regarding water allocation taking into account nature preservation requirements and an economic growth under conditions of the increasing water scarcity.

Based on the principle that water is not only a private good but also a public one may arrive to conclusion that public participation is the major component of water management.

Public participation also is the most critical factor for struggling against any kinds of "hydroegoism"[2]. The earlier existed administrative method of water management threatened water users with "administrative hydroegoism," under which the management of administrative and territorial bodies used the water supply systems, first of all, for their own sake, and at the same time there were conditions for corruption, arbitrary rule, and infringement of interests of others. A transition to water management based on hydrological principles cannot, in itself, provide genuine IWRM because there are prerequisites for "professional hydroegoism," since due to the lack of a public control, water management organizations themselves plan water allocation, establish water limits, adjust these limits, and finally audit own activity.

[2] A term "hydroegoism" is widespread in bibliography and is treated as a dominance of group and corporative interests in the process of water allocation and use over the national interests.

Therefore, public participation is the guarantee of fairness, parity, and consideration of all stakeholders' interests in the process of water management. A role of public participation is enhanced by means of establishing public bodies such as the Canal Water Users Unions, Basin Water Committees (Council) etc. in parallel with existing water management organizations.

These public representative bodies have to govern water management of a correspondent water supply system. A broad representation implies the participation of all stakeholders in the water management process namely: representatives of water agencies, representatives of water users of different economic sectors (irrigated farming, municipal water supply, industry, fishery etc.), and representatives of local governments, conservancies, and non-governmental organizations. A Union, Committee, or Council should co-ordinate activity of legal entities and natural persons related to water management and use within an irrigation system or the command area of a single irrigation canal. The main purpose of their activity (together with their executive bodies and under broad participation of all stakeholders) is to put the integrated water resources management principles (IWRM) into practice.

No matter how employees of existing water management organizations (WMOs) operate, there is an issue related to establishing new public organizations that enable us to provide the broad involvement of water users in water management as a matter of ensuring fairness and use of the potential of collective intellect; and in the future they can become genuine governing bodies bearing their complete responsibility for water management. Our experience shows that the management of WUAs and the Canal Water Users Committees participate insufficiently in the processes of water resources planning, allocation, and management as well as in decision making related to maintaining and rehabilitation of water infrastructure and in search of funding sources. At the same time, the practice and methods tested at pilot irrigation systems gain the future. It needs to prevent their conversion into bodies with only advisory functions or into "adjunct" of WMOs.

Public participation in water resources management should be built in such a way that representatives of water users and other stakeholders could really participate not only in monitoring of water agencies' activity but also in planning and implementation of water-related works at the expense of their own financing or other funding sources. Public participation has to provide "transparency" of water agencies' activity and to prevent the conversion of former administrative bureaucratic systems into a new professional and sectoral bureaucracy with its "hydroegoism." Water Councils of basins and sub-basins have to be composed of representatives of concerned regions (districts), principal water users, and water-conservation bodies. Water Committees of irrigation systems or canals should be composed of representatives of water management organizations, WUAs, and other water user associations. Finally, WUAs themselves should establish such a system of the partnership with the State and the private sector, which could be a driving force for transforming activity related to water sector development into the national action. Under public participation, functions between bodies that define a water policy (Water Committees or Councils) and executive bodies should be distributed as follows:

At the level of irrigation (hydrological) systems:

Functions of the Water Committee	Functions of the Executive Body (Management)
- Approval of water allocation regulations, water supply and disposal plans; - Monitoring of water supply and disposal plan implementation; - Approval of quotas for pollutants disposal; - Approval of the O&M plan; - Approval of funding; - Necessary funds formation; - Audit of financial activity; - Determination of water service prices; - Approval of the long-term development program - Implementation of the water saving and demand control policy.	1. Annual planning: • Identification of water demand and local water resources; • Water allocation and distribution taking into account water quotas (limits) allocated by higher organs; • Drainage and water protection. 2. Water use plans implementation and their adjustment. 3. Implementation of monitoring: • Water record; • Water saving assessment. 4. O&M of water infrastructure; implementation of measures improving irrigation system efficiency. 5. Involvement of water users and the public in the process of water resources management and use. 6. Establishment and maintenance of the information system. 7. Support of the consulting services. 8. Servicing charge collection. 9. As required, implementation of works to prevent or to repair consequences of emergency.

At the level of Water User Association (WUA):

Functions of the WUA Committee	Function of the Executive Directorate
1. Approval of the WUA charter and regulations 2. Approval of порядка членства и прием в члены АВП 3. Election and appointment of executive organs including managers 4. Approval of regulations and tariffs for water services 5. Approval of the water allocation and monitoring plan 6. Approval of the cost estimate 7. WUA development measures 8. Monitoring of water allocation equity and stability 9. Approval of audit regulations	1. Preparation of water use plan and its adjustment 2. Uniform water allocation among water users 3. O&M of irrigation and drainage network 4. Improvement of land reclamation conditions within the irrigated area 5. Keeping record of water resources 6. Data collection and database formation 7. Management of side work to improve the WUA financial status 8. Auditing 9. Promotion to farmers in water productivity improvement

Public participation is especially important in the process of developing principles and methods of water distribution within a former on-farm irrigation network. It became obvious only engineering tools are insufficient, especially now when the number of water users have considerably increased. The process of water management becomes extremely labor-intensive when a WUA consists of one thousand water users or even of a hundred water users. No a WUA could efficiently manage water resources without grouping water users or without a teamwork of farmers on command areas of on-farm irrigation canals. In the Fergana Valley, more than several tens of water management sites were established on each on-farm canal within the pilot WUAs. This is evidence of the complexity of equitable and stable water distribution at this level of irrigation systems under implementing the planned irrigation schedule.

Water distribution along main irrigation canals is also very complicated, because during the period of administrative subordination to local governments the number of offtakes that were not designed has increased many times (both gravity and pumping offtakes). The South Fergana Canal is a typical example; according to design documents, only 112 offtakes had to be constructed but at present, there are 260 offtakes including 100 offtakes with a carrying capacity less than 100 l/sec.

Under these conditions, along with planning water use according to the principle “bottom-up” taking into consideration requirements of water applications on fields and operational modes of on-farm canals (applying computers and optimization models) it is necessary to implement a number of measures to involve water users themselves into the process of planning and management including water distribution. It should be done on the basis of thought-out operational regulations and schedule for irrigation canals within WUAs taking into account a land use pattern and characteristics of water supply at higher level of the irrigation network. At the same time, taking into consideration a ten-days planning of flow rates in irrigation canals by a higher water management body, it is advisable to apply a water rotation among groups of water users that take water from one canal. However, specially trained professionals in water management together with sociologists have to identify for each WUA and each irrigation canal within an association’s area a procedure of water distribution, its cycles, and grouping of water users for each water supply cycle, implementation of intra-group monitoring, as well as an order and sequence of water distribution between and within groups.

All this engineering-management activity should be accompanied by social mobilization of water users that form these groups and relevant inter-grouped units on one irrigation canal in order to organize properly the water supply system and to obtain the potentialities for its adjustment. So-called “alternative water distribution system” proposed by experts engaged in the IWRM-Fergana Project (N. Mirzaev, and A. Alimjanov) provides a necessary flexibility of water management, however, on the assumption of not only an active participation of water professionals but also an internal self-organization of water users.

For example, in 2002, within the IWRM-Fergana Project an intensive mobilizing activity was undertaken among water users located along the main irrigation canals that resulted in the constituent assemblies for establishing the Water Committees on three pilot canals at the end of 2003. All stakeholders were participants of the constituent assemblies including representatives of water management organizations, WUAs, private and cooperative farms, non-agricultural water users, local governments, and non-governmental organizations (NGOs). Main outcomes of the constituent assemblies were an approval of the Regulations on Canal Water Committee (CWC) for each pilot canal, elections and approval of CWCs' members, election of CWCs' management (their chairpersons and boards), and elections of members of the Disputes Settling Commissions. A composition of CWCs' members is given in Table 4

Table 4. Composition of CWCs' members according to the pilot canals in the Fergana Valley and a share of participants from each group in percents

No	Members	The SFC		The AABC		The KBC		On average
		nr	%	nr	%	nr	%	%
1	Water professionals	5	24	3	20	7	28	24
2	Agricultural water users	12	58	8	53	10	40	50
3	Local governments	2	10	3	20	6	24	18
4	NGOs	1	4	0	0	1	4	3
5	Non-agricultural water users	1	4	1	7	1	4	5
	Total:	**21**	**100**	**15**	**100**	**25**	**100**	**100**

Technical, financial, organizational, and other matters are routinely considered at sessions of CWCs' boards and meetings of CWCs (where all members of CWC participate). In particular, a water distribution process on the pilot canal is evaluated based on indicators of efficiency, equitability, and sustainability of water supply to water users. In addition, issues of fee collection for water services, technical conditions of canals, ecology, and others are also discussed. As a result, decisions related to all discussed issues are made, and specific measures that can improve activity of CWCs are recommended. In the process of preparation and holding sessions and meetings, awareness of both water professionals and water users regarding water management issues is increased. Moreover, problems (such as meddling of local governments in the water distribution process), which were concealed from water users, or problems (such as a arbitrary rule of power supplier resulted in unstable water supply by pump stations; overuse of gravel deposits in the Khodjibakirsay channel resulted in erosion of river banks and decreasing a water infrastructure safety), on which have not paid proper attention earlier, are now discussed. During the growing season of 2004, three sessions of the CWC's Boards and three meetings of CWCs were held to discuss water management activities on each pilot canal. In addition, the general assemblies of water users of canals Aravan, Akbura, and Khodjibakirgan took place.

It needs to note that, step-by-step, the status and role of the Canal Water Committee will become transformed as follows:

- In the future, the state management of surface waters (presented by the Canal Administration) shall be certainly replaced by public water resources management (presented by the Canal Water Users Union) on the basis of "merging" of the Canal Administration and the Canal Water Users Union. At the same time, the

Council of Canal Water Users Union will be a governing body, and the Canal Administration – the executive body of Canal Water Users Union.

- Today one ought not to dictate a transfer from the state management practice to the public one, or to interpret this process as a delegation of powers from the State to water users. Under our conditions, it should be a phased move to the management practice when the State participates in governance of the irrigation systems and canals on a par with water users. At present, the Canal Water Committee already executes the following governance functions:

  - Approval and collection of assessed contribution of water users, and distribution of funds among water users;
  - Establishing the regulations of water supply and water use (an order of priority, adjustments of water supply schedule, monitoring, and reporting);
  - Arbitration and disputes settling between water users and the Canal Administration;
  - Approval of the working plan based on funds allocated from the state budget, collected fees, and financial resources received from different economic activities; and the regulations on creating and spending of financial reserves etc.; and
  - Decision making regarding credits reimbursed by water users.

  In the future, the Canal Water Users Union shall have more authorities with respect to staffing (specifying the number of personnel and its composition, hiring of managers), and more responsibility with respect to a financial self-sufficiency taking into account the state funding and creating reserves (including bonus fund). Another distinction is transfer of public property in <u>asset management</u> on terms specified in the contract (rather than a lease entailing rental fee).

- In the actual practice, a transition period will depend on rates of democratization in countries of the region. During the Phase III of the IWRM-Fergana Project, it needs to speed up a transition from the state water management towards a joint water management. For this purpose, over the 1.5-year period after the beginning of the project phase III, it is necessary to implement the large-scale organizational and training activities in order to provide an actually free-will consent of water users to undertake the responsibility for management of pilot canals, on the one hand, and to obtain the agreement of ministries and governments to resign their commission related to management of irrigation canals to water users, on the other hand. This delegation of their responsibility for management of pilot irrigation canals should be legalized in the form of a legal document on the delegation of powers (an agreement between ministries and Canal Water Users Unions).
- The Canal Water Users Union consolidate all stakeholders and water users located within the command area of the pilot canal, and in the future, matters of water distribution and use, and land reclamation will be under its jurisdiction. The role of the Canal Water Users Union has to consist in the co-ordination of activities of WUAs, co-operative farms, and other entities for achieving the maximum productivity of land and water resources taking into consideration social and environmental factors rather than in duplication of their functions.
- The Canal Water Users Union and the Canal Administration are now and will remain for the time being <u>“fragmental organizations”</u> performing <u>joint</u>

management. At present, ministries and the basin bodies play the leading role. After water users will agree to undertake O&M of canals and the State will delegate its responsibility for management of irrigation canals to the Canal Water Users Union (CWUU), the Council of the CWUU will perform the leading role, and the Canal Administration will be no longer the state body and will be reorganized into the executive body of the SWUU, within the framework of which the State remains the active and influential participant. Until this reform, the Canal Water Users Union has to operate and to develop its capacity as an independent legal entity.

In either case, joint management is based on joint financing of operational costs by the State and water users. In the first case, water users pay to a state organization (the Canal Administration) for water supply further to the state share of funding for operation, maintenance, and development of irrigation systems. However, for all that, the State is mainly responsible for a financial stability of this organization. In the latter case, there is joint financing of the same expenses by water users and the state bodies according to specified shares that provides a financial stability. At the same time, the financial stability should base not only on developing a proper business plan but also on measures for saving financial and other resources in the process of O&M, use of alternative inexpensive water sources (especially in case of pumping irrigation), and rational use of available assets (including land resources that are often used with a low efficiency owing to poor land-reclamation conditions).

As known, IWRM institutional aspects include: (i) a transition from water resources management within administrative boundaries to management within hydrological units; and (ii) public participation. In the process of introducing the principle of water resources management within hydrological units, the project had not any problems because it was objectively beneficial to water management organizations. As to public participation, a situation is quite different. As a rule, public participation is beneficial to employees of water management organizations but not to some water officials. Recognizing a leading role of water users (presented by the SWUU) "by word of mouth," these opponents of such an approach will try to transform the Council of the SWUU into an obedient "pocket" body. Therefore, a rejection in the legal registration of the SWUU as an independent, non-governmental non-commercial body of water users and in opening its bank account just contributes to SWUU's dependency on the Canal Administration. In this context, the rejection is beneficial to water management organizations rather than water users.

At the WUAs' level (the former on-farm level), some problems can be solved only with public participation. Under the prevalent practice, a primary water user (former collective farms, and nowadays shirkats or co-operative farms) supply water to secondary water users (private farms) at their own discretion, and as a rule, after satisfaction of own needs. Relations between primary and secondary water users are not specified even by a contract. Therefore, large co-operative farms infringe upon private farms' rights. Primary water users do not incur any liability for upset of water supply to private farmers according to planned schedules and volumes. Private farms often have not offtakes equipped with water meters, and water is supplied to them without actual water accounting.

Establishing and operating WUAs change the status of private farms (secondary water users). A water users association itself enters into contractual relations with water management organizations, and supplies water equally to all water users (members of WUAs) independently of their location along an irrigation canal (at its beginning or in a tail section). One of the major functions of WUA is distribution of available water resources among its members in an equitable manner, and in that way, to provide sustainability of their water supply.

A distinctive feature of establishing the WUA "Akbarabad" in Uzbekistan and the WUA "Zarafshan" in Tajikistan within the framework of the IWRM-Fergana Project is that the water management organizations are co-founders of WUAs. They transfer inter-farm canals within WUA's areas in WUA's use and accordingly finance their O&M. The specific number of participants with a vote represents a water management organization as a co-founder of WUA at the constituent assembly.

4.6. Nature is a Equal Partner under Water Resources Use

Over a long period of time, humankind considered itself as all-powerful and able to bend nature to its will. However, instead of a slogan: "We cannot wait for favors from the Nature. To take them from it - that is our task" has come the understanding that "Man gets nature not as a gift from his ancestors, but borrows it from his descendants." Such a concept becomes the basis for the growth of the ecological movement all over the world, and for developing the environmental requirements aimed at maintaining the sustainable co-existence of human beings and eco-systems.

In the water sector, it needs to be recognized that rivers, lakes and other water bodies are "water consumers" along with economic entities, and without specific ecological water releases they can lose their natural essence. Therefore, the following priorities should be established in activity of water management organizations: (i) maintaining the minimum ecological flows in natural streams supporting their eco-systems and capability for self-purification, (ii) sanitary water-releases for dilution of harmful ingredients, and finally (iii) satisfaction of water requirements of deltas and estuaries. At the same time, this approach should be applied not only to large rivers and water bodies, but also to small streams and water sources.

Environmental aspects of IWRM specify activities in two directions: (i) to prevent harmful events related to water resources, and (ii) to meet water requirements of eco-systems. From the point of view of ecology, the main features of water are its high mobility and ability to dissolve different chemical components of the natural complex. As known, that due to hydraulic heads, high dams and large irrigation canals cause underground outflow towards downstream areas resulting in their waterlogging. If these flows come through salt-bearing layers or other sediments containing toxic pollutants, a transfer of harmful substances at a long distance from their source is possible. For example, filling of the South-Golodnostepsky Canal, constructed along the upper edge of the alluvial plain, causes a raising of hydraulic head in observation wells located at the distance of tens of kilometers from this canal (usually in a few hours after filling). As a result, upward movement of salty groundwater from deeper horizons towards a land surface took place on the area of 70,000 to 80,000 hectares (about 30 percent of the total area of the irrigation scheme) causing soil salinization. The same phenomena are observed everywhere in the Khorezm Oasis and in numerous piedmont valleys that are crossed by irrigation canals. Under such conditions, it is very important to construct a row of interception wells to decrease a hydraulic head and to prevent processes of soil salinization and transferring of toxic substances. In piedmont valleys, uncontrollable natural waters and an excess of irrigation water are sources of soil erosion. It is especially topical in the pumping irrigation zones where expensive pumped water that is exceeding crop requirements becomes a cause of soil erosion and salinization, waterlogging, and deterioration of quality of surface water and groundwater. There are many such examples in the Fergana Valley: waterlogging of downstream areas due to irrigation on the Arsif massif or owing to construction of Kayrakum and Karkidon reservoirs etc. Dispersed sources of pollutants can dangerously affect natural waters: radioactive tailings of the Maylisy concentrating mill, salty deposits of Asht ridge etc. We observe the same picture in the Chirchiq Valley where under impacts of atmospheric precipitations, dumps of Chirchiq chemicals plants became sources of pollution of the water supply system of the Tashkent Agro-Melioration's settlement.

In respect to environment sustainability in a drainage basin, it is possible to propose an approach based on application of sustainability criteria, considering three major interrelated components: water quality in a water sources, accumulation of pollutants in economically-operated areas, and anthropogenic pressure on eco-systems. In other words, the criteria of a well-being of a drainage basin according to these parameters are represented as follows:

- The pollution level of the economically-operated area and affected eco-systems should not exceed the permissible concentrations, and trends of accumulation of toxic pollutants are to be negative, i.e. pollution reduction is in progress in the concerned area;
- The contamination level of water sources over all zones of the drainage basin, from headwaters to mouth, shall not exceed the maximum permissible concentrations for all water users using water from these water sources; and.
- Strength of anthropogenic pressure on eco-systems in a catchment area should not exceed the optimal limits that ensure maintaining of bio-diversity and bio-productivity of eco-systems.

No less important issue is observance of ecological requirements to water resources, under which we have in mind the requirements of eco-systems to water supply as the basis of sustainability of flora and fauna, and esthetic characteristics of natural complexes. It is important not only to preserve natural flora and fauna of small and large rivers, but also to keep their natural attractiveness for people. Undoubtedly, at present, many natural streams have lost their original status: rivers Zarafshan, Murgab, and Tejen have lost their connection with the Amu Darya, and in a similar manner, rivers Chu, Talas, and Assa have lost their connection with the Syr Darya River. However, our task is to stop this grievous process. This problem is considered in detail in such projects coordinated by the SIC ICWC as the project "South Prearalye – New Prospective" that implemented within the NATO program "Science for Peace" (2003), and the project funded by the NATO "Transition towards IWRM in lower reaches and deltas of Amu Darya and Syr Darya rivers" (2005). The features of eco-systems' conditions being formed during the period of current economic activities have been analyzed in the reports prepared in the process of project activity. Owing to extensive irrigation in Amu Darya and Syr Darya basins with irrevocable withdrawing of rivers' runoff that exceeds ecologically acceptable limits, aside from drying the Aral Sea the water quality in these rivers distinctly degraded. If in the 1960s, water salinity in deltas of the both rivers did not exceed 0.7 g/l, then nowadays it amounts to 1.3 to 1.5 g/l.

Degradation of the environment in area adjacent to the Aral Sea [8] due to its desiccation has mainly become apparent in the following:

- Decrease in the total water areas of lakes in the Amu Darya delta from 400,000 ha in 1960 to present 26,000 ha;
- Drop in groundwater tables up to 8 m depending on the distance from the former sea shoreline;
- Incision of river beds up to a depth of 10 m; ;
- Transfer of salts and dust from the exposed seabed with a rate of 0.1 to 2.0 ton/ha within the belt of 500 km width;
- Transformation of the top-soil – an area of hydromorphic soils decreased from 630,000 to 80,000 ha;
- Increase in solonchaks' area from 85,000 to 273,000 ha;
- Reducing areas overgrown with reed from 600,000 to 30,000 ha or 20 times;
- Reducing areas of tugai (riverain) forests from 1,300,000 to 50,000 ha or 26 times;
- Climate changes within a strip of 150 to 200 km width; and
- Drop in fish production from 40,000 to 2,000 ton/year or 20 times.

Physical degradation resulted in economic losses at the rate US$ 115 million per a year and in social losses at the rate US$ 28.8 million per a year. The same consequences, but less intensive, were observed in the delta of the Syr Darya River.

It is clear that IWRM shall provide active observance of ecological water requirements as the priority of hydro-ecological water management. At the same time, the main attention should be paid to the following measures:

- Maintaining of flow-through (flowage) in water bodies, especially in lakes fed only by drainage water (*it is particularly important to maintain flow-through during the growing season*);
- Maintaining of water salinity in water bodies with fishery not more than 5 g/l (*it is particularly important to keep this level of water salinity during spring and summer periods when spawning, larva hatch, and fry (newly-hatched fish) growth (April-May) take place*);
- Maintaining of water depth in water bodies during the winter period not less than 1,5 m (*such a depth ensures fish wintering and access of muskrat to food resources*);

[8] "Assessment of socio-economic after-effects of an environmental disaster – Aral Sea shrinkage", 2001, Chief-Editor V. Dukhovny, the INTAS/RFBR-1733 Project, the SIC ICWC, Tashkent.

- Prevention of slumping in a water level during the period of fish spawning and hatching because this results in drying up of shallow water bodies and in a death of fish fry;
- Prevention of jump in a water level during the winter period because this results in formation of ice mounds and in deteriorating conditions for winter nutrition of muskrat, and under extreme water level fluctuations - in destruction of its habitats and a death of small animals;
- Presence of shallow zones suitable for reed growing that provides habitats and food for hygrophilous bird species and muskrat;
- Long-term preservation of a water area of lakes to form a hydro-biological regime of water bodies that enables providing forage resources for fish and birds.

The Resolution of the Heads of State of Central Asia in January 1994 based on the Conception on Improving Socio-Economic and Environmental Conditions in Surroundings of the Aral Sea states that mitigation of the ecological disaster in the region should be implemented by means of creation of artificially regulated water bodies at a spot of former coastal and intra-delta lakes and sea bays together with relevant afforestation measures. Conservation of lakes and maintaining their hydrological and hydrochemical patterns in proper manner completely depend on inflow of river water i.e. water availability in the Amu Darya River at the Takhiatash Dam and in the Syr Darya River at the Chardara Dam. According to this Resolution in the planning process of water allocation and limits for water diversion from transboundary rivers, in recent time the Interstate Co-ordination Water Commission (ICWC) provides for water supply into the Aral Sea and Priaralie at the rate of 10 km^3/year through the Amu Darya River, and 4.5 - 6 km^3/year through the Syr Darya River.

Based on abovementioned, it is possible to formulate a number of aspects that needs to be considered in the water resources management practice from the point of view of the integrated approach.

1. According to IWRM principles, water, land, and other resources within a catchment area should be considered as components of joint use, management, safeguarding, and development. Rights and duties need to be distributed between water users in such a way that the water demand control facilitates preservation and sustainable development of a natural potential. Based on those considerations, all water resources within the basin have to be considered in their interaction with economic activities, taking into account some limitations in use of water, land, and other resources, and reclamation measures in order to ensure sustainable development.
2. On the basis of the laws, regulations, and international agreements, the State assumes the responsibility and, with the assistance of its conservancy agencies, monitors the implementation of ecological and sanitary water releases and the norms on preserving natural streams that were discussed above.
3. The State has to promote gradual including of the environmental component into IWRM not only in the form of the participation of conservancy agencies in decision making at all levels of the water management hierarchy as equal partners, but also transforming “Basin Water Councils” into “Basin Water and Environment Councils” that should consider maintaining the sustainability of ecosystems as the primary task of their activity.

4. Water resources management has to base on the rigid principle of ecologically permissible water withdrawal (EPWW) to decrease irrevocable water use. When the level of EPWW is exceeded (such a situation took place in the past), countries (consumers) shall make their contribution into the international basin fund as a payment for excessive use of natural resources and implement mitigation measures. For example, in the Aral Sea basin the recommended total water withdrawal from water sources is about 78 km3 against the present water withdrawal of 106 km3, and 123 km3 in the past (1990). If each water consumer that exceed the ecologically permissible water withdrawal will make its contribution into the fund of ecological safeguarding of a basin, then opportunities for usage of these funds to improve environmental conditions within a basin as a whole will emerge.
5. For the purpose of preservation of rivers and water bodies as natural ecosystems, a drawdown of water reservoirs and a rivers' runoff should not be less in summer and more in winter than mean annual runoff (that is specified based on long-term measurements) in respective seasons. The observance of this rule can prevent transformation of rivers to runoff ditches. Water requirements of ecosystems in deltas and estuaries, flow-through and closed water bodies, should be specified taking into consideration their bio-productivity and sustainability based on monitoring data as well as requirements of countries that are using water resources.
6. Environment aspects should be included into IWRM plans at the level of basin, sub-basin, and region. Ecological problems that need to be solved exist in each irrigation system or WUA. This includes such measures as: (i) rehabilitation of disturbed natural landscapes due to water erosion, waterlogging, and deforestation; (ii) introducing an order in matters of excessive water withdrawals and use of local water sources; and (iii) inventory of sources and spread zones of pollutants, and their control and localization. All these measures have to be implemented within the environmental component of IWRM and by public bodies established for management of irrigation canals and WUAs. At the same time, a department of ecological examination should be gradually introduced in the management practice at the level of basin and sub-basin as an effective measure for rehabilitation of natural ecosystems.
7. Drainage and drainage water management is the important component of nature protection. The interrelation of surface water, groundwater, and drainage is a very sensitive aspect of water and land reclamation management because excessive water supply for irrigation or leaching of soils results in not only losses and deterioration of water, but also in land degradation and losses of soil fertility. The incorrectly designed drainage systems mobilize vast volumes of salts from lower stratums. In addition, unevenness of irrigation and drainage results in increasing water losses and non-uniform crop over an irrigated area. In order to identify these shortcomings in water management in timely manner, it is necessary to enhance activity of land reclamation services, to equip them with relevant equipment and measuring instruments, to introduce GIS and remote sensing methods for monitoring and evaluation of land conditions. It also needs to take into account that land salinization and waterlogging are one of the main factors decreasing crop yield and water productivity in irrigated farming because apart from the fact that there is reduction in crop yield, water consumption is increasing.

It is clear that at present, water requirements of ecosystems cannot further be met according to “a residual principle” (delivering of residuary water after satisfaction of the economic needs). To meet water requirements of ecosystems should be one of priority activities within IWRM.

4.7. Water saving and efficient water use is the national concern

In recent years, despite of overall reduction of water withdrawal in all countries of the Central Asian region (mainly due to the economic crisis) the efficiency of water resources use is insufficient.

The main aim of IWRM is to achieve the potential water productivity based on “the norms of water consumption under applying advanced methods of water use” or “the promising level of technologies in water-consuming sectors.” The practical outcomes of a number of the projects (the WUFMAS, Best Practice, IWRM-Fergana etc.) implemented in the region in 1997 to 2004 demonstrate that it is quite substantively to achieve the potential water productivity. On the basis of the experience and results of these projects the following recommendations can be made for large-scale introduction of water saving technologies in the region:

- Improving the system of monitoring and assessment of water resources;
- Introduction of the progressive system of water charging applying incentive stepped tariffs and penalty sanctions for each cubic meter of water used in excess of planned rates etc.;
- Revising all water use standards based on the scientifically-founded computer programs “ISAREG” and “CROPWAT” that enable us to computerize the water use planning process and at the same time to take into account characteristics of different infrastructure and water availability in various years as well as to provide a basis for adjustment of water consumption rates depending on different water availability;
- Based on these water consumption rates it needs to revise water use limits that are overestimated in most cases causing extensive organizational water losses, excessive expenses, and increase in drainage rates;
- Developing the zonal indicators of potential water productivity, and on their base granting of preferences to water users, that provides performing these indicators, in the form of reduction in taxes or fee for water services;
- Creation of pilot water saving projects, as a primary measure to demonstrate rational water use;
- Application of water rotation and other organizational measures and technologies to control water losses or unproductive water use at the field level (short-length furrows, careful land leveling, alternative furrow irrigation etc.)
- Introduction of the state-of-the-art irrigation technique and methods; and
- Establishing an extension service for water users providing a technical assistance in rational water and land use and in achieving the potential productivity of water and land resources.

Establishing extension services is very important because after disintegration of collective farms and state farms, the agronomical services of farms were abolished, and high-skill specialists either became farmers or ceased work in the agrarian sector, and were replaced with people who have funds, but have not any experience of farming activity. It is necessary not only to train them in crop cultivation methods, but also to assist them to become efficient owners of land resources. At the same time, it needs to train them in addressing to changes of climate and market conditions. In developed countries, extension services are widespread due to state financial support. In our region, such services only arise in the Republic of Kyrgyzstan and Tajikistan. Today the options of establishing of extension services are studied at the demonstration plots within the framework of the IWRM-Fergana Project. Farmers support this initiative; they are even ready to pay for such services. The problem is to find the proper place for their establishment that they may become efficient tools for IWRM implementation. We propose to establish them either within the framework of WUAs or under subordination of BWOs depending on the specificity of existing conditions, and to provide the state support at the initial stage of their operation.

Drafting agronomical passports of farmers' fields (field passport) according to specific methodology and applying computer models should become one of <u>the main activities of extension services related to improving land productivity</u>. A field passport contains basic agronomical and land reclamation information, relevant data and recommendations that are necessary for applying scientifically-based measures to decrease specific water consumption and to provide the potential productivity. A field passport also includes data on agrochemical and agronomic soil properties, climatic data, information on: (i) humus and nutrients contents in soils; (ii) soil salinity and other soil characteristics; (iii) field micro-relief; (iv) recommended terms and density of crop sowing; (v) crop growing phases, and (vi) economic indicators of crop profitability. Drafting field passports includes assessments of: (i) maximum possible crop yield, (ii) potential possible crop yield in given locality based on a site index of soil without consideration of changes in climate, agronomy, soil salinization, irrigation practice, (iii) actual possible crop yield depending on actual soil conditions and limited by controllable factors, and (iv) actual crop yield that is impacted by correspondent organizational shortcomings. Evaluation of these indicators and differences between their values allows to specify short-term, medium-term, and long-term measures to approximate to potential productivity.

A low crop yield over most of irrigated fields is resulted from the following factors:

- The lack of proper land leveling and non-uniformity of top-soil that result in irregularity of crops growth over fields;
- Untimely water applications along with adverse impacts of excessive irrigation or water applications with insufficient rates;
- Low quality of obligatory land treatment and inadequate weed and pest control as well as non-uniform applying of fertilizers over the field etc.;
- Inadequate ability of farmers to manage the process of crops growth with the purpose to provide a maximum possible crop yield; and
- Low quality of seeds.

If the last problem is a matter of the state control, then one from the bottom may be settled by means of training and knowledge exchanging; and three first problems are grave physical and technological defects that should be addressed in the process of improving the land resources productivity.

The special study reveals that the most prevalent type of irregularity of crops growth over the field, from the point of view of productivity, is the following: each field with an average crop yield of 2.5 ton/ha has 30 percent of its area with a crop yield of 3.0 to 3.5 ton/ha, 20 to 25 percent of its area with a crop yield of 1.5 to 2.0 ton/ha, and 10 percent of its area with a crop yield less than 1.5 ton/ha. Thus, an average crop yield is gathered only on 30 percent of the field area. If a crop yield on soils with a low fertility would be increased on 30 to 35 percent, then an average productivity of the field would be raised up to 3.0 ton/ha. The main causes of such an irregularity of crops growth over the field are the following:

- An irrigated plot without proper land leveling that results in over-watering or under-watering of its different parts (this problem could be solved by means of laser land leveling without other expensive measures);
- A variable extent of salinization and waterlogging in different parts of a field (this situation can be improved by land reclamation measures);
- Soil texture heterogeneity that may be reclaimed by scattering sand or clayey materials; and
- The lack of humus at some parts of a field.

Drafting field passports reveals its efficiency, and is supported by farmers. At present, the process of drafting field passports can be improved by means of applying remote sensing methods and information databases.

Owing to its inertness and applying water rotation, the system of water distribution through canals comes into conflict with the regime of crop water consumption. Therefore, for the sake of water saving it is necessary to solve this problem. In the process of surface irrigation, the system “water - soil - drainage” is exposed to an irregularity factor and limitations that hamper the progress of water saving and require in-depth studying of interactions within this system.

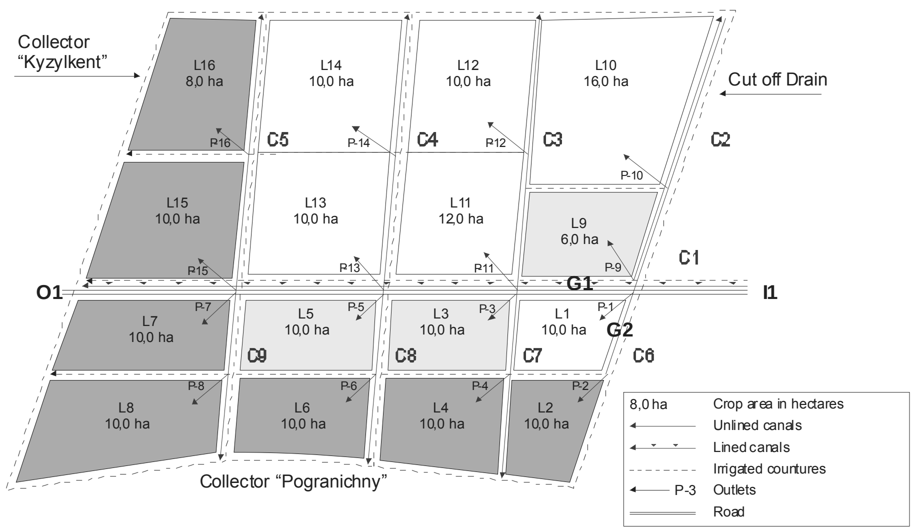
The international practice dictates that an irrigation schedule for crops should be designed with the aid of computer models “CROPWAT” or “ISAREG”. The scheduled terms and water application rates cannot be simultaneously provided over the whole command area, because it requires increasing a carrying capacity of an irrigation network many times. In addition, specific requirements to a water supply schedule are set to provide maximum productive use of water in a field and a maximum efficiency factor of the irrigation system.

Our studies in pilot farms in the Fergana Valley (for instance, in the farm “Azizbek” in the Akhunbabaev District of Fergana Province) have shown that both requirements predetermine a very intensive schedule of water supply through inter-farm canals resulting in the unevenness of water supply and in water losses in the process of water transit. To optimize water supply to farms it is necessary either to automatize operation of a head offtake according to downstream operational mode or to place an operator at a head offtake to communicate with those responsible for irrigation in farms and to control flow rates in compliance with their requirements.

It is clear that to operate a head offtake in such a manner is practically impossible since nobody permit such “twitching” of offtake gates under the established operational mode of a feeding canal. Thus, the first task is to coordinate a required irrigation schedule in a field with a water supply mode of the distribution irrigation network and further with an operational mode of the main canal not allowing heavy deviations from plant development requirements. At the same time, the following considerations should be taken into account:

- Employed irrigation schedules that are used in the practice of water use planning and water distribution are based on "mean annual data"; and therefore, water use plans are aimed at "mean annual outcomes";
- Adjustment (on the basis of water applications) of water use plans at the grass level takes place not only owing to weather impacts, but also due to economic conditions (availability of fertilizers, machinery, manpower etc.); and
- Water demand variations that depend on not only annual water availability, but also on weather conditions may be at the range of ± 2000 m3/ha!

Regional specialists have accomplished the above task. In the Fergana Valley, the practice of the pilot farm "Azizbek" has shown how to meet the water requirements of a water user (a farmer) under providing water supply conditions close to optimal ones according to flow rates and timing.



The following table of symbols is employed for the layout:
I1 inflow (inflow into an irrigated plot); O1 outflow (transit); G1, G2 gauging posts; C1-C9 irrigation canals; L1-L16 irrigated fields; P1-P16 inlets to fields.
Crops are indicated by different colors:
- cotton - wheat - corn

Figure 12. Layout of irrigation network on the pilot plot

It was only necessary to agree a feasible error in terms (± 4 days) and in water supply rates (± 5 %) and to develop a schedule of water delivery into canals and its distribution between irrigated fields based on optimization of the water use plan. As a result of applying developed methods and computer models, the co-ordination of operational modes of secondary and tertiary canals with an operational mode of the main canal became possible under establishing self-control of water running through.

Outcomes of the co-ordination of water demand, irrigation methods, and operational modes of irrigation canals based on simulation estimates are shown in Table 5 and in the form of diagrams of water applications over land plots in the farm "Azizbek" (the optimal option of water applications providing minimum losses of crop yield).

Table 5. Outcomes of the co-ordination in the farm "Azizbek"

Indicator	Actual	According to ISAREG	Proposed
Water supply factor (according to volumes)	1.876	0.6	1.0
Deviations from the optimal terms, days	± 12	± 0	± 3
Evenness coefficient	1.8	1.6	1.0
Organizational water losses in canals, %	26	24	3
Organizational water losses in a field, %	22.7	15.0	15.0
Water supply stability factor	1.8	2.1	1,0

The effectiveness of the proposed method to improve the land productivity was observed at all pilot plots of the IWRM-Fergana Project that was already demonstrated in Figure 10 (see above).

A ratio between effective water consumption, operational water losses, and seepage losses in a field (in 2002, when the effective water use factor on a field amounted to 42 to 51 percent) is shown in Figure 13 a. After the introduction of the proposed approach, the value of this factor has increased up to 69 to 81 percent (Figure 13 b). Thus, it is obvious that water saving reserves amount to 25 to 30 percent solely at the field level.

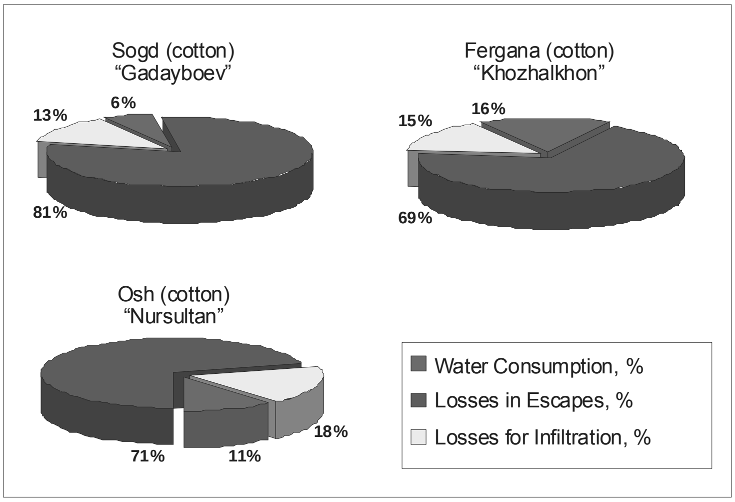


Figure 13 (a). A ratio between effective water consumption and water losses in a field prior to the project interventions

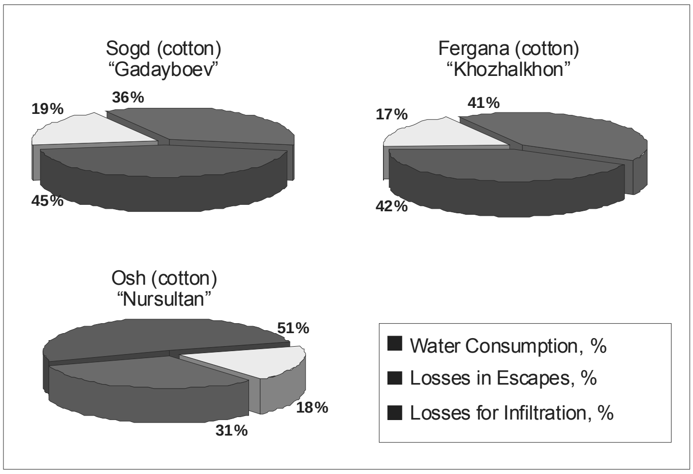


Figure 13 (b). A ratio between effective water consumption and water losses in a field after the project interventions

Another approach to solve this problem is employed in India, where water distribution between water users is made according to so-called method "varabandy" (water supply is clear-cut regulated at the range of 12 hours, and if farmer couldn't manage to irrigate his plot within this time limit, then he practically loses his water quota)[3]. Farmers construct ponds lined with a synthetic film at their plots, into which the water is supplied by gravity, and then, in their required time, the water is pumped and delivered to irrigated plots through pipelines or earth ditches. The State subsidizes procurement of pumps and pipes as well as 50 percent of expenses for fuel or power supply.

Along with organizational and engineering measures for water saving, the high implication consists in water demand management that is based on the state policy aimed at rational water resources use and includes the following:

- Establishing the legal basis for water use and support of water users;
- Introduction of the economic incentives system that should be supported at the State level for water management organizations and water users;
- Implementing the curricula that include water saving issues starting with school education;
- Motivating the pioneers of water saving by means of dissemination of their knowledge and creating of their positive image;
- Training of water users;
- Manufacturing equipment, instruments, and appliances to promote efficient water use; and
- The state support of procuring water meters to water users;

Introduction of advanced and ecologically sound technologies should base on the thought-out system providing the enabling environment (with applying financial, organizational, legal, and engineering tools). Low rates of introduction of these

[3] Recently this method of water allocation is tested in WUA "Japalak" in Osh province of Kyrgyz Republic within the "IWRM-Fergana" Project under supervision of IWMI staff (Iskander Abdullaev).

technologies were mentioned even in the European Water Directives. There are a few causes for this situation:

- For instance, ecologically sound and state-of-the-art equipment for biological sludge removal based on in-built micro-filtration modules is very efficient and has longer operational life (dozens of times in comparing with existing equipment), however, does not meet the present requirements to an internal rate of return. To put this equipment into practice it is necessary to provide specific discounts or incentives for investors (for example, at the rate of cost of additional water resources that are received as a result of applying this water treatment technology);
- Introduction water saving technologies for domestic purposes (faucets, shower-bath appliances, lavatory pans etc.) enables to reduce domestic water use pre capita up to 100 l/day. However, if all water users reduce their consumption, then a capacity of water treatment plants is not completely used. Therefore, an extent of introduction of water saving technologies is to be adjusted to the actual needs and alternative measures in that way when investments into water saving should less than investments into developing water treatment facilities without implementation of measures for water saving;
- Usually, in the process of bidding for the works the contract is awarded to bidders that proposed the least bidding price. However, as a rule, a new technology cannot be cheaper existing one, but it is more profitable regarding long-term and environmental aspects. It means that bidding criteria should be changed in favor of public profitable decisions; and
- The water prices established on the basis of complete reimbursement of all operational costs and profit unlikely will facilitate the introduction of more advanced and ecological sound decisions because they are based on the normative volumes of water consumption and treatment and specific current technology. Therefore, municipalities interested in conservancy should cover a part of expenses related to introduction ecologically sound technologies.

CHAPTER 5. LEGAL AND ECONOMIC ASPECTS OF IWRM [*]

The role of water governance[4] consists in establishing legal and economic frameworks for putting IWRM into practice, and at the same time forming the enabling environment in society.

After declaration of independence by the nations in the region, the differentiation of attitudes to water resources use and conservation took place and resulted in adoption of some legislative documents that state basic principles of water relations within the States and between them. In recent years, new Water Codes were developed in all countries of the region except Uzbekistan, where this activity was not completed. New Water Codes were put in force in Tajikistan (2000), Kazakhstan (2003), Turkmenistan (2004), and Kyrgyz Republic (2005). The IWRM principles are recognized as fundamental ones in Kazakhstan, Kyrgyz Republic, and Tajikistan. Some IWRM principles (the hydrological approach, establishment of WUAs etc.) can be found in the existing legislation of Uzbekistan. Public participation is reflected in the above-listed documents in different ways. For example, establishment of the Basin Councils as the mechanisms for co-ordination and involvement of all stakeholders in water management is stated in legislative documents developed in Kazakhstan and Kyrgyz Republic.

Establishing the legal framework that defines “the water rights” of all water users is the basis for water saving and responsibility for water-supply reliability of both water users and water management agencies. Unfortunately, these rights are stated in legislative documents only partially, and at the same time not for all water users. In reality, substitution of the water right by so-called “limited water use” creates conditions for abuse of power. Meanwhile, ensuring the water rights for all water users in the form of licenses or registration of the water rights “related to” the land rights shall establish the good base for making contracts with water suppliers, providing proper water delivery, and enhancing the responsibility for water saving; as well as it will be one of driving forces to introduce a water market.

The foreign practice shows that transferring the water rights to water users is extremely important for developing the agricultural sector. In some countries, in spite of the fact that water remains the public property, the water right based on licensing is a property right in itself. Water users that have got licenses for assured water quotas can sell their water savings to other water users on the mutually beneficial basis. At the same time, stocking water resources is based on applying the water-saving methods, intra-system daily-storage reservoirs, and other engineering measures that are especially effective when they are applied within WUAs.

In Kyrgyz Republic, the Law “On Water Users’ Associations” (2002), in particular, states the right of WUAs to sell the water, which was saved due to applying the state-of-the-art technologies, at market prices. The right to be a participant of a water market has to be granted to water agencies that make

[*] This chapter was written jointly with Mrs. D. Ziganshina who is the leading specialist of the SIC ICWC
[4] “Water governance refers to the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and delivery of water services at different levels of society.” (Global Water Partnership 2002)

investments in water saving and developing alternative water resources. At the same time, it is necessary to resolve the contradiction in financial interests of WUAs and farmers on the one hand and water agencies on the other hand. Introduction of payment for water services, especially according to progressively incremental rates, enhances water saving incentives for farmers and WUAs. However, water agencies that receive payment for water delivered hold an interest in increasing of water supply to consumers as much as possible otherwise they lose their financial welfare. In order to resolve this dilemma the State, first of all, should be reasoned in water saving since it reimburses most of expenses related to water supply, and in case of actual water saving the State shall reimburse to a water agency its operational costs as bonus. Finally, such an approach will be profitable for the State especially in case of complicated conditions of water diversion or pumping irrigation systems.

Top-priority measures on the introduction of economic instruments into the water sector are the following:

- Adopting the legislation that clearly defines the water rights of water users, especially of farmers, taking into consideration the size of their irrigated plots as well as the responsibility of water agencies for violations of these rights (at present, for example, the Law "On private farms" currently in force in the Republic of Uzbekistan states that the water quotas are established by water agencies in other words by organizations that are responsible for water supply). In the future, it is necessary to establish the water market to provide equitable and optimal water allocation from the economic point of view.

- Introduction of an advanced system of payment for water services and a differentiated fee for water as a resource, which should be at a minimum for water use within established norms and progressively increased in case of overuse (in India, for example, if water user exceeded norms within the range of 1 to 10 per cent then the fee for extra water volumes is increased 5 times, and for greater overuse 10 times!!!).

- Developing measures to enhance incentives to water agencies for water saving, for instance, reimbursing a share of operational costs at the expense of the state budget according to saved water volumes, or as is in common practice in Turkmenistan where 3 per cent of the profit received by agricultural producers is paid to water agencies that provided reliable water supply to farmers.

- Imposing a duty on water agencies to assist WUAs to establish the water record-keeping system, to equip irrigation canals with metering devices, to train their personnel etc. using special government funding for these purposes.

The financial stability of water agencies that operate based on the IWRM principles mainly depends on a proportion of annual inputs of water users and the government financing (at national, regional, and local levels). At the beginning of a move towards the market economy, an issue "a will to pay for water services" was repeatedly considered in the water sector, especially under the influence of international donors. It is more correct to put a question about "a capability to pay for water services" with respect to both non-agricultural water users (industrial enterprises are more capable to pay, and utility enterprises are capable to pay depending on social prosperity of the population) and particularly farmers whose capability to pay for water services is determined by their profit derived from irrigated farming. According to FAO data (2004) based on generalizations of the world practice of water charging, under irrigated farming an average possible fee for water services amounts to 5 to 10 percent of a net profit. In our practice, the fee varies at the range of 3 to 39 percent (Table 6).

The very important issue is the government participation in financing rehabilitation and improvement of water infrastructure. During the initial stage of a move towards market relations, there was a bias to put all these expenses on water users, though this practice contraries to the world experience. Owing to such an approach, for example, the rehabilitation of drainage tube-wells in Makhtaaral District of the South-Kazakhstan Province were not fully completed up to now since farmers do not want to reimburse these costs. Therefore, financial inputs into rehabilitation of water infrastructure should be distributed between the State and farmers taking into consideration income of farmers – the more income of farmers the less the share of the government participation in financing.

As a whole, the legal base for IWRM at the national level shall include the following provisions:

- Recognizing IWRM as the main way of improving water sector activities including such aspects of IWRM as establishing water management within drainage basin or irrigation system boundaries, public participation, and economic and social welfare in an equitable manner without compromising the sustainability of vital eco-systems;
- Setting of rights and duties of both water users and water agencies;
- Establishing procedures of water licensing or water rights regulation;
- Developing legislative regulations regarding an economic value of water and ecologic water releases as well as nature requirements on water supply;
- Introduction of paid water services and the principle “a polluter pays”; and
- Regulating the governmental participation in water sector maintenance and development, as well as tasks and obligations of municipal bodies.

Legal aspects at the local level shall include the following:

- Procedures for registration of WUAs, Canal Boards, and their Councils (Committees) as legal entities, and at the same time WUAs and Canal Boards should be registered as non-commercial, non-governmental organizations that are not levied by any taxes.
- Procedures for settling disputes that can take place in the process of water allocation, water supply, collection of water charge, and participation in public works etc. At the same time, it is necessary to use as much as possible the old traditions of public courts and arbitrages that acted in line with the Muslim and

pre-Muslim water legislation from time immemorial (so-called water use in accordance with the regular habits).

It needs to note that some countries in the region have already initiated a move towards implementation of above provisions of the reforms. For example, the National Conception on Rational Water Use and Preservation in the Republic of Tajikistan (approved by the Government Decree No 551 dated December 1, 2001) states the following practical measures:

- Introduction of economic instruments in the water sector on the basis of market relations, including mutual settlements between water suppliers and consumers, as well as between several water services within the irrigation system and organizations supporting them;
- Phased introducing the system of full reimbursing for operational costs to water suppliers at the expense of water users' fee and government subsidies in order to prevent deteriorating a working capacity of irrigation infrastructure;
- Annual financing the program of land reclamation and developing the water sector at the expense of funds from republican and local budgets and partial usage of financial means collected as the land tax;
- Developing and putting into practice the procedures of obligatory fee collection for allotment and withdrawal of land for new irrigation development or land reclamation to improve the farmland productivity;
- Involving the private sector and foreign investors in funding operation and rehabilitation of existing irrigation and drainage infrastructure and developing new irrigated lands;
- Improving the taxation and tariff policy in order to increase the efficiency of irrigated farming;
- Step-by-step introduction of normative funding into the irrigation sub-sector;
- Auditing the capital assets of irrigation systems to specify the need in financial resources for O&M;
- Top-priority funding of the most unique and vulnerable hydraulic structures;
- Recognizing construction and operation of water supply systems as top-priority interventions of the national policy; and
- Developing and putting into practice the advanced irrigation methods, as well as preferential terms for power supply during the transition period towards market relations in the zones of pumping irrigation where welfare of about two million inhabitants depends on irrigated farming.

Table 6. Water service costs and profit of farms belonging to different countries in the Fergana Valley (data was provided by Dr. Mier Pinkhasov)

In US$ per hectare

No	Indicators	Kyrgyz Republic, the WUA «Japalak»			Tajikistan, the WUA «Zarafshon»		Uzbekistan, the WUA «Akbarabad»	
		2002	2003	2004	2003	2004	2003	2004
1	Fee for water services of the water management agency	5.04	3.43	3.15	11.48	10.66	0	0
2	Fee for services of a WUA	2.85	3.9	4.2	3.5	2.13	3.2	3.3
	Total (water services)	7.89	7.33	7.35	14.98	12.79	3.2	3.3
3	Agricultural profit	266	294.7	330	207.4	32.9"	48.6"	48.4"
4	Cotton yield, centner/ha	-	-	-	19.3	22.8	28.7	27.2
5	Proportion of water service fee against the profit, %	2.96	2.48	2.22	7.22	38.9*	6.58	6.82

Note:

[1] – due to recession in cotton prices in 2004

*' – farm's profit under the state order for agricultural products (cotton and grain)

The important aspect of IWRM is the effective system of arbitration and conflicts settling at different levels of the water management hierarchy. The conflicts related to water distribution that become more strained under conditions of low water availability arise more often in comparing with other conflicting situations. According to the assessment made within the IWRM-Fergana project, conflicts related to water service payment take place, and in some cases, they have intensified. In Tajikistan, according to information of the Khodjabakirgan Canal Administration, there is some recession in water fee collection in comparison with the last year (as of August 2004) owing to establishing the WUA “Zarafshan” that is the biggest insolvent debtor among other water users. In experts’ opinion, the situation described above cannot be called as “conflict,” most likely this is violation of the contract signed by water users and the Khodjabakirgan Canal Administration. However, at present the efficiency of all canal administrations depends on settling in particular this problem. The Water Canal Committee tries to solve this problem, but as mentioned above, its abilities are severely limited yet. The conflict between water agencies and power suppliers is typical under conditions of pumping water supply, which takes place at the South Fergana Canal where water from the canal for the left-bank irrigation systems is mainly withdrawn by pumps. Power supply to the pump stations is very often cut off without warning that results in the tense situation in canal operation, sometimes emergency, and finally in instability of water supply. This situation is aggravated by a lack of or poor communication between the South Fergana Canal Administration and pump stations as well as by a high transit flow through the South Fergana Canal for additional water delivery into the Big Fergana Canal (BFC) and the Big Andijan Canal (BAC) in 2004.

CHAPTER 6. THE DECISION SUPPORT SYSTEM FOR IWRM (ENGINEERING AND MODELLING TOOLS)[5]

Integration processes and integrated water resources management are based on the co-ordination of institutional and economic activities at all levels of the water management hierarchy (see Figure 4), and are supported by the engineering measures and modeling outcomes. The most important aspects are cited below.

<u>Equipping and automation of the gauging stations</u> that belong to the hydro-meteorological services at the basin level for routine recording and on-line transmission of data on water flows and water quality in transboundary and national waterways, and water availability in lakes and water reservoirs to the control units and to the information system for general use. This activity has to be supported by signing the agreements between hydro-meteorological services and water management organizations (as end water users) in order to establish the system of free information interchange.

At the same time, it is very important to provide data on both water flows and water quality. In addition, water records at check gauging stations should be integrated with information of the Basin Water Organizations (BWO) regarding water diversions from rivers in order to draw up the water balances and to specify water losses from river channels and water reservoirs. This enables avoiding the present situations when especially in dry years the water rights of downstream users and the natural complexes are gravely disturbed. Establishing the SCADA system allows to solve this problem.

Figure 14. The Uchkurgan Hydroscheme on the Naryn River equipped with the SCADA system within the project financed by the SDC (the photo made by G. Poltarev)

[5] This chapter was written together with A. Tuchin – the leading specialist of SIC ICWC

Procurement of the equipment for flow rate measurements at the level of the river basin, irrigation scheme, and WUA including the computer-aided dispatch systems at all main hydraulic works and gauging stations on transboundary rivers as well as at all hydraulic facilities with a flow rate more than 10 m3/sec. This is the most low-cost activity under engineering renovation of irrigation systems that provides the basis for transparent and accurate recording of data on water resources and for establishing the database of the information systems. In addition, it allows solving some problems of modeling (in the first place, a water balance) and of establishing the monitoring procedures for water intakes, water reservoirs etc.

At the same time, setting of hydrometric instruments and their calibration should be implemented for each head intakes, and for balance gauging stations located at the end alignments of different sections of main canals; and flow rate measurements need to be performed at all control structures (outlets to the secondary canals) to the point of outlets into WUA' systems. On the WUA' area, at least, intakes of water user groups, which are established along each canals for applying water rotation within a irrigation system have to be equipped with hydrometric instruments. After all, these measures enable establishing a database for evaluation of indicators of water sharing and water use within sub-basins, irrigation systems, and WUAs.

It is obvious that, at present, setting of self-recording units or automated systems for monitoring flow rates and water quality is possible only at large control structures and water intakes with flow rates more than 5…10 m3/sec. However, as a whole, the routine monitoring of flow rates at the small control structures with applying curves of the function Q=f (H) or correlation tables for specifying water withdrawal volumes based on recording of electricity consumption by pumps is the mandatory requirement for reliable and sustainable water supply through the irrigation system.

Figure 15. Water-metering weir at farmer's inlet in the WUA "Zarafshan", Tajikistan (the photo made by V. Sokolov)

Accounting for all kinds of water resources for the purpose of their equitable use and of increasing in water availability. One of important shortcomings peculiar to the current water use is that surface water resources are mainly subjected to water sharing without consideration of groundwater and especially return water available. However, just the presence of these waters gives an opportunity for more equitable water allocation and meeting the water requirements under water scarcity. Therefore, the following management tools should be considered:

- Developing GIS layers under settling maps of groundwater and return water sources over maps showing local conditions (crop pattern, irrigation infrastructure etc.), and consideration of these water resources in the process of drawing up the water use program;
- Planning of water use and day-to-day management considering groundwater and return water available;
- Developing the methods of return waters use (sometimes after their treatment) for irrigation of technical crops or in various technological processes; and
- Considering replenishment of the aeration zone by an upward groundwater flow in order to reduce surface water use right up to establishing so-called conditions of "sub-irrigation."

Application of GIS for the following purposes:

- Specifying areas and characteristics of water demands of some water users with the purpose of their differentiation (according to soil types, hydrogeological conditions, water duty zoning etc.);
- Rating of crop density variation by applying remote sensing methods for subsequent trimming of soil fertility, land leveling as well as for reclaiming spots of saline soils in order to improve water use efficiency; and
- Monitoring trends of land salinization and water logging.

Developing and introducing the system of working out and adjustment of water use plans (this issue will be considered in the separate section in accordance with its importance for transition towards integrated water resources management as the basis of sustainable water delivery and distribution), and their co-ordination at various levels of the water management hierarchy.

Establishing of the information system that integrates databases (DB), a knowledge base, GIS, and a set of tools for their application, which are developed at various levels of the water management hierarchy. The modern computer equipment allows developing, equipping, and wide putting this system into practice as the basis for planning, monitoring and day-to-day adjustment of water management activity. At the same time, the dispatching is one of major technical elements that interrelates separate control objects and information (under considering their natural and economic diversity) with water management systems using a set of models and modules, which became the public mechanisms. In particular, this tool enables tracing the current changes in water use, water availability, and steadiness of water supply in order to provide maintaining at the planned level.

Management models indisputably cannot completely simulate all complicated processes that take place in the chain of consecutive events of water resources formation, diversion, protection, and consumption. Nevertheless, a combination of well-developed models reflecting the algorithm of dispatching rules and the certain management system at each hierarchic level can provide the maximum approximation of models to actual management situations. At the same time, they facilitate development of tools that improve sustainability and timeliness of water supply and productivity of irrigated farming as the main consumer of water in arid and semiarid zones. Taking into consideration all these aspects, we have developed models and indicators in linkage with the information system, which are the tools for water resources management and development.

The main task of developing this set of models is to simulate the productivity of "a field" or a farm. In actual practice, application of the recommendations based on modeling allows approaching the potential crop productivity under providing relevant land-reclamation conditions (by supporting the required drainage and salinization control) and the water supply regime that meets crop requirements under the existing crop rotation.

The set of models coordinates two-way activities: forming water requirements of consumers according to the principle "bottom-up" and establishing possible limits for water supply according to the principle "top-down" taking into account engineering parameters of existing canals. Models also provide the very important component of integrated water resources management – coordination of the hierarchic levels related to water supply according to the principle "top-down" and water disposal according to the principle "bottom-up". This enables to search extra water resources in case of water scarcity or impossibility to meet water needs of consumers due to technological restrictions.

Analysis of physical conditions and necessary resources for maintaining irrigation infrastructure that, within certain limits, depend on the scale of repairing and operation works plays the important role in the process of modeling and enables adjusting some measures if deterioration of physical conditions becomes apparent. In addition, we should focus attention on a long-term planning taking into consideration the destabilizing factors affecting water resources development and management, and develop mitigation measures.

Main phases of water allocation management.

Similar to other technological processes, the process of water allocating can be split into distinct phases, and at the same time tasks for different phases, which require specific information for decision-making, have to be specified. Rehabilitation and long-term development of irrigation systems are not considered in this paper, therefore one year (a hydrological year) is taken as the maximum period under consideration consisting of two sub-periods of time: a growing season and a dormant season. In turn, each period is split into ten-day intervals that are denoted by "t". For denoting a time within these intervals a symbol "τ", ($\tau \in t$) is applied. A ten-day interval under consideration will be denoted by "t", while a preceding interval and a successive interval by t - 1 and t + 1 respectively.

Assuming technical parameters of irrigation systems are constant over the whole management period, we propose that emergencies in the process of operating the irrigation systems are not considered at this stage of analysis, and they can indirectly be taken into account by reduction in values of “system controllability” or increase in values of “water losses within system”. In line with the local terminology, water management planning for a one-year period consists of three components:

- Annual planning
- Operational planning
- Operational management

Annual planning is designed for the whole year including a growing season and a dormant season (an out-of-irrigation period). Two tasks should be considered here.

Task 1: Specifying water users’ requirements.

Source information:

- Crop pattern;
- Data on land use;
- Distribution of cropped areas per water-duty zones;
- Crop water requirements;
- Leaching requirements for saline lands; and
- Average annual hydrological data in the region.

Solution procedures: the direct calculation approach; an optimization method is rarely used.

Results: water volumes that need to be supplied to each water user over the entire period and per ten-day intervals.

Indicators of solution results assessment:

- Specific water productivity average-weighted over the cropped area (US$/m^3); and
- Water productivity by crops (m^3/ha).

*Task 2: A*djustment of water supply in line with water allocation quotas (limits).

Source information:

- Data on the water availability forecast regarding a current year; and
- Engineering parameters of the irrigation system.

Solution procedures: the optimization method (distribution of water through the irrigation network with a limited carrying capacity).

Results: water volumes allocated to each water users during the entire period and per ten-day intervals.

Indicators of solution results assessment:

- Specific water losses within the irrigation system (the efficiency);
- Reduction in annual water supply to each water user in equitable manner; and
- Equal reduction in water supply to each water user per a ten-day interval.

Solution results of both tasks under the annual planning: the water use plan revised.

The annual planning is performed in two steps: at first, during a dormant season for an approaching growing season, and then during the growing season for the next dormant season. Figure 16 below illustrates a sequence of the solution process.

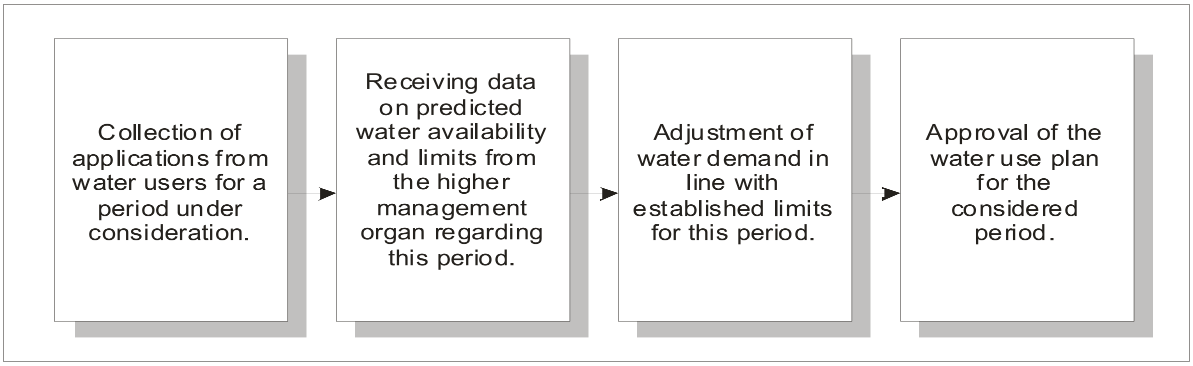


Figure 16. Flow-Chart of the Annual Planning Block

Operational planning is performed for each ten-day interval; “t” is a number of the ten-day interval under consideration. In this case, two tasks are also solved.

Task 1: Analysis of the water distribution process during the past period {0 ... t – 1}.

Source information:

- Water use plan;
- Applications of water users within the interval {0 … t – 1};
- Actual water supply to water users within the interval {0 … t – 1}; and
- Actual runoff hydrograph within the interval {0 … t – 1}.

Solution procedures: the statistical technology of analysis using the group of indicators.

Results: the set of indicators according to specified criteria within the interval {0 ... t – 1},

Relative indicators of solution results assessment:

- Water supply to water users during past periods of management;

- Water allocation among water users in an equitable manner; and
- Water losses within the irrigation system.

Task 2: Adjustment of water supply to water users within the interval “t +1”,

Source information:

- The set of indicators according to specified criteria within the interval {0 .. t – 1};
- The revised water supply plan at a point in time “t”;
- Applications for water of water users at a point in time “t +1” that are formed on the basis of actual sowing and irrigation dates as well as current weather conditions; and
- Predicted runoff hydrograph at a point in time “t + 1”.

Solution procedures: the optimization method (distribution of water through the irrigation network with a limited carrying capacity).

Results: water volumes allocated to each water users at a point in time “t +1”.

Indicators of solution results assessment:

- Proximity of actual water supply to water users’ demand;
- Reduction in water losses in the irrigation system; and
- Improving equability of water allocation among water users.

Figure 17 below illustrates a sequence of the solution process at the stage “Operational Planning”.

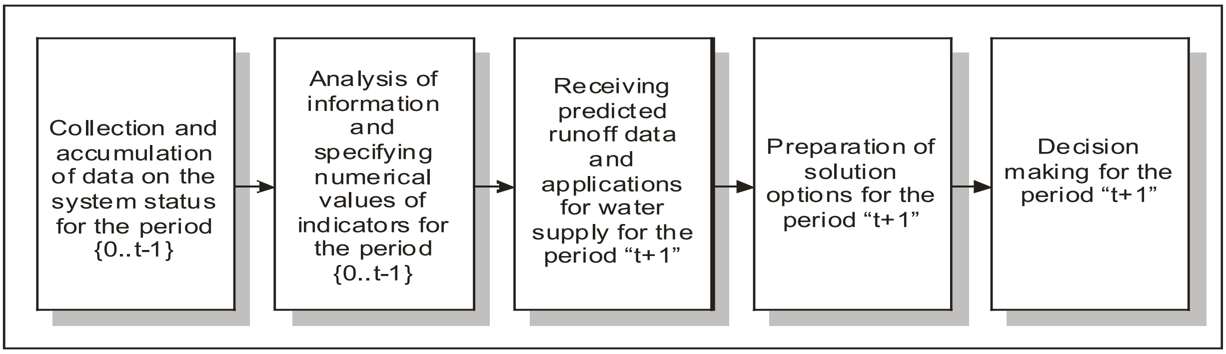


Figure 17. Flow-Chart of the Operational Planning Block

Operational management is performed on the daily basis (sometimes hourly). Two tasks are solved as follows.

Task 1: Water supply to water users in conformity with the rates specified during the operational planning stage for the interval “t”,

Source information:

- Water supply to each water users on the ten-day basis;
- Actual runoff hydrograph at a point in time $\tau \in t$; and
- Actual physical condition of hydraulic structures.

Solution procedures: the regularization method.

Results: daily (by the hour) water delivery to water users.

Indicators of solution results assessment:

- Statistical straggling of hourly and daily flow rates regarding established ones.

Task 2: Records of water supply.

Source information:

- Data on actual metering of incoming flow rates at a point in time “$\tau \in t$ ”; and
- Actual condition of the metering devices at a point in time “$\tau \in t$” (here τ is a point in time within a ten-day period

Solution procedures: the interpolation method.

Results:
- Designed flow rates under water delivery to each water users; and
- Designed water levels at different alignments of the canal.

Indicators of solution results assessment:

- A range of flow fluctuations, and specifying the metering devices errors.

The stage “*Operational management”* provides implementing solutions developed during stages of annual and operational planning. Figure 18 below illustrates a sequence of the solution process at the stage “Operational management”.

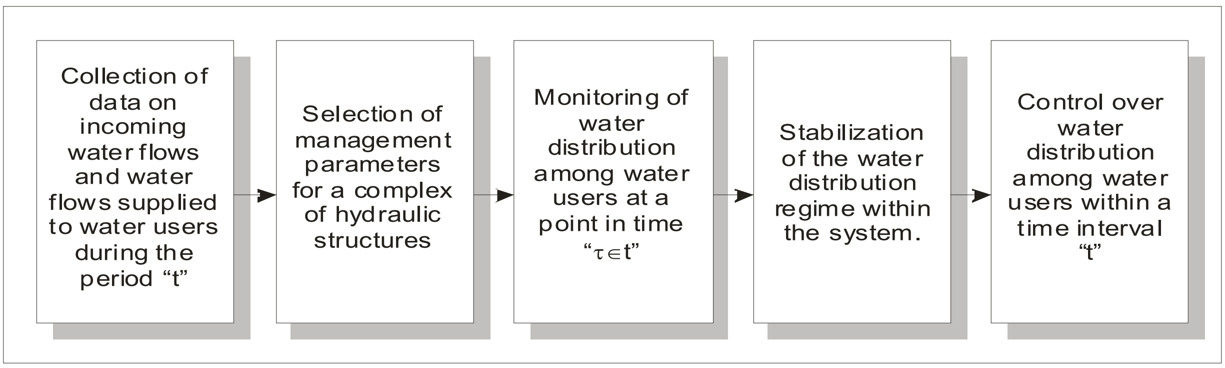


Figure 18. Flow-Chart of the Operational Management Block

Outputs of operational management form a feedback loop necessary for solving tasks at the stage of operational planning.

Initial outcomes of applying these tools within the IWRM-Fergana Project have demonstrated the real opportunity to improve the water management efficiency of both water users and water management agencies. Water supply equability was improved along the South Fergana Canal (SFC) within the range of 70 to 95 % in 2004 against 25…76 % in 2003 (Figure 19) as well as there is increase in management efficiency of the canal (Figure 20).

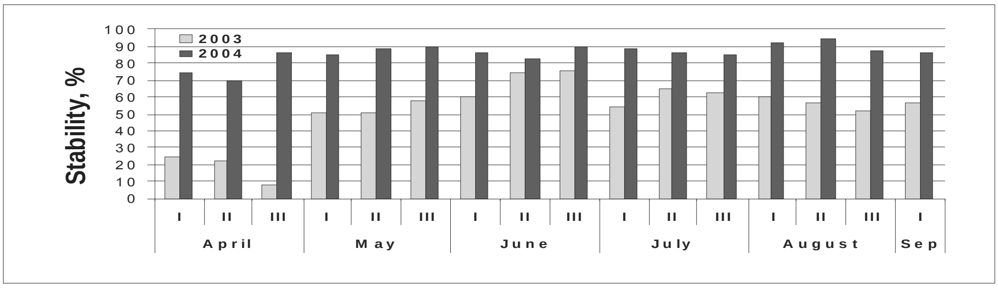


Figure 19. Stability of Water Delivery along the SFC in 2003 and 2004

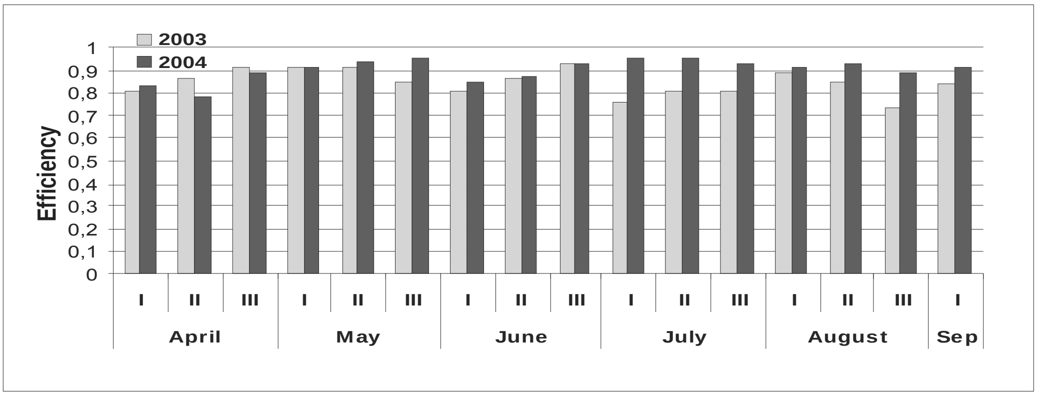


Figure 20. Reduction of losses along the SFC in the result of perfection of water delivery procedures in 2004

All these achievements resulted to enhancement of water supply stability at the WUAs' level (Figure 21). Peculiarities of extreme years (dry or wet years) should be taken into account under management of irrigation canals, irrigation systems, and irrigation networks within WUAs' areas. In wet years, the highest emphasis should be placed on protecting from mudflows (especially over steep hill-sides), preventing breaches of dams, flood control, and safe-keeping reclamation networks and structures. In dry years, water management includes establishing the so-called limits in water supply, excluding cultivation of wet crops and intercropping, and searching opportunities for groundwater and return water use etc. Special attention should be paid to establishing a water rotation ("avron"[6]) and coordinating the water rotation process within the water distribution system and the WUA's area (at their tertiary canals).

[6] The local term for water rotation procedure

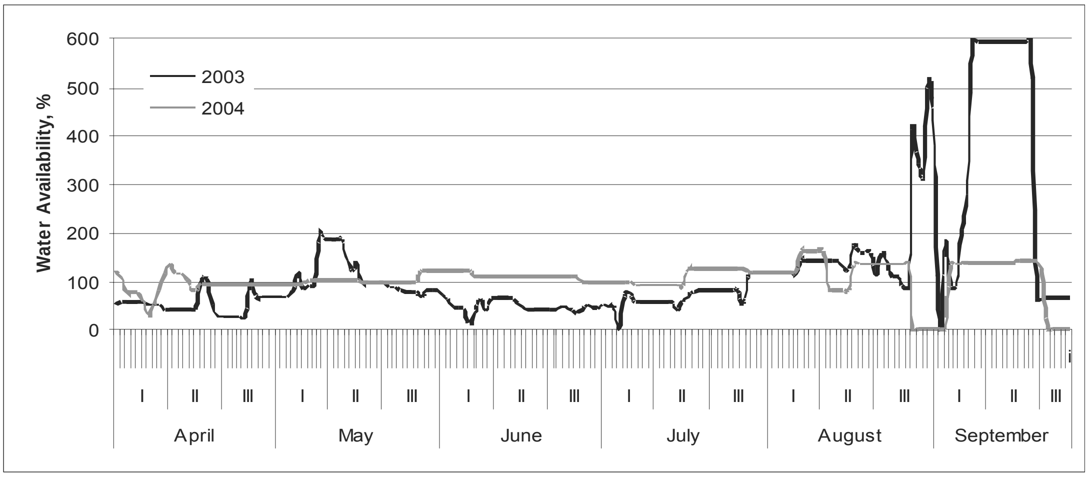


Figure 21. Variability of daily water supply along the canal "RP-1" within the WUA "Akbarabad" in 2003 and 2004

Initial outcomes are encouraging, but wide dissemination of gained experience requires extension of technical and institutional activities as well as social mobilization of water users and water management agencies.

CHAPTER 7. CHARACTERISTICS OF INTRODUCING IWRM IN THE INTERNATIONAL DRAINAGE BASINS

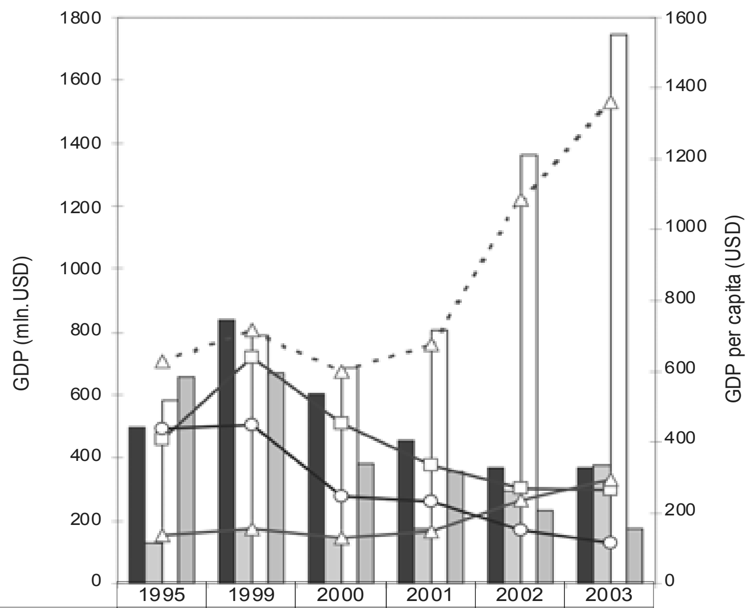
In the process of developing the project “Transition towards integrated water resources management in lower reaches and deltas of the Amu Darya and Syr Darya rivers,” the regional experts faced the characteristics of IWRM in the international drainage basins.

Similar to the Fergana Valley, the areas in lower reaches of both rivers are the most socially tense zones in Central Asia. However, if in the Fergana Valley the intensive population growth and a deficit of land resources are the key destabilizing factors that cause rural unemployment and the lower social security, then there is an abundance of land resources in lower reaches of both rivers, except Khorezm Province, and the primary problem is a growing scarcity of water resources and unstable water supply that is especially aggravated by neglecting equity and evenness of water distribution between upstream and downstream reaches of the Amu Darya and Syr Darya rivers particularly in dry years.

Another problem in these areas is insufficient care of eco-systems, but more often neglecting of their ecological requirements that resulted in desertification and degradation of eco-systems in the deltas. Therefore, a move towards IWRM in these regions cannot be restricted only by the national component as it was in case of the IWRM-Fergana project. Here, the whole system of water management in the basins of both rivers needs to be put in good order to ensure equitable and sustainable water supply at the transboundary level. In that way, at national and local levels the proper conditions can be built up for reducing wasteful water losses in all hierarchical components of water supply systems and increasing water use productivity as well as for providing assured water supply to water users and eco-systems of deltas and wetlands.

Downstream areas are mainly suffered from current water management at the transboundary level due to the numerous factors: (i) dependence from behavior and co-ordination of activity by upstream countries; (ii) operational mode of hydropower stations; (iii) observance of planned operational mode of upstream water intakes, and (iv) accuracy of water availability forecast, etc. In spite of the political will of Heads of the States and Governments of Central Asian countries that was stated in a number of international agreements (March 1993, January 1994, April 1999, and August 2002) and of the 15-years activity of the ICWC and its Executive Bodies directed on ensuring conflict-free water sharing, the experience of two dry years (2000 and 2001), especially in the Amu Darya basin, and of two wet years, particularly in the Syr Darya basin, proved a faultiness of the current water management practice.

As shown in Table 1, owing to irregularity in water distribution between upstream and downstream systems during dry years, GDP as a whole and per capita slumped and could not be recovered during two subsequent years (it was recovered up to the 1999-year level only in 2004, see Figure 22).



	1995	1999	2000	2001	2002	2003
Khorezm *(mln.USD)*	495.0	841.6	606.1	454.3	369.9	369.2
Tashauz* *(mln.USD)*	126.5	171.5	148.4	174.9	294.4	378.2
Tashauz** *(mln.USD)*	584.5	792.4	685.4	807.9	1360.0	1747.4
Karakalpakstan *(mln.USD)*	658.1	672.3	378.8	356.7	232.1	175.8
Khorezm *(USD per cap.)*	408.3	640.6	452.9	333.8	267.5	263.2
Tashauz* *(USD per cap.)*	136.0	155.6	129.9	146.1	235.1	294.4
Tashauz** *(USD per cap.)*	628.4	718.8	600.2	675.1	1086.1	1360.2
Karakalpakstan *(USD per cap.)*	439.0	447.3	248.1	231.1	149.3	113.0

Figure 22. Variations of GDP (*Tashauz Province, estimated in US$ according to the market rate; ** Tashauz Province, estimated in US$ according to the government rate)

The basic causes are the lack of differentiated regulations for water allocation and management and specifications for ecological water releases in years with various water availability as well as incomplete measurements of in-channel water losses and “hydroegoism” of some managers of large-scale hydropower units. In 2004 and 2005, emergencies were during the flood period on the Syr Darya River due to non-coordinated construction of the Arnasay Dam that affected water discharges from the Chardara Reservoir, non-compliance with the regulations/requirements of winter operational mode regarding river flows, faults in short-term runoff forecast etc.

At the same time, preconditions that enable to facilitate introduction of IWRM in international drainage basins in Central Asia are the following:

1. The availability of basin water organizations for managing the waters of international drainage basins (the BWO “Amu Darya” and the BWO) enables to enhance existing institutional frameworks for developing and strengthening the co-operation based on IWRM principles. From the point of view of institutional aspects of transboundary water management, the basin water organization should include:

- The Public Board (Council) of the BWO consisting of representatives from all countries and provinces situated within the basin, representatives of the most important organizations, which operate hydropower schemes and main irrigation canals, representatives of the hydrometeorological offices, and especially representatives of organizations engaged in managing the delta eco-systems who should form the special Hydro-Ecological Council;

- Taking into consideration the role and characteristics of forming return water in each drainage basin and its impact on river water quality, it is necessary to establish a specialized department within the frameworks of BWOs for monitoring and management of return water and water quality, which should develop proposals to the ICWC and Governments on measures for improving conditions of natural streams and for integrated use of groundwater and return water.

2. Applying the experience of earlier activities in modeling and establishing the DSS (activities of the USAID, SIC ICWC and others) to develop a set of models for water management in each river basin. These models should be used for annual and long-term water management planning taking into consideration interrelations of rivers and economic zones (water diversion from rivers and forming of return water). Based on modeling BWOs, national water agencies, and economic sectors will be able to develop alternatives of their activity, to assess impacts on downstream areas and other riparian countries, and to reach a consensus regarding their management decisions.
3. A system of recording and predicting river runoff should be considerably improved by means of technical reequipping that enable applying the remote sensing methods, and especially by arranging the data exchange between national hydrometeorological services and BWOs in order to enhance their ability to make forecasts. In addition, using available data on long-term monitoring of river runoff, it is also needed to specify dynamics of water losses in the river channel at different river sections and to elaborate an algorithm of their account in the process of estimating available water resources, which can be used.
4. On the basis of design, research and organizational works and modeling, the following regulations and guidelines on water management of transboundary rivers should be developed and preliminarily agreed:
    - Regulations on the Basin Councils (Boards) and their participation in planning and management of river water resources;
    - Guidelines on estimating ecological requirements of rivers, eco-systems, and wetlands in deltas regarding water resources;
    - Guidelines on specifying available water resources of rivers in years with different water probability;
    - Regulations on control and allocation of water resources in years with different water probability;
    - Operational rules of BWOs for activity during extreme years (wet years, and droughts);
    - Operational procedures for a cascade of reservoirs (a mode of filling and drawdown);
    - Regulations on financial relations between countries that participate in water management and rivers' runoff control;
    - Regulations on responsibility of countries and some large-scale water users to observe the rules of water use and operational modes;

The special attention should be paid to the following issues related to management of river runoff:

- Developing the plan for improving the system of predicting river runoff and water recording by national hydrometeorological services; co-ordination of their data with flow rate measurements made at the gauging stations of BWOs; and on-line data exchange and processing in order to co-ordinate water distribution and at the same time to specify in-channel water losses;
- Flood control including a warning system; developing the National Action Plans for emergencies and declaration of the state of emergency in the river basin; and co-ordination of all measures by BWOs etc;
- Establishing the limits for pollutant discharges into rivers with a view to maintain appropriate water quality (a concentration of pollutants should be below the values of the MPC) and the procedures of fining in case of infringement of established limits;
- Regulations on co-ordination of construction or rehabilitation of water infrastructure on transboundary rivers; and
- Establishing the Irrigation and Hydropower Consortium (and use of financial tools) for co-ordination of interests of the hydropower sector and irrigated agriculture under the individual approach to management of these sectors;

CHAPTER 8. MEASURES FOR THE IWRM PRINCIPLES IMPLEMENTATION

A move of the countries towards putting IWRM principles into practice indisputably is built up on the basis of the political will and appropriate social environment. Its initiation cannot be an instantaneous action and has to form gradually and quite systematically. Therefore, transition towards IWRM requires ensuring the thorough understanding and developing the Action Plan.

The progress in IWRM implementation abroad and our initial steps enable to demonstrate its great possibilities and the role of "water governance" for successful reforms. Governance, as the political aspect of successful water management, shall provide <u>the co-ordination of activity of municipal, provincial, and national agencies and involvement of all stakeholders</u> in the integrated planning and organizational interventions.

At the same time, orientation towards water demand management is of great importance because it allows refusing from extension of water infrastructure in line with the demand growth. Governance is of great importance for overcoming the inertia of "status quo." This conception covers a wider range of activities than simply the role of the Government. It includes wide interaction of institutional frameworks, the participatory process of "decision making," involvement of the private sector and a civil society as a whole. Based on such an extensive political and public platform it is possible to use forces of traditions and religious and national tendencies by means of education and establishing the priorities and an enabling social environment; to develop financial incentives for water saving by means of the system that includes fee collection, auctions, penalties, privileges, bonuses; and at the same time to specify fields of activity for private and local investments.

In addition, it is important to state that the payment for water on the basis of contracts with water management agencies should be coordinated not only with the amount of water supplied but also with the quality of water services. Therefore, governance should include a few important aspects:

- Specifying parameters of future development and relevant demands in water and other resources, as well as the possibility to use non-traditional water sources such as return water or wastewater after certain treatment etc.;
- Identifying the priorities both for water use and for interventions included in the National Action Plan;
- Developing the principle regulations that should underlie water management in general and water demand control especially, including (but not limiting) the following:

    - Necessary and possible options of an institutional set-up and practical measures for their adaptation;
    - Specifying what social layers are beneficiaries in order to involve them in water management; their interests and how these interests could be coordinated with water saving priorities because sometimes some social layers (for example, water management organizations) can be in opposition to any changes because reforms contradict with their

monopolistic interests to supply water as much as possible if their financial well-being will not be coordinated with water saving.

- Assessing social and ecological impacts of water demand management and convincing the stakeholders in their current and long-term benefits as a result of this approach;
- Ensuring the possibility for stakeholders to express their opinion/views in order to include these views into the water management plans;
- Direction of attention of all organizations toward "the best practice" (after its demonstration within the pilot projects) and its leading role in IWRM implementation, as well as dissemination of the experience gained at demonstration plots over all areas with similar conditions;
- Developing the system of cross-sectoral co-ordination and cooperation of all hierarchical levels of water management for achieving the general ultimate goal;
- Capacity building of IWRM by means of establishing the system of financial support, pilot projects, training centers, investment organizations and consulting firms; and
- Establishing the monitoring system over implementation of IWRM plans.

It is preferably to draw up the plan of establishing "water governance," which according to the experience of different countries can consist of the following phased measures:

- Developing and consolidating the network of politicians, scientists, and stakeholders interested in improving water management;
- Gaining a general understanding of advantages, possible benefits, and complexity of putting the IWRM principles into practice under providing sustainable development; and
- Identification of key political actions for creating efficient tools for water management;

Further, it is necessary clearly to define how "governance" will oppose group interests that become apparent in the form of a sectoral or administrative resistance (Figure 23) and other risks. In our view, the following interventions can facilitate IWRM introduction:

- On the basis of political pressure "up-down" and "bottom-up" to gain the public understanding of the growing danger and the necessity of water crisis control. The widespread information campaign regarding negative impacts of water crisis that can be in each country, province or district in the future should be initiated. In addition, what consequences wait for the civil society (enormous extra expenses, the risk of water supply failure, and the crisis of water users) and the nature (what we give our descendants) need to be elucidated; and
- Education of the future generation (in kindergartens and schools) to form its behavior and attitude toward water as extremely respectful and economical. There is a wide range of tools for the special education: the WET program, the training on the basis of traditions, social and religious principles etc. This is not only a matter of attitude toward water but also forming a healthy way of life

including transition to other diet (to a greater extent of vegetarian diet) that is more economical from the point of view of water saving.

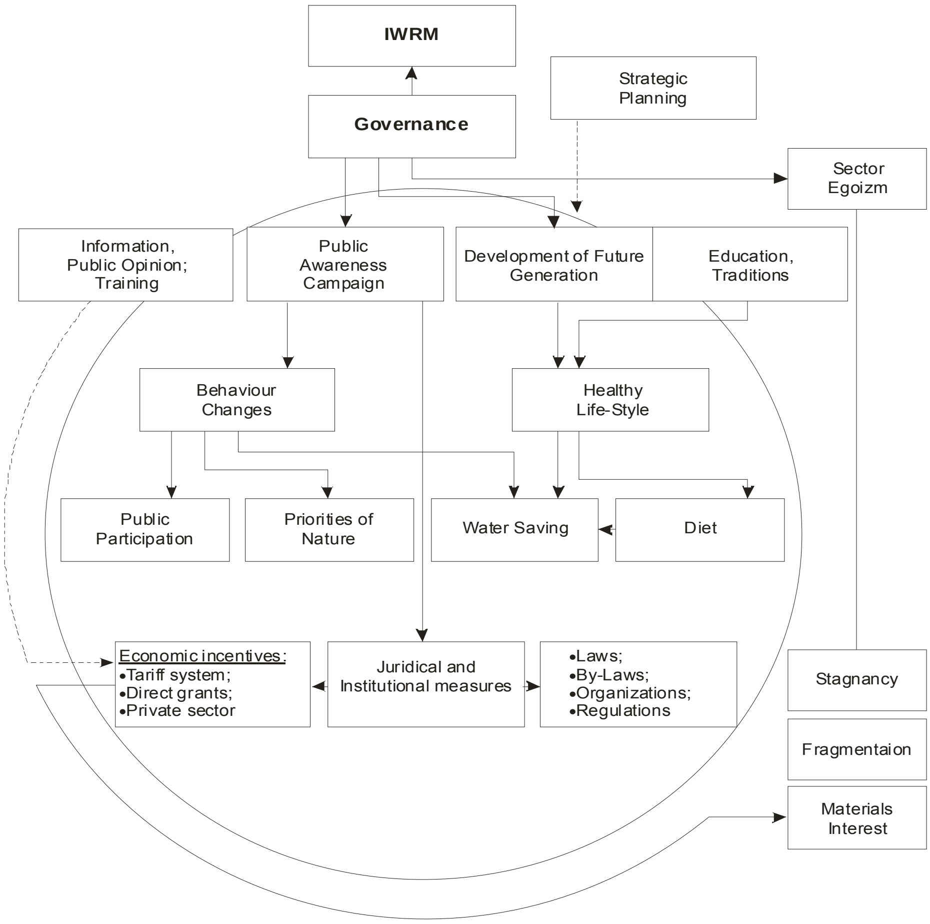


Figure 23. Interrelations of "Governance" and IWRM

Both interventions should radically change a people behavior, their attitude toward uneconomical water use including wasteful water releases. It is important that changes in a people behavior and their attitude toward water do not require the capital investments but result in enormous saving of water.

Another two interventions that facilitate water saving are the following:

- Legal and institutional measures including enacting the appropriate laws and regulations and establishing the special water management framework based on wide public participation and equitable involvement of stakeholders;
- Developing the economic tools such as incentives for water saving, payment for water services (it is advisable to collect a fee based on the block system), penalties for water pollution, fee for forming water resources, and especially the co-ordination of hierarchical levels of water management.

The last two interventions promote the efficiency of the first ones due to improving water management and use on the basis of such measures as water charging, keeping records of water supply etc. According to “Environment Canada” and the environment management project “Polis”, only introduction of water metering can decrease water demand of water users on 15 to 20 percent. Therefore, it should be done on the irrigation systems of substantial water users at their expense, and at the expense of municipalities or other bodies for the poor. In this case, the financial participation of the Government sets a good example, and at the same time provides the economic benefits.

These interventions, all together, should promote IWRM and withstand the counteraction mainly within the water management surroundings. For example, let’s consider the interests of water management organizations. Water saving by water users (WUAs) can results in drop of incomes of water management organizations and their financial losses. For example, in Tajikistan we met the actual resistance of managers of provincial water management organizations. Therefore, the State shall guarantee against loss of water management organizations by paying them compensation according to water savings, but it will be justified due to a decrease in running costs including power supply of high-head pump stations that reimburses this compensation on the safe side.

So-called “hydroegoism,” in contrast to “hydrosolidarity,” has three symptoms: administrative, sectoral, and parochial interests. The coherent policy that declares a rejection of water management on the basis of the administrative-territorial principle and a transition towards water management within hydrological boundaries should withstand parochial interests. All territorial units interested in water management within a drainage basin or an irrigation system should be presented in the Public Water Management Committees and on equal terms participate in both decision making and developing the regulations related to the basic rights and duties of water users. Public participation politically supported would also withstand the sectoral “hydroegoism” when representatives of all sectors (hydropower, irrigation, water supply, and recreation) would be equally represented in the Water Councils of irrigation systems or drainage basins to develop mutually acceptable rules of water management in co-ordination. All this would be possible if the State would adopt relevant laws and regulations and monitor their implementation.

There is another characteristic of public participation. It is necessary to form the understanding in society corroborated by legal and organizational measures that public participation is not only the rights to assert own interests but also duties, which each participant of public water management should take upon himself (in financing and other issues) proportionally to his share of water resources used and the role which he wants to play in water management.

The fragmentation of duties is another counteractive factor. At any level of water management, as a rule, a few responsible bodies or managers make a decision. Bureaucratic behavior and official ambitions often mean that the co-ordination between them and timely decision-making are sacrificed. We have faced these bureaucratic phenomena repeatedly in the process of implementing ICWC’s decisions when authorized representatives of some countries after signing the interstate protocol on agreed actions delayed their implementation, to put it mildly, since they were afraid to incur anger or disfavor of the higher echelon or colleagues from their sector. To cure this "bureaucratic disease" it is necessary to provide the following conditions:

- Ensuring the state leadership in water management that often takes place only in case of droughts and extreme floods or other emergency (landslides, dyke breaches etc.);
- Ensuring efficient and timely co-ordination under the direction of a person authorized by the national, provincial or local government taking into consideration the cross-sectoral interests; and
- Giving credence to decision makers (persons or bodies) authorized by the national, provincial or local government in respect to relevant decisions.

Regarding this issue it is possible to refer to the excellent experience of the International Joint Commission established by the United States and Canada that manage the water resources of both countries including the basins of Great Lakes, Saint Lawrence River, Red River, and many others. According to the Boundary Waters Treaty of 1909, the Commissioners act as a single body seeking common solutions rather than as separate national delegates representing the position of their Governments. The solutions of this Commission cannot be rejected by the Government of any country and are mandatory for implementation. Owing to such a status, the Commission, one of the best water management organizations in the world, is successfully implementing its complicated program during 100 years. After considerable deterioration of water quality of transboundary water bodies over the period of 1920 to1970, due to activity of the Commission during the period of 1970 to 1995, water quality was greatly improved.

Finally, a policy of water resources development should be built based on the strategic planning in order to predict and mitigate destabilizing factors such as the population growth, climate changes and their impacts on availability of water resources and water demand, changes in the set-up and development of water-consuming sectors, and especially dynamics of market relations (prices, global impacts etc.) in timely manner. It is necessary to keep in mind that owing to a complexity of water infrastructure and numerous actors in the water sector (water management organizations and water consumers) practically covering the whole society it is impossible to obtain prompt results in fundamental reforming the water sector. Therefore, the reforms require a certain time and funds that can be justified by the water vision that has to take into consideration use of transboundary water sources and forecasting the policy of riparian countries (the co-operation with other riparian countries should be built up on the basis of the interstate agreements, joint plans and actions in conformity with the international law and regulations).

Transforming the IWRM concept into the national action plan is based on the following fundamental activities:

- Developing the strategy for IWRM implementation;
- Establishing the training system for improving the understanding of IWRM principles at first among water professionals and then among communities' leaders (especially NGOs' leaders), and for disseminating knowledge at first among those people who involved in the pilot projects and then among proper stakeholders at all levels of water management hierarchy;

- Social mobilization of water users and other stakeholders; and
- Drafting the national IWRM plans and their approval by the governments.

Advocating the IWRM concept in the countries of Central Asia was started in 1996 when owing to international contacts of the Interstate Coordination Water Commission (ICWC), first of all the recent trends in developing and improving the world water sector have met with support among leaders of water management and environmental agencies in Central Asia. At the same time, initiatives of the ICWC had the great significance, and they have been supported by the Governments of all five countries in the region and by some international donors such as the Canadian International Development Agency (CIDA), UN ESCAP, NATO, the World Bank and later by GWP, SDC, and the US Department of State.

At first, the adherence to IWRM was officially set in the report prepared by the regional working group established under the project “Principle Provisions of the Water Management Strategy in the Aral Sea Basin” funded by the Global Environmental Facility (GEF) in 1995 to1997, which was approved by all five countries of the region. Further, putting IWRM principles into practice was supported by the following activities:

- Developing the training activity within the project funded by the CIDA; and
- Elaborating principle provisions of the IWRM strategy in the region.

Developing the training network for promoting implementation of the IWRM principles was launched by the series of introductory workshops held by the CIDA with participation of water professionals from Israel and France who presented the experience of their countries. After that, the study tours to Germany, the USA, Italy, Spain, and the Netherlands were arranged for regional leaders of water and environment agencies. In addition, some of them participated at the conferences of the IWRA and ICID, as well as at the World Water Forum in Hague in 2000. This activity enabled senior policy makers to realize the needs of reforms in regional water sector management. The public awareness process was supported by publication of international forums’ documents concerning the world tendencies and achievements in IWRM as well as outlook of settling difficult problems that take place in the water sector in the region. In 2000, after approving the training programs for water professionals by the ICWC, their implementation was launched by the ten-day workshop for senior managers of the ICWC and its executive bodies, when the policy and phases of training activity were specified. Senior officers of ministries and departments, then managers of regional and basin water management bodies, and finally specialists of water agencies were step-by-step involved into the training process. They studied the IWRM principles and their practical application, national and international water legislation, advanced technologies applied in irrigated farming and land drainage etc. In the period of 2000 to 2005, more than 2500 water professionals become acquainted with the experience of putting IWRM into practice and were trained according to the special curriculum.

Since the initial IWRM workshops held at the ICWC Training Center (TC ICWC) ministers, deputy ministers, and senior managers of regional and national water agencies were not only an audience but also their active participants as lecturers and moderators. Therefore, workshops were conducted in the interactive manner of training and discussions that has become the distinctive feature of the training process at the TC ICWC and its branches. Thus, senior managers of water management agencies in the region served as an example to specialists of their subordinated organizations promoting the forming of positive perception of IWRM principles among all employees of the water sector.

Since 2000 until 2005, the IWRM training activity was progressively building up (Figure 24), especially after establishing branches of the ICWC Training Center under financial supporting of the CIDA and other donors. At present, the Training Center became the standing “round table” where representatives of water management organizations and water users have an opportunity to express their opinion on challenging water problems and to come to a consensus in the process of an interactive training. Outcomes of the training sessions, workshops, and round tables are presented in the form of the minutes and submitted to the decision-making bodies and the members of the ICWC from five countries of the region. It is important that the developed network of Training Center’s branches and field workshops at the pilot sites enable improving the professional skill up to 2,000 water professionals and enhancing public awareness. Over the period of Training Center activity, about 350 trainers were trained, and now they are able to disseminate knowledge gained in the Training Center.

A move of Central Asian countries towards IWRM principles (rather than towards new programs of technical rehabilitation since it was before) is based on the following:

- The need to search non-governmental funding to improve water infrastructure at the expense of various forms of public participation. At the same time, it is necessary to take into account centuries-old experience of water management and traditional forms of funding and involving of water users’ input (mirabs, arik-aksakal, khoshar, etc.); and
- High dependence of social prosperity, economic growth, and environmental safety in countries of the region on sustainability and effectiveness of the water sector under conditions of the arid climate.

It became a platform for the co-operation with the UN Economic and Social Commission for Asia and the Pacific (UN ESCAP) that since 2000 implements the project “Capacity Building in Water Resources Strategic Planning and Management in Asian and Pacific Countries”. In August 2002, within the framework of this activity, the Central Asia Water Resources Strategic Planning and Management Project (WRSPMP) was launched. The WRSPMP directed its efforts towards IWRM principles implementation in order to ensure the sustainable operation of the water sector. This is the indispensable condition for specifying priorities and solving primary and long-term tasks of social and economic development.

In this context, at the beginning only IWRM approaches may be appraised at the pilot systems in the framework of the WRSPMP with following preparation of recommendations on phased transition of the water sector and other economic sectors towards the IWRM principles.

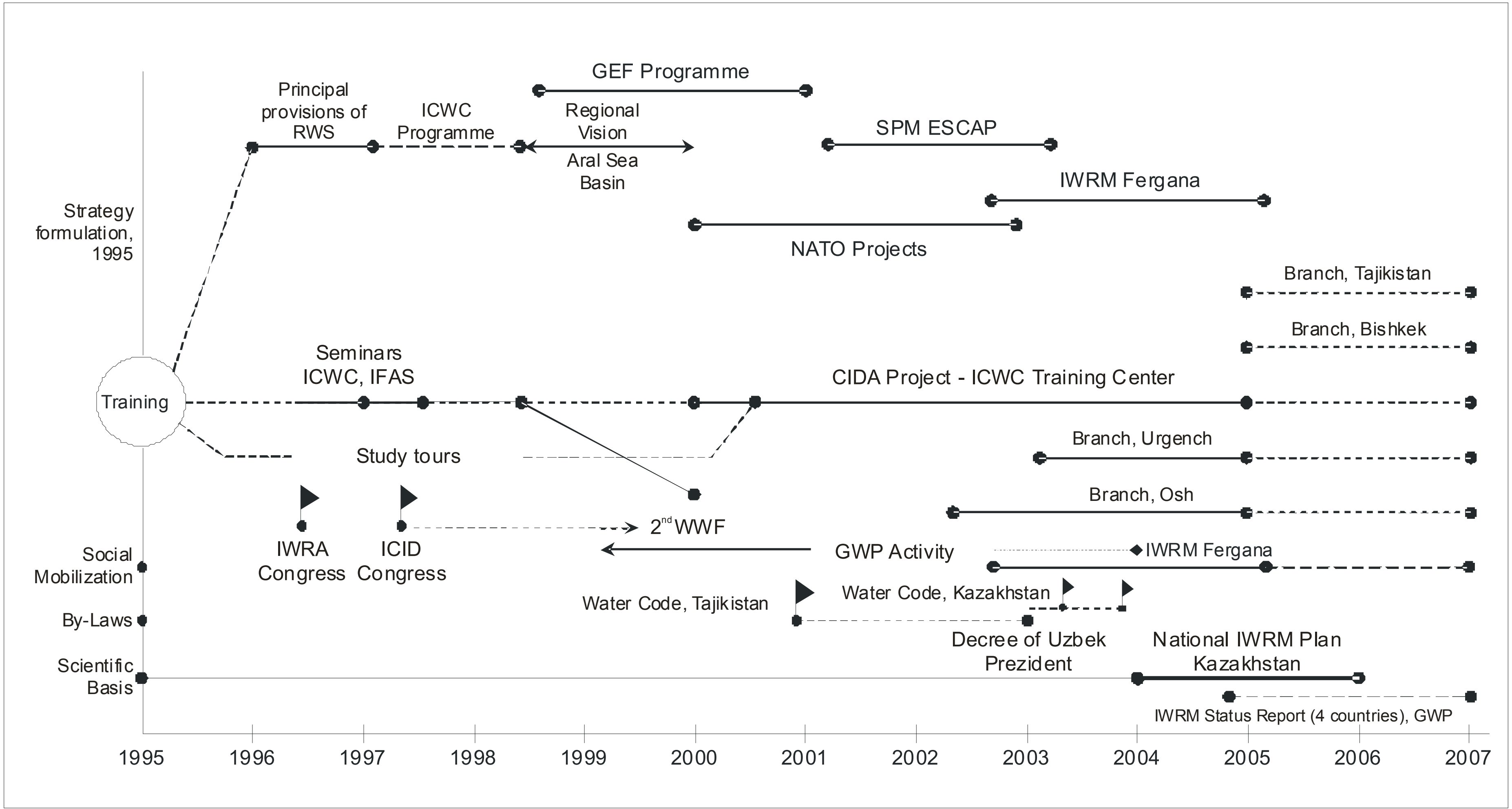


Figure 24. The schedule of IWRM process development and implementation in Central Asia

The UN ESCAP initiative had the great value for selecting proper methods and applying the long experience under designing survival policy in the conditions of growing water scarcity in the region. Participation of experts representing the Ministries of Agriculture and Water Resources of five countries of the region in drafting these documents helped to specify primary institutional, technical and legal measures as well as the format of public campaigns promoting the provision of necessary funding.

At first, the IWRM project in the Amu Darya delta funded by the NATO and then mainly the IWRM-Fergana Project under participation more than 250 persons from three countries (Kyrgyzstan, Tajikistan, and Uzbekistan) provided the great assistance in practical understanding and involvement of water management agencies' employees and water users in the IWRM process. The IWRM-Fergana Project affects the interests of hundreds of thousands of people and enables them to understand all possibilities and perspectives of IWRM and to create incentives for its development.

All these actions promoted step-by-step including of the IWRM principles into the official and legal documents in Central-Asian countries such as the Water Code of Kazakhstan (July 2003), the Water Code of Kyrgyzstan (December 2004), the Water Code of Tajikistan (November 2000), the Decree "About the Most Important Directions of Agricultural Reforms" of the President of Uzbekistan (March 2003), the Laws on WUA in Kazakhstan and Kyrgyzstan etc. Establishing the GWP Technical Committee of Central Asia and Caucasus in 2002 was the very important event for putting IWRM into practice. The regional office with assistance of the GWP headquarters and under the financial support of the Governments of Norway and Finland carries out the large-scale activity for disseminating IWRM ideas over the region. Drafting of the National IWRM plan in Kazakhstan and basic provisions of the national IWRM plans in other countries of the region was initiated by the GWP, and in addition, a number of workshops, conferences, and round-tables were held to discuss and disseminate the guidelines, technical papers, and reports prepared by the GWP concerning IWRM issues. In the process of developing the Strategic IWRM Action Plan for the entire region and for each country of Central Asia, the evaluation of attitude to different components of IWRM and the general preparedness to IWRM introduction in the region (Table 7) was performed; and at the same time the scope of works and the phases of the Strategic Planning and Management (SPM) were specified.

Table 7. Preparedness to put IWRM and SPM approaches into practice

SPM components	Kazakhstan	Kyrgyz Republic	Tajikistan	Turkmenistan	Uzbekistan
The IWRM concept					
The general understanding of IWRM	good	good	good	good	good
Infrastructure and operating experience	good	good	good	good	good
The technical framework of IWRM	good	good	good	good	good
Legal and institutional frameworks	good	good	good	good	good

SPM components	Kazakhstan	Kyrgyz Republic	Tajikistan	Turkmenistan	Uzbekistan
Social and economic frameworks	satisfactory	week	satisfactory	week	good
SPM introduction at the national level					
Water resources in the National Vision	satisfactory	week	satisfactory	week	good
Coordination with the Aral Sea Basin Program	week	week	week	week	week
Perspectives and scenarios	good	good	good	good	good
Preparation of the basis for IWRM introduction					
Political frameworks	+	+	●	-	●
Institutional frameworks	+	+	●	-	●
Legal frameworks	+	+	●	-	●
Infrastructure	●	+	●	●	●
The understanding of the IWRM integrity	+	+	●	-	●

In particular, the following activities need to be included into the Strategic IWRM Action Plan.

1. Mandatory preparation of the IWRM National Action Plans in co-ordination with SPM provisions. Under financial support of the Norway International Development Agency through the GWP and UNDP, Kazakhstan commences this activity, and it will be a good example for other countries in the region. The principal goal of preparing the IWRM National Action Plan is to develop the efficient framework for putting IWRM into practice and to specify objectives, tasks, phases and scope of works, impacts, and mitigation measures.
2. Providing the political will and commitments regarding IWRM and settling water-related problems. As a practical matter, the proposal of water professionals from Kazakhstan and Kyrgyz Republic regarding establishing the Coordination Water Committees at the level of the Government/the Parliament under the direction of Vice-Premier with involving NGOs seems to be the sound decision.

3. Wide public participation in water management at all hierarchic levels. To this end, it is necessary to ensure the legal registration of the Public Water Councils, the Canal Committee Boards (CCB) and WUAs, to develop the financial mechanisms for their involvement, and to provide training and wide popularization of IWRM principles and achievements with water users' participation.

4. Establishing the Training Centers and managing the training process.

5. Legal and financial justification of IWRM and establishing its legislative basis, improving water charging mechanisms, legal and financial coordination of efficient water use aspects at all hierarchic levels; specifying the role of the Government in the case of WUAs, CCB etc.; establishing water-saving funds; elaborating the environmental water requirements and ensuring nature priority under water allocation procedures.

6. Technical measures:

a. Introduction of water record keeping;
b. Participation of hydro-meteorological services in IWRM;
c. Establishing the extension service for improving the water productivity;
d. Computerization of managing the irrigation systems; and
e. Water-saving interventions.

At the same time, the mechanism of interstate consultations to coordinate water sharing, a regime of water use at transboundary rivers, and further economic development keeping in mind the regional interests was established. An analysis of the water management situation in the region has revealed the following destabilizing factors:

- Demographic growth and stability of rural population (the purest part);
- Applying the water-sharing principles developed by former centralized water management agencies of the USSR that were included into the Basin Master Plans of Integrated Water Resource Use and Conservation (BMP IWRMC) – they neglected the needs of ecosystems;
- Disagreement of countries regarding water-power resources and lack of mechanisms to tackle this issue;
- Construction of water infrastructure exerting transboundary impacts without the coordination with other riparian countries;
- Developing the hydropower plans in upstream countries - Tajikistan and Kyrgyzstan without the coordination with other riparian countries;
- Uncertainties related to global warming;
- Lack of conflict resolution mechanisms and procedures to recover losses due to breaching the agreements on water sharing;
- Insufficient information interchange among riparian countries, first of all, exchange of hydro-meteorological data to ensure the more accurate forecast of water availability and to improve transboundary water management;
- Lack of policies and programs of the regional economic integration, and insufficient co-operation to improve the irrigated farming productivity on the basis of the model that enables optimizing the differentiation of labor in the region; and
- Vagueness at the regional level such as the prospects of water use by Afghanistan etc.

Also, in the parallel way the interstate consultations and experience exchange regarding the following internal (national) water challenges are extremely useful:

- water scarcity and pollution at the national level;
- supplying the population with safe drinking water;
- low water and land productivity or low output of an irrigated hectare;
- insufficient developing of the national legislative regulations;
- high-accumulated depreciation of assets owned by water organizations;
- an insufficient material and technical basis of water organizations;
- inability of water users to pay for water delivery services;
- institutional issues (organizational and governing shortcomings);
- the poor cross-sectoral integration (between main water users);

- shortcomings of the personnel policy in the water sector;
- return flow management issues; and
- transboundary ground water use.

The initial experience of preparing the National IWRM Plan of Kazakhstan (supported by the UNDP, the Committee of Water Resources of Kazakhstan, and the GWP) shows that developing the concept needs to be performed by the national coordinating board that has to include stakeholders from all water-related sectors and all territorial units of river basins rather than by foreign specialists requested by the donors.

The National IWRM Plan shall encompass:

a) Analysis of destabilizing factors and their impacts on the social-and-economic situation;
b) The general environment for putting IWRM into practice in a country, and specific conditions in its different zones;
c) The IWRM introduction schedule at both the national level and the basin one; and
d) IWRM introduction mechanisms.

The general diagram of the IWRM planning process for the river basin is given in Figure 25. It demonstrates the logical path of necessary stages and measures as well as the periods when public participation in the planning process is necessary. The implementation sequence of basic IWRM principles is shown in the right-hand part of the diagram, Introduction of the IWRM plan are based on the following actions:

- establishing the certain organizational mechanisms for integrating all hierarchical levels of water management (vertical links) and for the cross-sectoral co-operation (horizontal links) both in the country as a whole and in separate river basins;
- co-ordination of surface, ground and return water management;
- integration of water-use and land-use, as well as irrigation and drainage systems, and water agencies and land-reclamation bureaus with land-users and water-users;
- taking into account and meeting all social and economic requirements;
- specifying environmentally admissible water diversion from water sources within the basin;
- co-ordination of all above actions with a set of measures on water-saving;
- establishing the database and information systems in all river basins that shall include not only water information but also data on all aspects of water management and use as well as data on economic, social and environmental impacts on water-users and the nature;
- developing the system for social mobilization of water-users and their involvement in IWRM and providing their role as active driving force.

Other three components that should create the framework of the National IWRM Plan are the following:

- the plan of technical improvement of water-use and water-demand management;
- the plan and the organizational framework for all stakeholders training; and the plan of establishing the pilot projects at the zonal level taking into consideration their specific features.

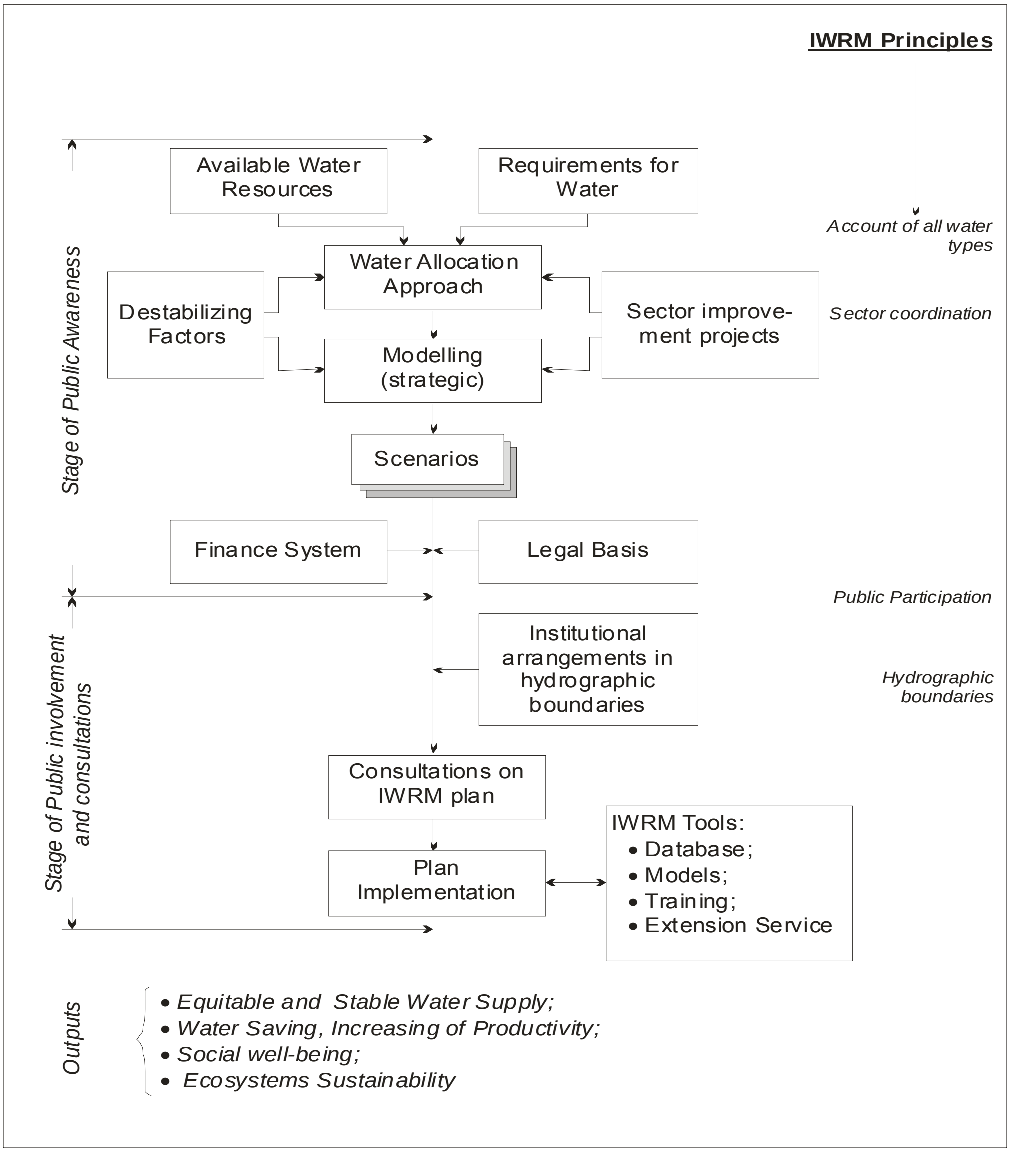


Figure 25. Diagram of steps in IWRM National Planning and Implementation

All planned interventions to introduce the IWRM principles shall be implemented on the basis "bottom-up" with involvement of public bodies and NGOs, with participation of available institutions at the grass level such as Rural Water Users' Cooperatives, WUAs, Land-Reclamation Condominiums, and farmers' associations.

CONCLUDING REMARKS

It is difficult to overestimate the importance of wide introducing IWRM into the water sector practice and irrigated farming in Central Asia. The region was, is, and will be in increasing dependency from use of its available water resources. After disintegration of the USSR, the hope related to water transfer from neighboring regions became unachievable for the current generation. Meanwhile, by 2025, the population of the region will increase by 30 percent, and, at the same time, water resources will be used more intensively to meet requirements of the hydropower sector (resulting in reduction of available water resources for other economic sectors).

Rise of environmental awareness and social requirements of the population in lower reaches of the Amu Darya and Syr Darya rivers, where more than six million people reside, will result in the need to increase water delivery into their deltas no less than on 4 to 9 cu. m per year at that. Under total available water resources allowable for use (103 to 106 billion cu. m), water supply per capita amounts to 1,400 to 1,600 cu. m per year that is below the water supply level recommended by the United Nations. Taking into account increase in the recurrence of extreme events such as floods and drought it is possible to say that the situation related to water resources availability in Central Asia becomes critical.

Putting IWRM into practice enables us to reduce unproductive water losses by 25 to 30 percent, to improve evenness and stability of water delivery and the degree of water availability. At the same time, due to raising water productivity, it is possible to increase the total agricultural output, at least, by 50 percent and provision by foodstuff reducing the food shortage and likelihood of famine.

IWRM promotes developing infrastructure of associated sectors (integrated processing of agricultural products, supply of machinery and equipment, engineering, manufacturing of agricultural chemicals etc.), and all-inclusiveness of the agrarian sector decreasing the unemployment rate of rural population.

Finally, IWRM with its component of drinking water supply can improve sanitation conditions of the rural population and access to safe water supply. Thus, using the least investments into infrastructure, IWRM facilitates the achievement of the Millennium Development Goals in the region.

The practical progress in reforming water management in Central Asia countries can be obtained by applying IWRM principles described in this paper and by resting on appropriate institutional, engineering, and other measures under sufficient funding that needs to be allocated. The main measures include the following:

- Providing sustainable water supply, equitable and regular water sharing between sub-basins and irrigation systems along with significant reduction in unproductive water losses on the way to water users;
- Introduction of the democratic principles into the water management practice by using the participatory approach and involving all stakeholders in the process of step-by-step transferring the governing functions to them at lower levels of the water management hierarchy as well as their active participation on an equal footing with the Government in supporting and developing of water supply systems;

- Solving of some social problems related to equitable water supply of the population, especially ensuring safe drinking water;
- Settling environmental problems related to water sector’s activities; and
- As a final goal, the increase in the efficiency of water and land use.

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