INTEGRATED WATER RESOURCES MANAGEMENT:

PUTTING GOOD THEORY INTO REAL PRACTICE

Central Asian Experience

Tashkent-2009

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Integrated Water Resources Management: Putting Good Theory into Real Practice. Central Asian Experience.
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This book is aimed at a wide range of specialists – water management professionals, including policy-makers in the water sector who define trends and meaning of modern reforms of water governance and management.

At the same time, this book is also intended for a wide range of civil society representatives interested in implementing proper reforms within water management. Content of this book allows readers to recognize that civil society and nature all over the world are facing serious problems concerning water resources. At present, these challenges cannot be tackled efficiently using the customary, prevalent during last decades, traditions, governance structure, and methods of water management. Therefore, Integrated Water Resources Management (IWRM) is here treated as a promising new approach to solve above-mentioned problems. The experiences gained while introducing this new approach to Central Asia are generalized in the present book.

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ACRONYMS AND ABBREVIATIONS

AAC	Aravan-Akbura Canal
BAC	Big Andijan Canal
BFC	Big Fergana Canal
BISA	Basin Irrigation System Association
CA	Canal Administration
CIDA	Canadian International Development Agency
CWC	Canal Water Committee
CWUU	Canal Water Users Union
DB	Database
DF	Drainage Flow
DSS	Decision Support System
EF	Efficiency Factor
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization
FWC	Field Water Capacity
GEF	Global Environment Fund
GIS	Geoinformation System
GWP	Global Water Partnership
GWP CACENA	Global Water Partnership for Central Asia and Caucasus
ICID	International Commission on Irrigation and Drainage
ICWC	Interstate Coordination Water Commission for Central Asia
IWRM	Integrated Water Resources Management
IWRUP	Integrated Water Resources Use and Protection
IWRA	International Water Resources Association
KB	Knowledge Base
KBC	Khoja-Bakirgan Canal
MLRWM	Ministry of Land Reclamation and Water Management
MPC	Maximum Permissible Concentration
NATO	North Atlantic Treaty Organization
NGO	Nongovernmental Organization
PF	Private Farm
SA	System Administration
SCADA	Supervisory Control and Data Acquisition
SDC	Swiss Development Cooperation
SIC	Scientific and Information Center
SFC	South Fergana Canal
SMP	Strategic Management Planning
VAT	Value-Added Tax
UNDP	The United Nations Development Program
USAID	US Agency for International Development
WEMP	Water and Environment Management Project
WMO	Water Management Organization
WUA	Water User Association

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PREFACE

(V.A. Dukhovny)

When water occurs in the atmosphere, or infiltrate into the earth's interior or occurs in the origins of streams and rivers (that are fed by precipitations or melting glaciers), it does not surmise (although Japanese scientists discovered that water is possessed with memory and sensitiveness) further down its' intended use. Human beings could use it for drinking or sanitary purposes, for industrial production, to grow crops, or sent through turbines to generate electric power. In spite of impacts of modern life, water may still remain as a part of virgin nature that existed over thousands of years. In the very same nature, which humankind has selfishly subjugated with its ruthless actions to satisfy its own daily wants.

The integrity of water resources, as the great natural substance, requires that its management is implemented in an integrated manner, meaning the total consideration of all kinds of waters on earth; all kinds of water users; and all consequences that determines whether the water use is sustainable, effective, and/or harmless. Therefore, integrated water resources management (IWRM) is quite accessible for understanding and is considered as a specific objective that is perceived and recognized by the society and its political leaders. This is reflected in numerous declarations, decisions, and slogans. Today, if, a public opinion poll is called to answer a single question: "Do you support IWRM or not?" The answer is clear and loud. Most of people will say, "Of course, we support it.".

However, the modern world is divided by means of political boundaries, natural barriers (mountains, oceans, and deserts), administrative frameworks and corporative interests, as well as by local features and social (communal) formations.

In addition, there are sectoral and professional priorities, political ambitions and confrontations. In the end, water meets the needs of six billions people (in future, it may be even ten billions!) as end users. In order to meet all needs of the society and nature (needs of the present population and its future descendants, as well as of flora and fauna – everything that God or other supreme intellect has created), it is necessary to review and overcome all divides and antagonistic barriers on our way!

We have stated earlier that the IWRM objective is to achieve a balance between water resources availability and it's use over the time and area (therefore, the integration of all kinds of waters and uses is important) [3]. However, an assessment of the consequences in the process of integrated water resources management are equally significant. Because, the consequences are having a feedback that can affect on water sources and the uses that are integrating. It is known that these affects can result in reducing of available water resources (or change the conditions of their availability in such a way that they cannot be used anymore); or deteriorate their quality (salinity, pollution, and eutrophication); or increase O&M costs; etc,. Many things can happen with water due to our own activities, which are supposedly implemented for the general benefit. One of the most visible consequences is the occurrence of return waters that, up to a certain extent, can be used without much of damage, but beyond that, it can deteriorate river or groundwater quality, affect soil fertility due to salinization, and cause the problems with water use as a whole.

As soon we transform this balance the between "resources and consumption" as previously proposed by us, into this new triangle of "resources – consumption - consequences", there at once reveals a number of more complicated interrelations in the integration process. They include inseparable pairs, both according to their mutual dependence and their specific colliding: "water resources – land resources"; "quantity - quality"; "upper watersheds – downstream areas (deltas)"; "climate – water resources"; "seas and rivers"; and many others (see Figure 1). It is also necessary to mention about multi-stage relations and those impacts that each water user exerts on macro- and micro-economic and social indicators, public environment and welfare, as well as on other sides of the existence of a human beings and nature.

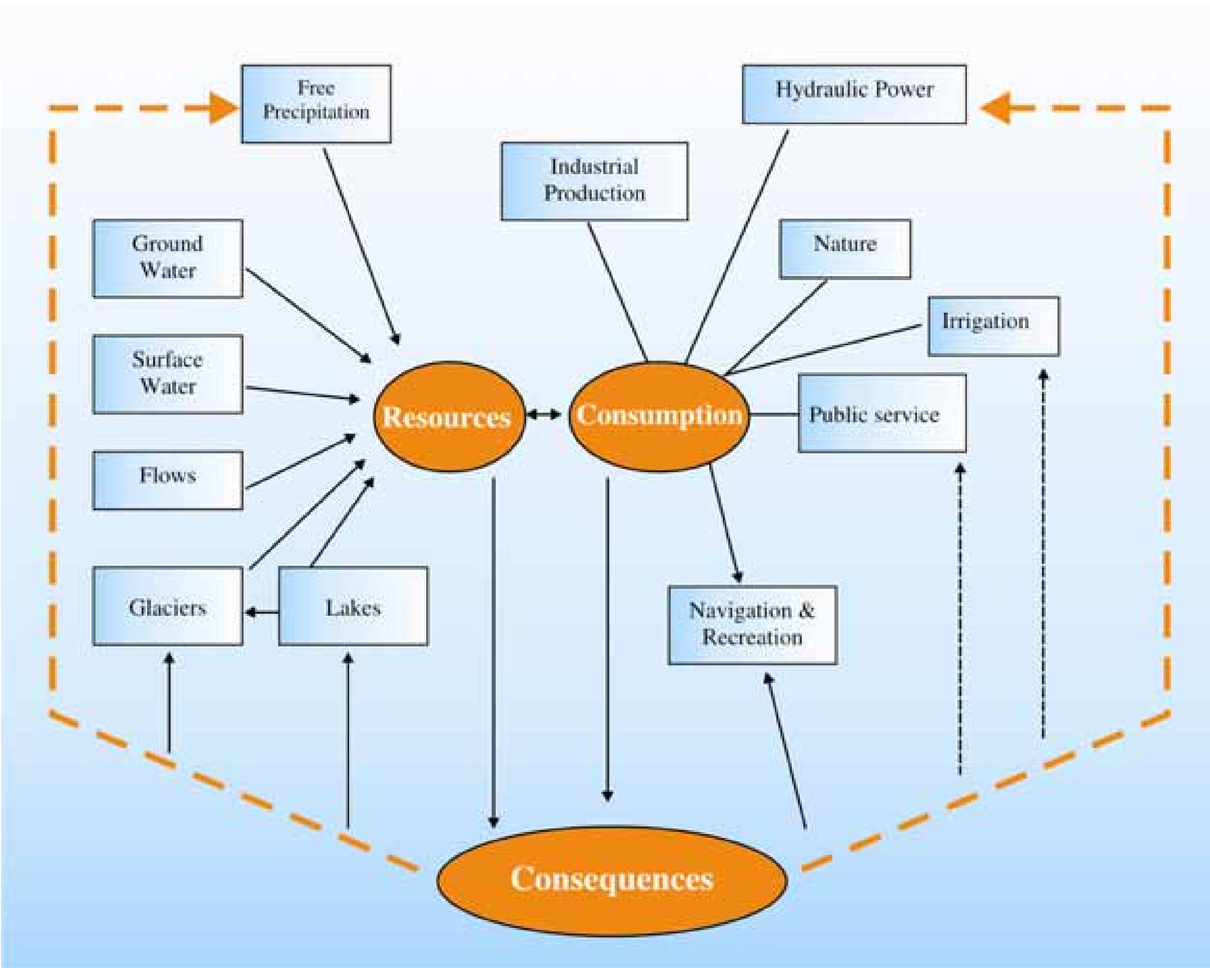

Figure 1 Interrelation in the Triangle: «Resources – Consumption – Consequences»

There are some additional aspects for the integration similar to consequences. They are: integration of changes in resources over time (for example, due to climate changes, glacier melting or depletion of aquifers); changes in consumption (on either directions); changes in conditions of natural or man-made watercourses (meandering and erosion of riverbeds, deteriorating of water infrastructure; increase in seepage losses, sedimentation in water reservoirs and irrigation canals etc.).

Proclaimed objective, for the introduction of IWRM principles, at a certain stage, was the sustainable co-existence of a human being and nature to be reached. We should remember that this integration has to be provided in three dimensions: over an area, through all levels of social hierarchy, and over time. Obviously, the integration of all the above components and aspects cannot happen only through water management organizations; This should be the joint activity of all stakeholders and society as a whole, in which politicians and representatives of the integrated sciences (social, political, natural, and engineering sciences) should play a leading role. A place within this process should be provided for all, because it is difficult to find an economic sector or aspect of science, in which the water as a factor of their environment or a subject of investigation is not considered.

Why our society does only now addresses to integrated water resources management? Because, in contrast to the 20^{th} century, when we lived in habitual conditions, in the current millennium we carry a grave burden being witnesses of a growing water deficit almost everywhere. If now, fresh water resources available for use are estimated as about 750 m3/year per person living on our planet, in 2050, this amount will decrease, on average, to the level of 450 m3/year per person, even without considering climate changes. It means that the line of water deficit, according to the UN classification, will be crossed by more than 80% of countries in the world. Only Canada, Russia, Brazil, most of Europe, northern part of the USA, and some tropical districts in Africa, South Asia and South America will remain as blessed oases in this global desert.

Whether our society will overcome this deficit or our world, consumed by egoistic aspirations, will give up its hopes shall depends on its wisdom! There arises the question – water is not the only resource that will be depleted in this century; oil, natural gas and many other minerals are close to extinction. Why are we trying to integrate only water resources management? May be the integration of all-scarce natural resources in the world would be useful. The problem is that all scarce natural resources became the basis for the runaway growth of easy money due to the speculative increase in prices; and it is impossible to stop this process in the capitalistic environment. None of global efforts related to the integration of oil production (for example, OPEC's activity) could overcome the egoism of entities prospering based on extracting of this raw material. On the contrary, such integration has established the community of property owners-monopolists of this raw material contradicting the interests of the entire world. The different countries started to search alternative options for replacing natural minerals; and bio-fuel, thanks to which Brazil has managed with the deficit of energy resources, was invented. There are also other alternate materials: use of wind and solar energy, and the hydropower.

Water is a unique resource that nobody and nothing can replace; and, therefore, in the process of water management and use, our society has to demonstrate that it consists of "homo sapiens" rather than "homo-egoists." Overcoming all temptations to transform water into an economic good, instrument of pressure or profit, the global community may and should avoid the transformation of water into "an apple of discord" and use it as "the basis for co-operation." Just as the situation when the energy crisis has facilitated the development of prosperous European Community, the water should promote the creation of integrated global and rational water community. That is why IWRM, as an advanced concept is the most important and needed direction of development in the new century.

At the regional summit held under the motto: "IWRM is the Basis for Socio-Economic Progress in Central Asia" authors of this book have heard the following remark: "Governments provide the socio-economic progress, not the IWRM." Weak persons' long-standing hopes on God, tsar or political leaders are noticeable in this remark. Meanwhile, IWRM itself, if this process is developing in the right direction, initiates activities and interactions of common water users, political leaders, and society as a whole, and, in such is leading water users, local authorities, and central governments to achieve Millennium Development Goals[1] adopted at the UN Millennium Summit in 2000, namely:

- IWRM, through achieving uniform sustainable and secure water supply and land reclamation, results in eliminating of crop losses and increasing water productivity, and consequently *facilitates the increase in incomes as well as poverty eradication.*
- IWRM, through the development of closely-related economic sectors, attracting own and foreign investments, as well as through water saving and creating the conditions for extending additional areas under crops or areas with double crops, *promotes the increase in the employment and incomes*. For example, in 2002 to 2006, sustainable irrigation water supply into the delta of the Syr Darya River has resulted in the increase of national income in Kazalinsk and Aral districts of Kyzyl-Orda Province almost two times!!!
- IWRM, through establishing the system of sustainable potable water supply and improving water quality in rivers and other water sources, *promotes health improvements.*
- IWRM, by means of accounting diverse roles of water in ecosystems and of saving water for the needs of nature, facilitates the environment rehabilitation and conservation.
- IWRM widely uses energy of water for developing the hydropower sector and for providing its sustainable operation, promoting reliable supply of electricity to the population.
- *Finally, the involvement of the considerable number of people in IWRM facilitates the rise of educational level and the acquirement of new knowledge related to water problems using the knowledge database*.

[1] The Millennium Development Goals – the ambitious program on poverty eradication and raising the living standards, which was agreed by the world political leaders at the UN Millennium Summit in September 2002. One or more tasks were specified within the frame of each goal, most of which should be solved up to 2015, using the Year 1990 as the reference point. Additional information is provided at UNDP website http://www.undp.org/mdg/

Thus, IWRM is "a corner stone" for achieving the UN Millennium Development Goals! Each program on implementing the IWRM principles should show ties of its outcomes with the MDGs' indicators:

- Reducing the level of poverty and unemployment;
- Health improvements;
- Improving power supply;
- Rehabilitating the environment;
- Increasing the investments;
- Improvement of education;
- Involving women

Just these indicators (in aggregate with indicators of water productivity, sustainability of water supply, and water availability) will characterize the long-term social and ecological sustainability of IWRM as the modern system of solving water problems. Thus, IWRM indicators are not mere technical indicators but also include and can characterize a wide range of impacts that are consequences of introducing the IWRM concept.

INTRODUCTION - IWRM BACKGROUND

(V.A. Dukhovny, V.I Sokolov)

"Each thing given to us from heaven should be used
with special care and benefit, because it is not "our thing",
and it is entrusted to us only temporarily."

The Teaching of Buddha: "The Four Noble Truths"

Understanding the need for a holistic approach to water management was not something just invented today, yesterday, or even in the last century with its progress in technologies and science. Comprehensive water properties and links were not possibly studied and described in detail earlier, as it was done in the UN report "Water – a shared responsibility" [43]. However, as civilization progressed, people intuitively used water in its different states and in various economic activities, understanding perfectly well its role, first of all, in supporting the most valuable thing on Earth – life. It is no mere chance that today the investigations of life existence on other planets arebased on the only criterion – whether traces of water are on them, and only then searching traces of living organisms can be started.

During the hydrologic cycle, water passes through different stages: it evaporates from the earth's surface, condenses in clouds, and then falls back to the earth as precipitation (rain or snow), increasing the thickness of glaciers in mountains and snowfields near the North Pole and South Pole, as well as running into streams and rivers, and replenishing groundwater.

On its way through rivers and aquifers to seas and other sinks, creating waterfalls, lakes and wetlands, waters is used for irrigation, hydropower generation, water supply, recreation and other uses. Water both pollutes and cleans. While the water cycle on the earth is subject only to natural impacts there are no real problems in the natural process. However, if a human being starts to interfere with this natural process, resulting in considerable water abstractions and water pollution, the natural mechanisms are disturbed, and the water environment is degraded. There is a : depletion of water resources, loss of potential for water renewal, and deterioration of water quality etc.

The laws of nature rule water as the holistic "whole" in all points on the earth. Man does not follow this principle due to his disassociation, egoism, consumerism, and, to some extent, owing to a lack of understanding of the relationships and sequence of water processes, in which we often interfere like "a bull in a china shop." This often is not only the result of a lack of understanding the consequences of our own impacts.The fact is that today each economic sector (water users and consumers) is responsible only for its narrow strip of impacts, and usually does not want conceptually, administratively and financially to beyond these limits.

We can use different kinds of water resources: surface water, groundwater and return water. Who manages them, and who maintains records? The Hydro-Meteorological Services keep record of surface water resources, but the Ministries of Agriculture and Water Resources are responsible for water use in all countries in our region, and the Ministries of Geology are responsible for groundwater use. At the same time, return water is managed by all ministries, but actually by none of them. Here is an example of a situation related to the monitoring of water quantity and quality: All the above ministries are responsible for monitoring water quantity and have to be responsible for maintaining water quality (de jure), but de facto only the Ministries of Nature Protection (State Committees on Environment) are monitoring water quality. Let's review the situation in water use: the Ministries of Agriculture and Water Resources are responsible for irrigation; Ministries of Communal Services and local authorities are in charge of water supply and sanitation; Ministries of Energy or agencies that replace them (concerns, joint-stock companies etc.) are responsible for hydropower engineering. In addition, the fishery and forestry sectors have their own owners!!! One can say that "too many cooks spoil the broth." Such a situation is observed not only in our region but in most countries of the world. Each ministry or organization has its own plans, resources and tasks; and each of them tries to be good in its own shere of activity where water plays a fundamental rolel As a result, we face a situation:called a "cats' concert." In our culture. Sectoral interests are at the top level of state hierarchy; however, water is used and consumed at the "bottom level"; and the responsibility of each government is to provide water rights for each water user: farmer, factory, household etc. Each economic sector responsible for water use and its protection at different levels has its own "hierarchical stairs" of governance and management for delivery of water from the source to water users. On this structure a water user or a water consumer stays at the lowest tier being lonely, powerless, and helpless. Israel, where all water issues are covered by the Ministry of Infrastructure and coordinated by the United Water Commission, may be, a single exception.

An understanding of the need for consolidating all kinds of water resources and all water-consuming sectors and even coordinating all water users (but, of course, not by the only body or even around the biggest round table) was formed long ago and was characterized by many actions undertaken by people and society at different stages of its development. One can recollect, for example, the Valencia Tribunal in Spain (the public gathering and trial), which has met from the 12th century to the present time (on a weekly basis) in the central square in Valencia in order to discuss water availability for different users, and the efficiency and sustainability of water supply, was a real attempt at participatory coordination of water users. In the history of Muslim countries, there were the councils ("Majlis of Mirabs"), which represented the consulting meetings of "water owners" for solving water problems important for all.

Today, consolidation, coordination and integration of all interested participants in the process of water use and consumption should be linked to the issues of water relations. Step by step, an understanding of the need to apply this approach started to predominate at the end of 19th century and in the beginning of the 20th century. Integrated programs of the Tennessee Valley management in the USA and of river basin management in India (under the sway of Great Britain) were developed. Their action plans covered the interests of all economic sectors in an integrated manner (so-called Master Plans abroad, and Schemes of Integrated River Basin Water Resources Use and Protection in the former USSR). These schemes contained a forecast of water consumption and it's extent against available water resources within an area under consideration in countries or specific zones in river basins. This took into consideration all sectors: hydropower engineering, irrigation, water supply etc. The schemes were coordinated with all republics for inter-republican watercourses and with provincial authorities for inland watercourses. Of course, these schemes had some shortcomings: they disregarded the requirements of the natural complex and took into consideration only the ecological flows through rivers without accounting for the requirements of the Aral Sea. While planning for increases in the efficiency of water use (the efficiency of irrigation systems; decrease in the rates of flows etc.) they did not include the necessary measures for its realization. These schemes were mainly focused on the planning bodies rather than on water management organizations. The shortcomings of these schemes became especially obvious in the forecasted period of complete use of available water resources (the end of 20th century), when the planned irrigated areas were developed, but the scheduled water saving measures merely remained on paper.

In 1992, the modern concept of integrated water resources management was proposed at a well-known conference in Dublin[2] in the form of four principles that became the basis for reforms in the water sector [34].

Principle 1: Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment.

The notion that fresh water is a finite resource arises as the global hydrological cycle on average yields a fixed quantity of water per time period. This overall quantity cannot be increased significantly by human actions, but it can be considerably reduced owing to anthropogenic contamination; and this is happen very often. Fresh water is the natural resource, which needs to be maintained ensuring necessary water services. This principle suggests that water is necessary for different purposes, functions, and services; therefore,

[2] The international conference on water resources issues and the environment, Dublin, Ireland, January 1992.

water resources management should be holistic (integrated) and take into consideration both the opportunities to meet water demands and risks of depleting and contaminating water sources.

It is logical that according to this principle, the river basin or its catchment area should be a unit of water resources management. Hence, it follows that it is necessary to use the so-called hydro-geographic approach for institutional establishment of a water resources management system.

Principle 2: Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.

Water is a subject in which everyone is a stakeholder. Real participation only takes place when stakeholders are involved in the decision-making process and in implementing the decisions or, at least, monitoring the implementing decisions. A participatory approach is the only means for achieving a long-lasting consensus and common agreement. Participation means an acceptance of responsibilities, recognizing the effect of sectoral actions on other water users and aquatic ecosystems, as well as accepting the need for charge to improve the efficiency of water use and allow the sustainable development of this resource. However, the possibility of across-the-board participation is absurdity, in the literal sense of the word; and realization of this principle is possible only through forming representative non-governmental organizations, of local and production organizations created on a democratic base, that are expressing shared, territorial and other public interests. It should be noted that participation not always results in consensus and, therefore, arbitration processes or other conflict resolution mechanisms will also need to be put in place.

Governments also have to help in creating participatory capacity, particularly amongst women and other marginalized social groups. It has to be recognized that simply creating participatory opportunities will do nothing for currently disadvantaged groups unless their capacity to participate is enhanced. Decentralization of the decision-making process up to the lowest appropriate level is the only strategy for strengthening public participation in solving water problems.

Participation of all stakeholders is one of the ways that promotes the development of poor countries. A restrictive factor for development is a lack of information or limited access to necessary information in these countries. Opportunities, potential, and motives of public participation require further investigations and support.

Principle 3: Women play a central role in the provision, management, and safeguarding of water.

The role of women, as major providers and users of water in households, as well as defenders of the environment, is widely promoted in mass media for demonstrating those hardships and concerns, which they are bearing under low incomes. However, their role is seldom reflected in institutional measures aimed at water resources development and management. It is widely acknowledged that women play a key role in collection and safeguarding water for domestic purposes, and in many cases they, carry out hard manual labour in agricultural activity, and suffer, more from receiving less output due to irregularities in irrigation and drainage services. At the same time, they have a much less influential role than men in management and problem analyses and in the decision-making process related to water resources.

IWRM requires gender awareness. In developing the full and effective participation of women at all hierarchical levels of decision-making, consideration has to be given to the way different societies assign particular social, economic and cultural roles to women and men. There is an important correlation between the equal status of men and women, correct use of their different gender features and sustainable water resources management. Participation of men and women, who are playing influential roles at all levels of water resources management, may accelerate achieving sustainability. At the same time, water resources management in an integrated and sustainable manner makes a considerable contribution to achieving gender equality by improving the access of women and men to water resources and related services in order to meet their essential needs.

Principle 4: Water has an economic value in all its competing uses, and should be recognized as an economic good.

In the frame of this principle, first of all, it is necessary to recognize the basic right of all people to have access to clean water and normal sanitary conditions under acceptable payment. Water management, considering water as an economic good, is the important method for achieving social objectives such as effective and equitable water use and incentives for water resources saving and protection. Water, after diversion from its source, can be evaluated in cost parameters as an economic, ecological, and social substance. Most of the previous shortcomings in water resources management were related to the fact that in the administrative system and structure, economic indicators were used in a distorted form, in particular, a cost characteristic of water (as a resource) was not recognized, as well as the structure of full water value and sources for cost recovery were not considered. Eventually,during the period of transition to a market economy, this results in the financial instability of the water sector, loss of its production potential and general degradation. At the same time, such a situation is typical not only for CIS countries built on the ruins of "imperfect" socialism but also for Eastern and Central European countries, which preserved some features of "primitive" capitalism in their economics. These realities are described in the section "Water and Globalization" (see Chapter 6).

An economic value of water is considered in works of many authors. In some countries, for example, in Asian countries, water has a social, cultural, and religious value, which here is more important than an economic value. It can be explained by less developed economic and market relations here than in European countries or in the USA. Cultivating high-value crops for profit in developed countries, undermines the food security of the poor in developing countries.

Value and charges are two different things; and we have to distinguish clearly between *valuing* and *charging*. The *value of water* in alternative uses is important for the rational allocation of water as a scarce resource, whether by regulatory or economic means. *Charging* for water, along with governmental regulation in the form of subsidies, is applying an economic instrument, which is used for covering necessary expenditures and supporting vulnerable social groups [34]. One cannot but take into account that the correct use of these economic categories in the process of governance affects the behavior of different entities in terms of conservation and effective water usage, to provide incentives for demand management. This is to ensure cost recovery, and to the signal consumers' willingness to pay for additional instruments in water services.

It is important to recognize the fact that water, which is used under specific conditions, especially, when there is a water deficit, takes the form of an economic good, and becomes the important instrument for decision-making related to water distribution between different economic sectors or among different water users within the sector. This is especially important when a further increase in water supply is impossible and also when evaluating competing demands, for example, in dry years.

In many countries of the world, the basic principle of water resources management with some elements of integration was employed long ago when water users gave preference to long-term interests rather than opting to receive quick personal profit, and started they to co-operate,. Instances of collective activity related to water resources management show the advantage of such an approach, especially taking into consideration the dynamics of water relations, which never can "harden" in "status quo":

1. Under the introduction of a united management structure within the integrated hydro-geographical system, water consumption is adjusted in accordance with real *water requirements;*
2. The system of agreed rules specifies rights and duties of each water user and, at the same time, organizes the water sharing process and input in O&M of irrigation and drainage systems;
3. There is a general understanding that such coordination is profitable for all, i.e. an average profit of each water user becomes higher when all water users co-operate rather than compete with each other.

Arguments in favor of using this system are quite convincing; and it is possible to expect that, at present, the growing shortage of water as a whole and water of good quality in particular can stimulate establishing and developing the basin organizations. However, the real situation is different from a desirable one. There are examples of basin water resources management in the world, but what efforts were spent? Today known systems of cooperation at the basin level have a long history of overcoming many problems. For example, to create a modern system of basin water resources management, the Murray-Darling Basin Commission in Australia has spent almost 80 years overcoming many environmental conflicts and institutional problems, since the states within this basin have refused to transfer their rights on water resources to each other or to the Commission. However, even this system is not completely perfect, since the problems of soil salinization and increasing water salinity are growing in the basin. Another example is the Rhine River which was a sink of wastewaters in Europe as the agreement on joint actions was not signed by countries in this river basin. It took 50 years until the 1997 Agreement was signed on joint management of the river system Apalachicola-Coosa-Tallapoosa-Alabama-Chattahoochee-Flint (ACT-ACF) in the south-eastern part of the USA.

One of the first experiments in the world relating to the realization of the hydro-geographical principle of water management was carried out in Spain based on the concept of the joint body - association that united the interests of the State and water users. This idea of independence from the state administrative system in the process of grouping national territories having common hydrographic boundaries was the starting point for establishing the Hydrographical Confederations or simply "basin organizations".

The Creation of Basin Confederations was approved by the Royal Decree dated March 5, 1926 that has clearly defined the national water resources management system. This system is in place to date. Drawing up plans for the use of water resources and coordinating the interests of different water users in each river basin were entrusted to the Basin Confederations. Irrigation which uses about 70 to 80% of water resources is the biggest consumer in some river basins. It is important to note that 24% of territories in Spain have a surplus amount of precipitation; 72% of territories have precipitation amounting to 300-800 mm/year, and 4% - less than 300 mm/year. Irrigation is concentrated in the second and third zones; and the total irrigated area in Spain makes up 3,400,000 hectares. A total river discharge is evaluated at 93.4 km^3 of which only 24.3 km^3 are annually used for irrigation. The first basin confederation was established in the Ebro River basin, and then confederations were created in all other river basins.

In compliance with Article 19 of the 1985 Water Law (heretofore the 1879 Water Law was in force in Spain), basins with rivers flowing through a single autonomous region are managed by the Basin Water Councils *(Confederaciones Hidrograficas)*. These are organizations with their own legal status, different from the state, which are coordinated by the Ministry of Environment and have complete autonomous authority. Therefore, a river basin is considered as the territory (including the network of tributaries of the main river), through which water flows from the source of the river towards the sea. A river basin, as the water resources management unit, is considered indivisible. Thus, the activity of the basin organizations covers the territory of one or a few river basins, which can be limited only by international boundaries. For purposes coordination, aquifers located within these territorial boundaries are under control of the basin organizations as well.

The French water resources management system based on three conceptual principles is also quite interesting:

1. ***Legalization of decentralization***. This principle permits each autonomous hydro-geographical basin organization comprising of all parties (interested in water supply and responsible for its realization), to solve, at the local level, all conflicts of interests of industry, irrigation, fishery, communal administration, different associations and local population. Key decisions are locally made by the basin organizations. Funds, collected as a result of water supply services, are mainly used for developing the water supply infrastructure. The polluter pays principle was adopted in the French legislation in 1964.
2. ***Water is a common property of society***. All people responsible for water management or interested in this should come to an understanding that water is an integral part of the environment and belongs to all. However, water has a cost because it should be cleaned and delivered to consumers, and these activities require a certain expenditure.

3. ***Water pays for water***. The French system is based on the principle that water consumers including "bottom" users, local organizations and national departments should completely cover all expenditures related to investing into water infrastructure development and its O&M, distributing these reimbursements among them in the specific proportion.

The French experience is the fine demonstration of creating the clear-cut operational organization that united all stakeholders for conflict-free water resources management within the hydro-geographical basin. Basin organizations perform not only planning and regulative functions but also implement operational and monitoring functions. This unique system for financing all necessary functions for environmental protection, practically using the "polluter pays principle adopted" in the legislation, was established in France. France also has considerable experience in public participation in the water resources management process.

Readers can look through the information on the above –mentioned experience of Spain, France and other countries in detail on the website: **www.cawater-info.net/library/refer.htm**

Water resources management organizations can be of different forms. According to data from World Bank experts [27], at present, a few hundred "basin agencies" all over the world are operative over a sufficiently long period with good results. Data on institutional models of agencies different in their tasks and structures were collected. Presently, there are more than 20 different types of organizations. On the other hand, these "models" have many general characteristics or components and institutional principles as well. There is no doubt that any basin agency should perform the specific *management functions;* and its institutional structure has to have a number of corresponding *components (characteristics) and principles of structuring.*

It is important that basin management is the only iplatform for developing integrated water resources management. Therefore, the required structure and functions should be mentioned for specific activities being implemented in all sectors of water use. In other words, a basin management organization has to co-ordinate and supplement activity of all interested agencies. According to the global experience, many basin agencies, being either secretariats or commissions, only carry out coordinating functions and sometimes financing, while local authorities are engaged in developing water infrastructure, O&M, and land reclamation activity. Therefore, the establishment of a new basin organization or analysis of the activities of already existing organizations should begin with clear-cut specifications of functions. Functions, in their turn, define the institutional structure of a basin organization. An optimal structure of basin organization depends on specific administrative, legal, natural and socio-economic conditions, hydrological factors, and a time period for its creation. An acceptable structure for specific regions depends on the following factors:

- Physical and morphological characteristics of the water management system, its expected changes, and opportunities for the development by means of realization of infrastructural and institutional measures;
- The framework for specifying water requirements, expected changes, potential and possibilities of water users for paying for services;
- Administrative, legal and legislative aspirations of society and the government for improving and strengthening the structures. In Europe and the USA there was such a transition from "state interference" in the 1930s to 1950s to the political consensus based on market principles in the mid 1970s. In China, the transition from the planned economy to the two-storied semi-market economy took place after the 1980s;
- Historical experience and preferences conditioned by existing culture (traditions) regarding the governance, collective actions, settling of conflicts etc.
- Implementing joint actions both at institutional and physical levels.
- A main principle of creating the institutional structure consists in differentiating the spheres of influence and activities. In modern economic and social spheres, it is recognized that the most effective approach consists of the separation of regulating and executing functions. It was said that one of the causes for disrupting the activity of water organizations in England in the

1970s was distrust towards organizations that simultaneously had both supervisory and executive functions i.e. the organizations were both "forester" and "poacher." A basin organization should have only those functions, which it can execute to the best advantage – more efficiently, actively and stably than other organizations existing in the country. Thus, other agencies also need to execute their part of the functions only within the framework of the overall water resources management system.

- In some cases, new agencies for integrating basin water resources management are not created. In this case, adequate basin management can be established by means of voluntary co-operation of existing engineering organizations. Such an institutional structure is suitable for small and sustainable basins in the presence of a high level of public awareness, especially if administrative or another activity is already in progress; and/or establishing a new agency will not provide sufficient advantages. The most simple but the least effective form of basin management is fixed distribution, when an amount of water that can be withdrawn by each water user is specified beforehand. Such a system usually arises as a result of political negotiations (for example, the agreement between India and Pakistan concerning the Indus River signed in 1960).
- In-depth understanding of the role of an integrated approach in developing the water sector in Central Asia was intrinsic to the great Russian scientist and water professional, professor G. Rizenkampf who in the beginning of last century in his book "Golodnaya Steppe Irrigation Project" [12] has written; "The irrigation network is a canvas on which "life" will be embroidered; and in the process of its creation it is necessary to clearly see all aspects of future life. Development of an irrigation system should not be the end in itself; it is part of the integrated whole – the revival of a desert, from which the basic assignments arise and with which the irrigation system should be inherently linked … A key requirement is to provide the most rational arrangement of all life rather than only construction of irrigation networks, as well as achieving of the maximum effect as a whole rather than in any details. Among different engineering and economic requirements those which lead to the best organization of all life should be met, first of all. It is necessary not only to design the irrigation system but also to draw up the plan of developing an area under consideration including the scheme of roads, sites for industrial and market centers and pointing the most rational sources of energy in order to supply future factories and workshops. It is also necessary to prove that the designed irrigation system is inherently linked with future livelihood needs and is a good-designed part of the integrated whole."
- In this manner, the integrated development of large areas of virgin land in Central Asia was implemented in practice (Golodnaya Steppe, 1956; Karshi Steppe, 1964, and others); and these projects, in fact, are unique examples of the integrated and comprehensive development of large irrigation districts. However, this integrated approach had some shortcomings - lack of public participation and incomplete consideration of ecological requirements. Nevertheless, in all other aspects it has fully met modern requirements of the IWRM concept. Developing desert lands in the Golodnaya Steppe based on irrigation included the following activities:

- Irrigation and agricultural development;
- Construction of drainage systems to control soil salinization;
- Developing the residential area;
- Implementing measures for water saving at all levels of water management hierarchy;
- Construction of water and engineering infrastructure (water supply pipelines, roads, transmission facilities, communication lines, gas pipelines); and
- Institutional development and establishing the O&M system for both water infrastructure and other facilities.

As a result, in the 1960s to 1980s, sufficiently high indicators of irrigation systems' operation (irrigation system efficiency – 0.78; specific gross water requirement – 8,500 to 10,500 m^3/ha under an average crop yield of 2.8 – 3.2 tons/ha) were provided on the area of 320,000 ha in the Golodnaya Steppe.

After independence, the existing realities in Central Asian countries confirm the need for reforms in the governance of the water sector. These reforms, taking into consideration market conditions, have to provide adequate water management structures with farming on irrigated lands, as well as the co-ordination of all other economic sectors - water consumers, and, at the same time, to ensure a sustainable environment.Most importantly, the reforms are to be the basis for general sustainable development.

It is our firm opinion, that the introduction of IWRM is a process of long-term development taking a spiral path rather than linear one. Each cycle must have specific objectives, and its realization should be accompanied by appropriate monitoring and evaluation and adjustment of initial plans. A basic requirement of IWRM is to change the existing operational methods of water management organizations, taking into account the overall situation in the region. By introducing IWRM, we aspire to put elements of decentralized democracy into the practice of water management with emphasis on the participation of all stakeholders in the decision-making process, at all levels of water management hierarchy. Such an approach while providing new opportunities also creates new risks. IWRM needs to develop the mechanisms that allow all participants in water management and its use, often with obviously opposite interests, to work together.

An **agreed action plan,** containing the methods of reforms' realization in each country, is needed to introduce IWRM in Central Asia. Reconciliation of the regional water strategy, which should be based on national strategies and reflect the principles of sustainable water resources management, should be a starting point for its development. Undoubtedly, putting his strategy into practice will require reforming the water legislation and activity of water management organizations. This process has already started. It will be rather long and has to be accompanied by intensive consultations with the public and organizations that will be reformed.

An objective of this book is to demonstrate the experience of introducing the IWRM principles in Central Asia, including the advantages, comparing it to global achievements, and shortcomings that should be remedied in order to promote the adequate and effective practical realization of integration processes in the region.

CHAPTER I. IWRM PRINCIPLES

(V.A. Dukhovny, V.I Sokolov, H Manthrithilake., N Mirzaev.)

As was stated in our previous publication [3], we understand IWRM as follows:

"IWRM is a management system, based on taking into account all kinds of water resources (surface water, groundwater, and return water) within hydrological units, and coordinating the interests of different economic sectors and hierarchical levels of water use, involving all stakeholders in decision-making, and promoting the effective use of water, land and other natural resources to meet the requirements of eco-systems and human society through a sustainable water supply."

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

- Water resources management is implemented within the 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) and the climatic features of the regions;
- Close co-ordination of all kinds of water users 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, WUA, and farm as the end user);
- Public participation not only in the water management process, but also in financing, planning, maintaining and developing water infrastructure;
- Setting the priorities of eco-systems' water requirements into the practice of water management organization;
- Participation of water management organizations and water users in activity related to water saving and control of unproductive water losses; water demand control along with resources management;
- Information exchange, openness and transparency of the water resources management system; and
- Economic and financial sustainability of water management organizations;

In our opinion, IWRM may be considered as the complete system when all the above-mentioned elements and principles are put into practice, although forms and methods of introduction can differ. Partial introduction of some principles, for example, the basin method or participatory approach, cannot be the basis for statement and recognizing of the fact that IWRM is the complete system.

Let's describe the crux of main IWRM principles, because it is important to understand what kinds of measures are necessary for its practical realization.

1.1. Management within the Hydro-Geographical Boundaries or according to the Hydrological Principle

As known, water does not recognize the administrative division. Following the laws of physics, almost all the water on the earth has passed through the hydrologic cycle countless times - it evaporates from the earth's surface, condenses in clouds, falls back to the earth as precipitation (rain or snow), and eventually either runs into rivers, from which it can be withdrawn for use, and into the seas or re-evaporates into the atmosphere. An Earth area, where surface stream (river) is formed, is called a catchment area (hydro-geographical or river basin). Within the river basin, water is in permanent motion and naturally crosses the administrative boundaries delineated by human beings on the basis of geopolitical considerations. Thus, it is understandable that to manage all factors affecting the hydrological cycle, it is necessary to keep control over the entire river basin by a body or consortium of closely interacting organizations. An organizational set-up within the administrative boundaries, which does not usually coincide with hydrographic boundaries, results in loss of record-keeping and control of some components of the hydrologic cycle, affecting the sustainability and equality of water supply i.e. the key tasks of water management.

Most water professionals feel that river basin boundaries should be adopted following the catchment area pattern, in compliance with the regulations of Article 2 of the Helsinki's Rules (1966). However, in the so-called runoff dispersal zone, the effects of water management often transcend the boundaries of catchment areas and spread, especially, under pumping irrigation, over the command areas of irrigation canals. For example, the command area of Amu-Bukhara Canal (water abstraction from the Amu Darya River) covers practically the whole territory of another river basin (the Zerafshan River). The same takes place in the command areas of Karshi and Kara-Kum canals, which cover the basins of several rivers, and in many other water management systems in the region. A more complicated situation is observed in the Fergana Valley where the modern dense network of main irrigation canals with water diversion from the Syr Darya River, which have been designed and constructed during the second half of 20^{th} century, has overlapped the ancient system of oasis irrigation with water abstraction from small rivers, local streams and aquifers, forming a complex combination of water ways with double and, sometimes, triple feeding.

Figure 1.1
A Leaf of Tree as a Single Organism with the System of Feeding Capillaries

Thus, reviewing the boundaries of water management following the hydrological principle in each specific case, it is necessary to define clearly the limits of real and appreciable impacts of water sources, and territories, which are significant for IWRM. Infrastructure for regulating river flows, especially large dams for irrigation and hydropower, as well as ramified irrigation systems form the intricate anthropogenic morphology of water management systems within the basin as a whole or in part. These are very complicated systems for all kinds of water supply and for drainage as well. As a rule, they have the form of a complex "tree" of water system hierarchy with subordinated branches (main, inter-farm, on-farm irrigation and drainage canals).

Interconnection of these systems creates the intricate complex of objects related to integrated management, use, protection, and development of water resources, which should be covered by the specific governance system. Apart from water resources themselves and water infrastructure, this complex includes related land and other natural resources not only on the catchment area but also in the zone of so-called intensive water-economic influence. It absolutely does not require, and it is often impossible, to manage the territory of a whole hydro-geographical complex by using one water management organization. A good example of a possible approach is the French basin management organizations, which rely on the public participation in the framework of the so-called basin agencies that interrelate respectively with the subordinated public organizations at the sub-basin level.

Governance based on the hydrological principle, thus, can have a united organizational structure at national level; however, more often, it should coordinate a complicated hierarchical configuration vertically, and that will be described below. A major instrument of water resources governance within the hydro-geographical boundaries is the build-up of organizational structures according to the hierarchy of watercourses, first of all, natural streams and then man-made ones.

So, what does water governance in compliance with the hydrological principle mean? An illustrative example of the hydro-geographical principle under organizing water governance can be a leaf of a tree on which the configuration of arteries and their integration into a single organism are visible (Figure 1.1). Any water management system where the whole area of water use is linked to the hydrography of a major watercourse – a river or main canal with many off-takes into its laterals, through which water is delivered to the end user , is arranged in the same manner. Nature itself created the hydrological cycle, which is related to the specific territory, and this approach should be applied without disturbing the natural harmony of vital functions.

Let's imagine what can happen when an administrative border crosses a leaf as the border between two countries or, in other words, water (nutrition) supply over a leaf will be arranged within these "administrative borders" in the non-coordinated way. For example, the upper part of this leaf draws more water than necessary and intercepts water supply to its lower part. It is clear that such water distribution can result in partial degradation of the leaf or even complete damage. Water does not recognize the administrative borders established by mankind in line with geopolitical or other considerations. Therefore, water governance should be built up for a single hydrographic network rather than according to the administrative borders.

A system of the South Fergana Canal (SFC) in the Fergana Valley can be used as a model of the hydro-geographical unit (Figure 1.2).

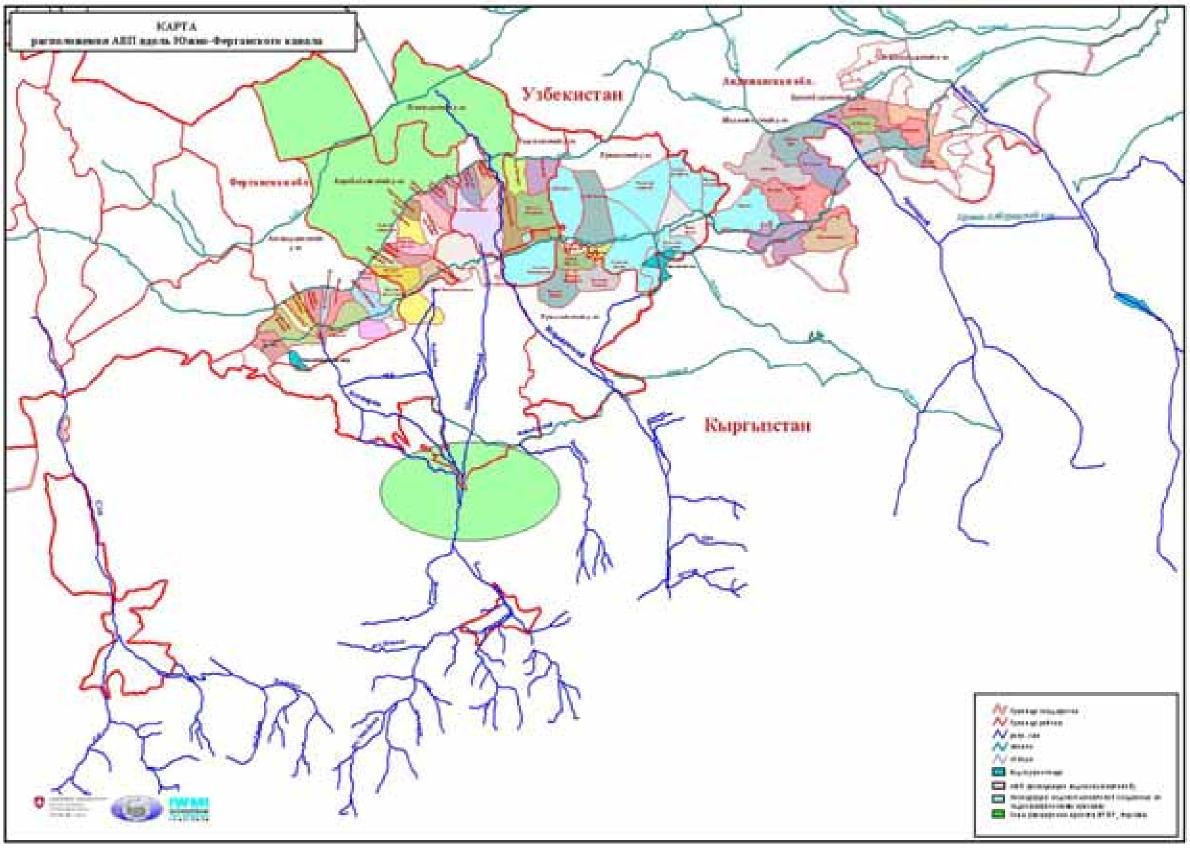

Figure 1.2 Irrigated Lands in the SFC Command Area

The head works of the SFC is located on the Shakhrikhan-Say that is the tailrace canal of the Andijan Dam on the Karadarya River. The total length of the canal amounts to about 120 km. The size of the SFC command area is 83,844 ha, and it covers mainly the territories in the Andijan and Fergana provinces and partly in the Osh Province in the Republic of Kirgizstan (about 2500 ha). In 1962, in order to increase the water availability in the SFC command area, the Kirkidon Reservoir (having a capacity of 218 million m^3), which was partly was filled by water from the Isphara-Say River, was built. to fill the reservoir during periods of excess water resources in the SFC, the supply canal 26 km long with a carrying capacity of 18 m^3/sec that diverts water from the SFC, was built 6 km upstream of Markhamat Settlement. Since 1967, the Kirkidon Reservoir is annually filled up to a total volume of 170 – 180 million m^3. The lined tailrace canal is 2.7 km long and with a carrying capacity of 50 m^3/sec it releases its water back into the SFC during periods of water shortage. Since 2003, this entire system, from the outlet of Andijan Dam to the tail section of this canal in the Altyaryk District of the Fergana Province, was handed over to the SFC Administration for integrated management. However, in the process of introducing IWRM within the SFC system, the need to link this management with operational regimes of a number of small rivers, which cross this canal, has arisen; because their unregulated flows considerably affect the operation mode of the SFC system as a whole.

Thus, the morphology of basin or system is a key factor for transition to management based on hydro-geographical principles, in the framework of which appropriate limits and requirements should be specified in accordance with specific features of this morphology to provide the sustainability of natural complexes. At the same time, the monitoring and drawing up of the water balance for the basin as a whole, separate sub-basins or irrigation systems (their close coordination with using institutional, economic, technological, and managerial instruments and involving stakeholders) should be provided.

An overall co-ordination of all hierarchical levels of water resources management (Figure 1.3) is founded on two fundamental principles:

- Achieving potential water productivity at all hierarchical levels right up to the basin level;
- Reducing specific water consumption within the system (against water diversion) up to the level of water consumption being equal to the evapotranspiration of crops.

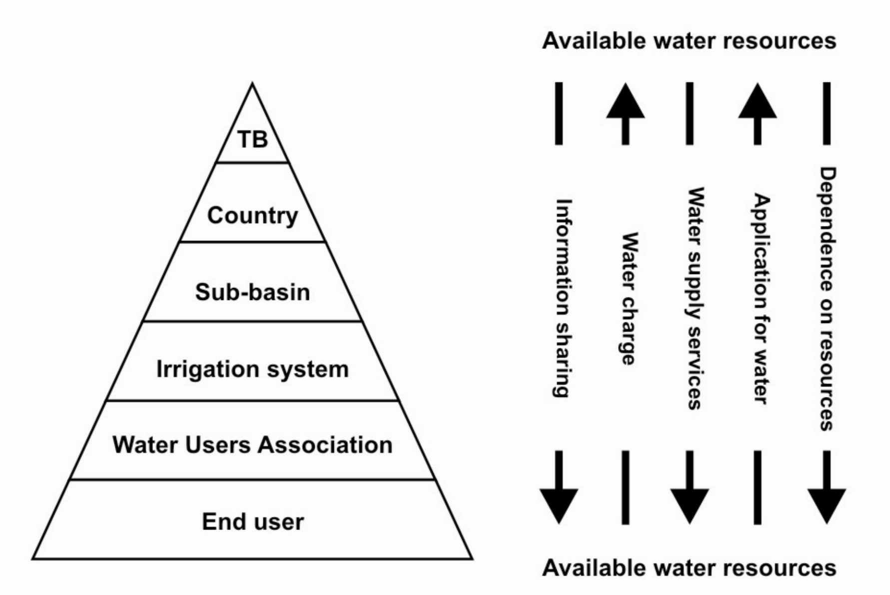

Figure 1.3 Levels of Water Governance Hierarchy and Main Links in the IWRM System

One more feature of water resources management grounded on the hydro-geographical principle is the fact that it is unique for each basin, irrigation system, and WUA because the basin morphology, soil and hydro-geological conditions as well as organizational and economic relations of water suppliers and water users are extremely diverse. We should not look for general patterns or solutions for different systems; it is necessary to develop only the overall principles of implementing IWRM.

1.2. Accounting and Use of All Kinds of Water Resources

Water resources used within the boundaries of a drainage basin are abstracted from surface and underground sources. One problem is that the different organizations are responsible for the assessment and record keeping of water resources in these sources. However, a more serious problem is that the different organizations control and manage the use of these water resources without the necessary coordination. Such a practice results in chaos in collecting of data on water resources status, and failures of equality and equity in water use. This problem is especially obvious in dry years.

Mr. Sorokin has clearly shown the shortcomings of existing water monitoring and record keeping in the Syrdarya River basin by analyzing of the water shortage situation in 2007 (the project CAREWIB). Figure 1.4, adopted from this analysis, shows that water releases from the Toktogul Reservoir (a major regulator of river flows) considerably differed from target indicators. Under these conditions, national water management organizations, and accordingly water users, were receiving water with high deviations from target amounts, approved by the ICWC as their water use limits (quotas), due to the following factors: unreliable forecast of water releases from the reservoirs, inaccurate information on flow rates, and lack of data on drainage water disposal into the river.

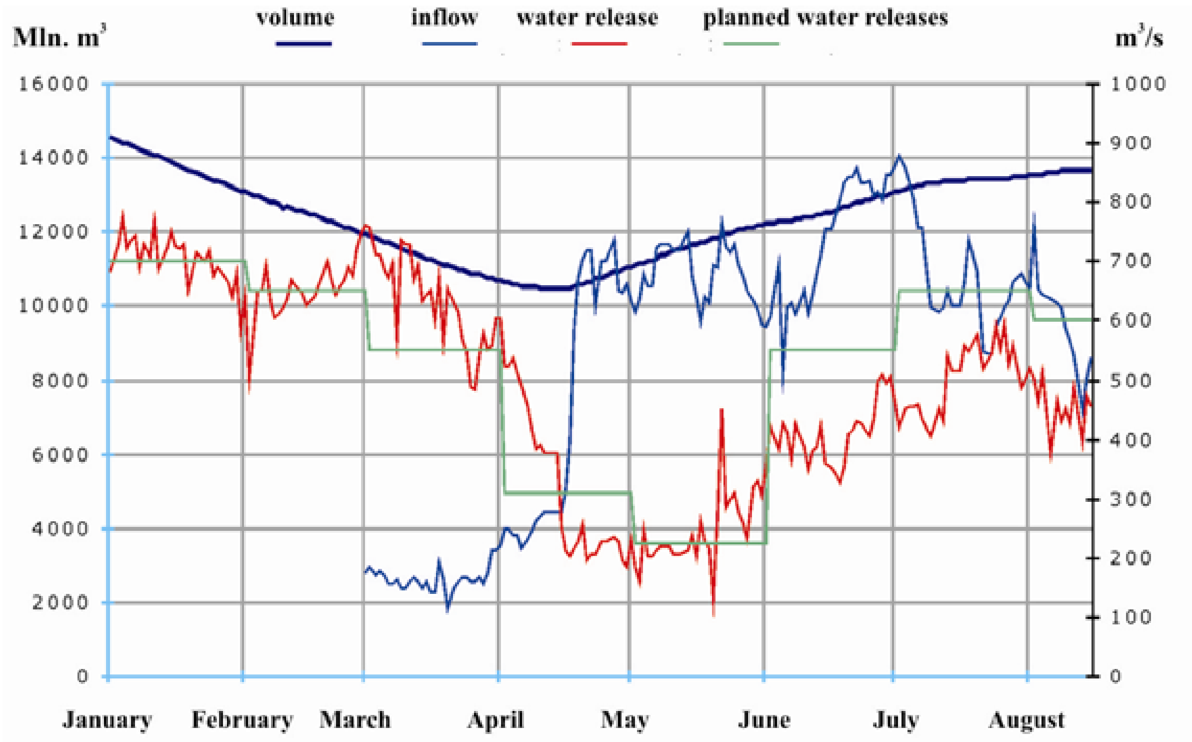

Figure 1.4 Deviations in Water Releases from the Toktogul Reservoir against the Planned Regime

You can image the constrained circumstances of a water user who knows that he will receive less than a planned amount of water, but doesn't know how much and when. Naturally, he tries to adjust his water needs but he does not have a forecast of weather conditions (temperature, rainfalls etc.) for revision of his irrigation schedule.

We do not think that the united system of forecast and record keeping can be today provided by one organization for the entire region (such an attempt was undertaken in the USSR by means of introducing the special statistical reporting in the Ministry of Water Resources: the Form "2-TP Vodkhoz"). The main idea is to establish: a) a monitoring and record keeping system that will meet standard requirements and be adopted by all states in the region; b) an information exchange system, using standard indicators and prescribed accuracy of data; c) access to all databases on all kinds of resources; and d) a reliable system for forecasting the flow rates (based on joint activity of all national hydro-meteorological services in Central Asia).

Most of naturally renewable water resources are formed over the surface of a catchment area and drain into the river network. Formation and transformation of run-off along the rivers are monitored by national hydro-meteorological services. Water management organizations are in charge of delivery and distribution of the water, diverted from rivers, among water users. Small water sources are under the jurisdiction of local authorities.

Another component of renewable water resources is groundwater, which according to its genesis can be divided into two types: groundwater is naturally formed in mountains or over a catchment area; and groundwater is formed due to infiltration on irrigated areas. Groundwater resources within the basin are assessed based on hydro-geological exploring, and following it, useful groundwater resources that can be used are approved. Ministries of Geology are in charge of assessment and use of useful groundwater resources without sufficient co-ordination with water management bodies.

Return water that is formed after primary use of natural run-off makes up part of waters used within the boundaries of river basins. It is formed due to releases of excess water from fields and by natural or man-made drainage. Owing to its high salinity, return water is the major source of contaminating water objects and the environment as a whole. Under current conditions in the river basins with an arid climate, 90% of return water consists of drainage water disposed from irrigation land, and the remaining part is waste water from industrial enterprises and public utility companies. Water management bodies and hydro-meteorological services are mainly responsible for monitoring and record keeping of return water, however, nobody practically controls the reuse of these waters. Although many research and promotional works were implemented to assess the possibility of return water use, up to now there are no comprehensive normative documents and regulations for its use. As a result of the haphazard use of return water for irrigation, land salinization takes place, resulting in a considerable decline in land resource productivity.

In addition, 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 correspondingly reduced, and at the same time, water salinity will increase.

On the one hand, accounting of all water sources is very important in order to meet the requirements of water distribution in an equitable manner but, on the other hand, from the point of view of controlling water quality, management of return water has great implications, since return water formed under all kinds of uses is the major source of polluting natural waters. At the basin level, tools for controlling groundwater and return water are the following:

- Record keeping of renewable groundwater, linked to zones of their replenishment, and estimating allowable amounts for their use as well as quotas (water use limits) for water abstraction depending on annual water availability. At the same time, it is very important to apply the principle of artificial groundwater recharge in wet years in order to use water reserves during average and dry years. During devastating droughts in 1974 and 1975, in the Fergana Valley more than 1,000 water supply wells, drilled in shallow freshwater aquifers, helped reduce water scarcity in this zone. In areas of its use, groundwater tables have steeply dropped; and underground inflow into the river has decreased, but in subsequent years, when water supply wells were put out of operation, the regular groundwater regime has been restored;
- Regulations on drainage and waste water disposal into international and national rivers and sinks including restrictions for releases of pollutants taking into consideration water availability in rivers; 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 irrigation.

It is very important to select proper tools for planning and management at the irrigation system level. Applying the Geographic Information System (GIS), areas if possible, economically and technically, using groundwater and drainage water (water abstracted from irrigation and drainage tubewells) need to be specified for each irrigation system, taking into account the texture of soils and water salinity. In order to specify additional water sources, overlapping of thematic maps with water demand zoning maps (thematic layer of the GIS) has to be carried out. These data are included in water use plans to ensure more equitable water allocation. Particularly favourable conditions for return water use at the level of farm, WUAs or main irrigation canals are formed in inter-mountain valleys within cascade location of irrigated areas when return water from upstream irrigated areas can be delivered to canals in downstream irrigation systems by gravity

The use of industrial sewage for needs not requiring a high- quality treatment is an effective method of water resources reuse. In the irrigation sub-sector, such an approach is applied in Australia and Israel for cascade irrigation of salt-tolerant crops, where drainage water formed after irrigation of grain and forage crops is subsequently used to irrigate first sunflower plots, and finally plantations of trees and bushes.

1.3. Cross-sectoral Integration of Water Users (Horizontally)

There is an impression that the cross-sectoral co-ordination is needed only during periods of water shortage, and while a water deficit is absent each sector can regulate its own rules for water use. However, it is far from the truth. By way of example, we review the Chirchik River basin – sub-basin of the Syr Darya River that was studied in the frame of the project "RIWERTWIN" (www.cawater-info.net/rivertwin). As a whole, this river basin has excessive water resources, which in average years considerably exceed the water needs of all consumers – hydropower, irrigation, natural complex, water supply, and industry. A surplus of water resources reaches three cubic kilometers; but, at the same time, some irrigation schemes suffer from insufficient water delivery due to lack of co-ordination of different sectoral interests.

The question is that even under the availability of excessive water resources, should the integration of interests of different sectoral water users be implemented taking into consideration a regime of water releases and water supply, requirements to maintaining water quality in rivers and other water bodies, and provision of regular operation of the basin complex? By way of example, we describe the experience learned in the Rhine River basin where, under general excess of water, upstream industrial enterprises, especially factories of the chemical industry and the cellulose industry, released so much harmful ingredients with their waste water, that the river has lost its fisheries and recreational functions. Signing a special agreement and 20-years of joint work were needed in order to rehabilitate the "ecological health" of this river.

From the point of view cross-sectoral (horizontal) integration, water management organizations should fairly represent the interests of all water users in different economic sectors and provide a priority of water saving and eco-system preservation within the boundaries of each hydro-geographical unit. As mentioned, above, the problem is that different departments manage the use of different kinds of waters. For example, surface water is managed by the Ministries and Departments of Water Resources, first of all, in the interests of irrigated farming, and, at the same time, by the Departments of Energy in the interests of power generation etc. At the same time, all the above-mentioned public departments and ministries, as a rule, do not co-ordinate their activity with each other. If during the Soviet period there were statistics on water use in all sectors (Form "2-TP Vodkhoz"), currently nobody has even general information, and this form of reporting is maintained only in some departments and ministries.

Gathering all economic sectors under "a single organizational roof" is not needed at all. Furthermore, as noted correctly in the GWP handbook [31], this approach can be even harmful since a sectoral professional specialization is important for an effective activity of specific production. However, the main basis for cross-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 conflict settlement should be developed to integrate contradicting interests. It may be achieved by involving the representatives from different sectors in public governance 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:

- Overall planning and co-ordination of water resources use;
- Coordinating the economic growth of sectors;
- Information exchange; and
- Participation in material and financial inputs of mutual interest

Relevant public conciliation bodies play a positive role in 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 large water users in the Irrigation System Councils, as well as water users in the WUA boards). In many countries, the National Water Councils, consisting of leaders of all sectors interested in the use of water resources as well as key scientists and water professionals, were established under the direct guidance of Prime Ministers of these countries.

1.4. Coordinating Different Levels of the Water Management Hierarchy (Vertically)

As known, a modern water management system, especially, in the irrigation sub-sector, is a multilevel scheme of water supply and distribution that starts from a basin, mains, secondary and tertiary canals, irrigation network within water users' associations (WUAs) or the water distribution network of utilities and industrial water users (WUO) and finishes on irrigated fields of farmers (see Figure 1.2 above). 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 overall inefficiency of the water management system. We suffer from losses owing to 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 levels of water management. A situation where each water agency develops its own criteria and approaches that do not correspond to the overall objective of IWRM to reach maximum water productivity needs to be removed. Provincial and basin water agencies have an interest in supplying water to consumers as much as possible, and, in their turn, water users are interested in reducing their water consumption to the minimum (if they pay money for water).

Each level of governmental water management hierarchy tries to take the maximum possible water volumes from a water source and to allocate these water resources to those persons who require more, or according to instructions from their superiors. At the same time, water agencies do not sufficiently take care of maintaining a high efficiency of irrigation systems and of preventing operational water losses. In addition, having excessive water reserves, they often dispose of unused water (considerable financial resources are spent for water delivery, especially under pumping irrigation) into the drainage system.

To create the overall interest of all hierarchical levels in minimizing unproductive losses and in uniform and equitable distribution of water among consumers, the specific goals of the government and society to develop and support a set of management measures and instruments needs to be promoted.

A basic tool needed for coordinating activities at different levels of the water management hierarchy (both according to horizontal and vertical links) is public participation in decision making of the properly established institutional structure. An organizational chart of the modern institutional water management structure is shown in Figure 1.5. There are the following levels: the upper level is a basin that can be divided into sub-basins; the next level is irrigation systems (having a common water intake and main drainage network) or an administration of single main canal; further, the level of WUAs (in the sub-sector of irrigation) or of WUOs (in case of other water consumers); and finally water users (farmer, enterprise, residential district etc.). In case of an inland drainage basin, a basin water organization (BWO), which 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 in the basin and sub-basins according to the regulations of the BWO (similar to the BWO in the international basin). Basin Councils, consisting of the representatives of different "interested entities" with different rights and duties depending on national legislations (for example, with the consultative status as in Kazakhstan or the decision making status as in France, Spain, and The Netherlands where they are called "Committees" and "Boards") can be established under the BWO.

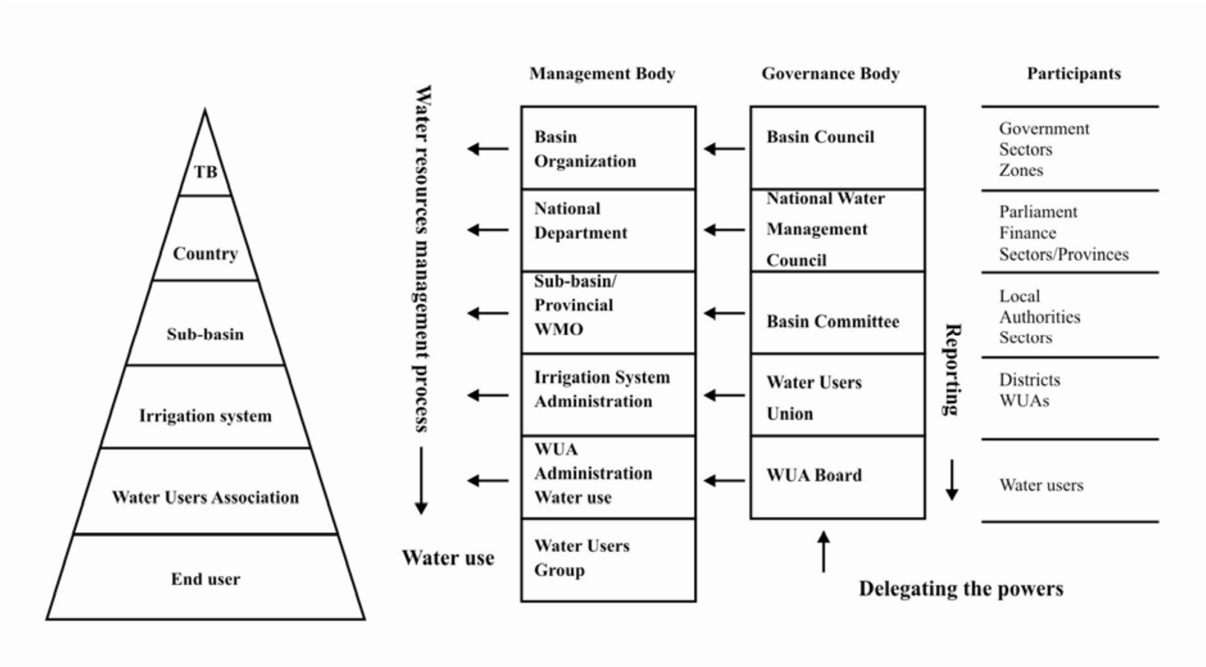

Figure 1.5 Levels of Vertical Water Management Hierarchy and its Key Actors

The management of irrigation systems diverting water from basin water sources is the prerogative of an organization located at the next hierarchical level, and which may be subordinated to the BWO or may be a coorporative public-and-governmental organization. In any case, at this level of the water management hierarchy, the representatives of public or public-and-governmental organizations should be involved in works of the governing body "BWO Council." WUAs, with their own administrative staff and mechanisms of public participation and with the similar proportion of rights and duties in managing of irrigation systems or single canals, are the next hierarchical level. Such a principle was applied in the governance and management of all pilot irrigation canals in the frame of the IWRM-Fergana Project. Although, it was necessary to take into account the presence of one more complex structure of the irrigation hierarchy (inter-district irrigation canals), because in contrast to the command areas of Aravan-Akbura and Khodja-Bakirgan canals, here only some of the WUAs were supplied with water directly from the SFC, but other WUAs were supplied from the canals of the lower level.

The next element of co-ordination is contractual relationships based on the practice of applications for necessary resources that are formed according to the "bottom-up" approach with restrictions in the form of water use limits and relevant water supply schedules that are formed according to the principle "top-down." Contractual relationships between BWOs and irrigation system administrations have to be regulated by the specific planning system in the frame of the overall state regulation, where the water rights and duties of both sides are fixed within a range of permissible deviations. A water management organization should ensure implementation of the planned parameters of water supply agreed on by both parties. Similar relations are established between the irrigation system administration and WUAs, but they are already grounded on the specific financial relations and relevant sanctions.

When the irrigation administration is a subdivision of BWO, the contractual relationship is formed only between the BWO and WUAs. In parallel with management according to the "bottom-up," principle, participatory water management 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. In the framework of IWRM, the priority functions of these organizations are not only water management itself in agricultural, industrial, hydropower, and trade sectors but also the responsibility for effective water use in those sectors. It is clear that in order to perform these functions it is necessary to have appropriate mechanisms and instruments of dialog and coordination.

Management instruments (see more details in Chapter 5):

- Record keeping of water at all levels of the irrigation system from basin to farm; and strict water consumption rationing;
- Drafting the coordinated plans of water allocation and use at all hierarchical levels of water management that include organizational water loss control;
- The reporting system that shall provide not only annual and quarterly reports but also an operational report with planned criteria and indicators for timely adjustment of water supply;
- Improving 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 restrictions 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, the above-mentioned instruments should be an integral part of the management information system (MIS) that is an important component of introducing the IWRM principles (see details below).

Legal and economic instruments are closely interrelated and mutually complementary. Principle instruments are given below:

- Water user rights and their protection by the State;
- Contractual relationship between water users and water management organizations, and also between water management organizations operating at different hierarchical levels;
- Legislation covering 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 service quality);
- Penalties for water pollution;
- Fee for water as a resource;
- Government control of rights and duties of water management organizations and water users, as well as the state liability regarding the support of both parties;
- Incentives and preferential terms for water users and water management organizations to rationalize the water use; and
- Fines for surplus water abstraction.

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

1.5 Participatory Water Resources Management and the Government's Role

An extremely important component of putting the IWRM principles into practice is the broad involvement of public organizations and other stakeholders (local authorities, municipal water users etc.) in the management process. Water resources management issues need to be considered in the context of interactions between civil society and the State.

The participatory approach has to create an environment of *transparency and openness*, where the likelihood of decisions not meeting the public interests is reduced.. The higher the level of public participation the less favorable conditions for corruption and ignoring of public interests. This is an instrument for preventing local or sectoral egoism in water use. This is the platform for making equitable and well-thought-out decisions regarding water allocation, taking into account nature preservation requirements and economic growth under conditions of increasing water scarcity.

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

Public participation also is the most critical factor to control any kind of "*hydro-egoism*"[3]. The previous administrative system of water management threatened water users with "administrative hydro-egoism," 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 hydro-egoism*," since due to lack of public control, water management organizations themselves plan water allocation, establish water use limits, adjust these water use limits, and finally audit their own activity. 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 Unions of Canal Water Users, Basin Water Committees (Council) etc. in parallel with existing water management organizations.*

They are public representative bodies that govern water management activity within the appropriate irrigation system. Broad representation implies the participation of all stakeholders in the water management process, namely: representatives of water agencies, representatives of water users from 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 the activity of legal entities and individual persons related to water management and use this within an irrigation system or the command area of a single irrigation canal. A major objective of their activity (together with their executive bodies and under broad participation of all stakeholders) is to put integrated water resources management principles into practice

No matter how employees of existing water management organizations (WMOs) operate, there is an issue related to establishing public organizations of a new type that enable us to provide grreater involvement of water users in water management as a matter of ensuring fairness and using the potential of collective intellect; and, in the future, these can become genuine governing bodies bearing complete responsibility regarding water management. Our experience shows that the management of WUAs and the Canal Water Users Committees do not participate enough in the processes of water resources planning, allocation, and management, as well as in decision making related to maintaining and rehabilitating of water infrastructure and seeking funding sources. At the same time, the practice and methods tested at pilot irrigation systems are gains for the future. We need to prevent the conversion of these bodies into ones with only advisory functions or into "an adjunct" of WMOs.

The system of public participation in water resources management should be built up 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

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

their own financing or other funding sources. Public participation has to provide "transparency" of water agencies' activity and to prevent transforming of former administrative bureaucratic systems into a new professional and sectoral bureaucracy with its "hydro-egoism." Water Councils of basins and sub-basins have to be composed of representatives of concerned regions (districts), principal water users, and water-conservation bodies. The 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 partnership with the State and private sector, which could be a driving force for transforming activity related to water sector development into national action.

Public participation is especially important in the process of developing principles and methods of water distribution within the former on-farm irrigation network. It became obvious that engineering tools alone are insufficient, especially now when the number of water users has 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 WUA could efficiently manage water resources without grouping water users or without the teamwork of farmers in command areas of on-farm irrigation canals. In the Fergana Valley, big number 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 system under implementation of the planned irrigation schedule.

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

Under these conditions, along with planning water use according to the "bottom-up"principle, taking into consideration the 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 in 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 a higher level of the irrigation network. At the same time, taking into consideration ten-days planning of flow rates in irrigation canals by a superior water management body, it is advisable to apply water rotation among groups of water users that divert water from one canal. However, specially trained professionals in water management together with sociologists have to identify each WUA and each irrigation canal within an association's area. This includes procedure of water distribution, its cycles in the growing season, and grouping of water users for each water supply shift, 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 the system of rational water supply and to see the potential for its adjustment.

As known, the institutional aspects of IWRM include: (i) transition from the principle of water resources management within administrative boundaries to management within hydro-geographical units; and (ii) public participation. In the process of introducing the principle of water resources management within hydro-geographical units, there are no problems because it was objectively beneficial to water management organizations. As for public participation, the situation is quite different. As a rule, public participation is beneficial to employees of water management organizations but not to some water officials. Recognizing by word of mouth the leading role of water users presented by the Canal Water Users Council (CWUC) the opponents of such an approach will try to transform the CWUC into an obedient "pocket" body. Therefore, disallowing the legal registration of the CWUC as an independent, non-governmental and non-commercial body of water users and in opening its bank account just contributes to the dependency of CWUC on the Canal Administration. In this context, the rejection of legal registration is beneficial to water officials rather than water users.

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

The status of private farms (secondary water users) is changing under establishment and operation of the WUA. A water users association itself enters into contractual relations with water management organizations (district water authorities or irrigation system administration), 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*.

1.6. Environmental Approach: Nature is an Equal Partner

Over a long period of time, mankind considered itself as all-powerful and able to bend nature to its will. However, instead of the slogan: "We cannot wait for favors from Nature …" has come the understanding that "a human being has got nature not as a gift from his ancestors, but borrows it from his descendants." Such a concept adopted in the water sector, first of all, implies the recognition of rivers, lakes and other water bodies as "water consumers" along with other economic entities, and without specific ecological water flows they can lose their natural essence. Today, the priorities of water management organizations, frankly speaking, are aimed at current momentary needs of mitigating the consequences of floods and droughts as well as the satisfaction of daily wants. It is easy to see that even people living in the vicinity of the epicenter of environmental disaster in the Pre-Aral region in the end of 1980s and suffering from a decline in fisheries and loss of the river delta, nevertheless have preferred to take away the water from their sea for increasing rice production in Karakalpakstan and Kyzyl-Orda Province in Kazakhstan. After independence, some shifts in raising ecological awareness of society affected by this crisis took place. However, on the whole, conservation and especially restoring the disturbed environment are staying in the "backyard" of water policy and, to some extent, are being an obvious attempt to follow the fashion. the water culture level of a country, region, zone, and even water management administration is defined by the observance of nature protection regulations in current practice. This concerns such areas of activity as: (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, water sources and affected entities.

The environmental aspects of IWRM specify activities and awareness going in two directions: to prevent harmful events related to water resources, and to meet the water requirements of eco-systems. From the ecological point of view, the main features of water are its high mobility and ability to dissolve different chemical components of the natural complex. A key condition providing the sustainable natural and anthropogenic cycles is to minimize the negative impacts of interacting sources of water and territories in use, as well as the interaction of surface and ground water.

In respect to providing environmental sustainability in the drainage basin, it is possible to propose an approach under which such principles and interrelated conservation factors, as water quality in its sources and accumulation of pollutants over areas under economic use are taken as sustainability criteria. In other words, the criteria of well-being in the drainage basin would be represented as follows:

- The pollution level of the area under economic use and affected eco-systems should not exceed the permissible concentrations, and trends of accumulation of toxic pollutants are to be negative, i.e. gradual reducing of pollution over the concerned area is in progress;
- Concentration of contaminants in water sources over all zones of the drainage basin, from headwaters to its mouth, shall not exceed the maximum permissible concentrations for all water users utilizing water from these water sources; and
- Anthropogenic pressure on eco-systems over the catchment area should not exceed the optimal limits that ensure maintaining of their biodiversity and bio-productivity.

An another important issue is the observance of ecological requirements for water resources, when we keep in mind the requirements of eco-systems for water supply as the basis of sustainability of flora and fauna, as well as of aesthetic 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, many natural streams have lost their original status: rivers Zarafshan, Murgab, and Tejen have lost their links with the Amu Darya, and in a similar manner, rivers Chu, Talas, and Assa have lost their links with the Syr Darya River. However, our task is to stop this grievous process.

It is clear that IWRM shall provide the real observance of ecological requirements of water as a key task of hydro-ecological management. A number of the provisions that need to be considered in the practice of water resources management may be formulated from the positions of an ecosystem-defined approach.

1. In compliance with the IWRM principles, water, land, and other resources within a catchment area should be considered *as components of joint use, management, conservation, and development*. Responsibility and duties should be distributed among water users at national, sectoral, local and "bottom" level in such a way that the regulation of water demand and use would provide sustainable preservation and/or development of the natural potential as well as preventing its reduction. 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 legislation, regulations, and international agreements, the State assumes the responsibility, with the assistance of its conservancy agencies, water management organizations and public mobilization, to monitor ecological and sanitary flows and the norms on preserving natural streams that were discussed above.
3. Step by step inclusion of the environmental component into IWRM in the form of the participation of conservancy agencies in decision making at all levels of the water management hierarchy as equal partners should be accompanied by the introduction of hydro-ecological management, as a top stage of IWRM. This type of management is formed by means of priority-driven consideration and observance of environmental requirements, assessment of ecological service and transforming the Basin Water Council into the Basin Council of Natural Complexes that should consider maintaining the sustainability of ecosystems as its primary task. In the BWOs "Amudarya" and "Syrdarya", the initial phase of such an approach should be the inclusion of the Delta Water Users Association as the most important and full member into the Basin Council for defending the interests of natural complex.
4. Water resources management has to be based on the rigid principle of *ecologically permissible water abstraction* (EPWA) to prevent the possibility of irrevocable water consumption. When this level is exceeded (such a situation took place in the past), countries-consumers shall make their contribution to the international basin fund as a payment for excessive use of natural resources and implement mitigation measures. For example, in the Aral Sea basin, this recommended level of total water abstraction from water sources is about 78 km^3 against the present water abstraction of 106 km^3, and 123 km^3 in the past (1990)! If each water consumer who exceeds the ecologically permissible water abstraction will make a contribution to the fund for ecological safeguarding of the basin, then opportunities to use these funds to improve environmental conditions within the basin as a whole will arise.
5. For the purpose of preserving rivers and water bodies as natural ecosystems, drawdown of water of reservoirs and river flows *should not be less in summer and more in winter than mean annual runoff (that is specified based on long-term flow rate measurements)* in respective seasons. The observance of this rule can prevent transformation of rivers into runoff ditches. Water requirements of ecosystems in deltas and estuaries and flow-through and closed water bodies should be specified taking into consideration their bio-productivity and sustainability, based on monitoring data along with taking into account requirements of countries that are using water resources.

6. Environment aspects should be included into IWRM plans at the levels of basin, sub-basin, and region. Ecological problems that need to be solved exist in each irrigation systems or WUA. These activities includes: (i) rehabilitation of disturbed natural landscapes due to water erosion, water logging, and deforestation; (ii) correcting such matters as excessive abstraction and use of local water sources; and (iii) inventory of sources of pollutants and damaged zones, and their control and localization. All these activities 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 control should gradually introduce the management practices at basin and sub-basin levels as an effective measure for rehabilitation of natural ecosystems.
7. Drainage and drainage water management is an important component of nature protection complex. The interrelations 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 water losses and deterioration of water as a resource, but also degrades the land and loss 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-uniformity of crop over an irrigated area. In order to identify these shortcomings in water management in a timely manner, it is necessary to enhance the activities 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 is note worthy to remember that land salinization and water logging are some of the main factors causing decreased crop yield and water productivity in irrigated farming, because apart from the fact that there is a reduction in yield, water consumption is high.

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). Meeting of water requirements of ecosystems should be one of priority activities within IWRM.

1.7. Principle Concern: Water Conservation and Rational Water Use

Efficient and effective use of the water diverted from water sources should be planned and conducted according to two directions. It is clear that water use by direct water users is the first and, likely, most arresting aspect for water saving activity. However, there is another direction that shouldn’t be out of attention of actors in the water sector. High reserves are in hands of managers in the water sector due to mismatching of water demands and supply, as well as due to the instability of flow rates in any water management system.

A key objective 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.” Practical findings of some projects (the WUFMAS, Best Practice, IWRM-Fergana etc.) implemented in the region over the period of 1997 to 2004 demonstrate that it is quite substantively to achieve potential water productivity. On the basis of the experience and results of these projects the following recommendations can be made regarding large-scale dissemination of water saving technologies in the region:

1. Improving the system of water resources monitoring and assessment;
2. Introduction of the progressive water charging system applying incentive stepped tariffs and penalty sanctions for each cubic meter of water used in excess of planned rates etc.;
3. Revising all water use standards based on the scientifically-founded computer programs “ISAREG” and “CROPWAT” [32] 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 effective adjustment of water consumption rates depending on different water availability;
4. 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;
5. Developing the zonal indicators of potential water productivity, and on their base granting of preferences to water users that provides the achievement of these indicators, in the form of reduction in taxes or fee for water services;
6. Creating the system of pilot water saving projects, as a primary measure to demonstrate rational water use;
7. 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.)
8. Introduction of the state-of-the-art irrigation technique and methods; and
9. Establishing an extension service for water users providing a technical assistance in rational water and land use and in achieving potential productivity of water and land resources.

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

- Establishing the legal basis for water use and supporting water users;
- Introduction of the economic incentives for water saving by water management organizations and water users at the State level;
- 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, including study tours;
- Manufacturing equipment, instruments, and appliances to promote effective water use; and
- A state support of procuring water meters for water users;

The introduction of advanced and ecologically sound technologies should base on the thought-out mechanism providing the enabling environment (with applying financial, organizational, legal, and engineering tools). Low rates of introduction of these technologies were mentioned even in the European Water Directives. There are a few causes for this situation:

- Ecologically sound and state-of-the-art equipment, for example, 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 (in opposite case these funds would be confiscated by the State at more considerable rates);*
- Introduction of water saving technologies for domestic purposes (faucets, shower-bath appliances, lavatory pans etc.) enables to reduce water consumption per 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 the 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 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 publicly profitable decisions*; and
- Water prices established on the basis of complete reimbursement of all operational costs plus 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 the introduction of ecologically sound technologies.*

Measures aimed at water saving and increasing water productivity are described in detail below.

It is usually considered that efforts to combat irrational water use within the water management systems consist in improving two types of the efficiency - technical and organizational. It is well known that the enhancement of the technical efficiency can be provided by means of eliminating leakages in water pipes, lining of irrigation canals or replacement of earthen canals by pipelines and flumes etc. to prevent seepage losses. Enhancing the organizational efficiency is reached by means of preventing unproductive irrigation water disposals into the drainage network; idling runs of water through irrigation canals, and unauthorized water diversions, as well as by means of construction of intra-system reservoirs accumulating and storing excessive water supplies and daily regulative basins that smooth the daily unbalancing of water supply and water diversion from the sources. However, substantial attention also should be paid to eliminating lack of uniformity in water distribution between subordinated canals or among water users.

Entropy, which is higher if increase in the number of hierarchical levels and a lesser extent of regulation and limitations take place, is intrinsic to any distribution systems, including water management systems. Increase in deviations from average water supply, as moving away a water source, is also typical for water management systems, and this fact is obviously illustrated in the diagram below (Figure 1.6).

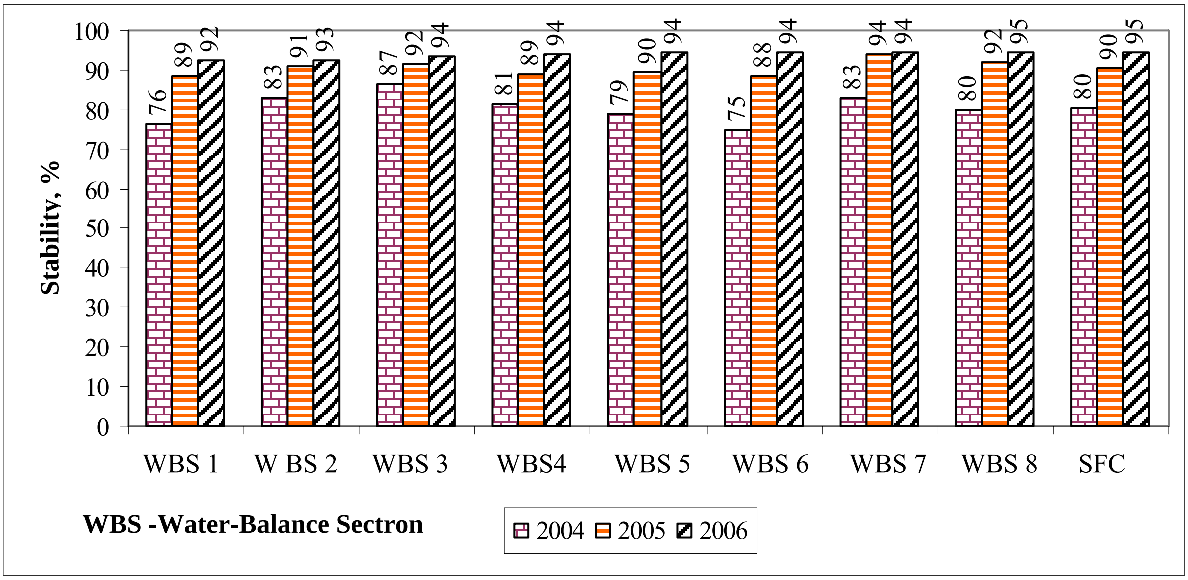

Figure 1.6 The South Fergana Canal: Stability Index of Water Supply during the Growing Season

This figure shows that in dry years the deviations are less considerable due to the enhanced control of water supply and distribution speaking about the extent of operational orderliness. Thus, the task of reducing unproductive water use comes to proper organization and control of O&M activity.

1.8. Information Management System – Management and Feedback Instrument

In the management process, all-round information on a controllable object is the foundation for successful operation. It is impossible to maintain any machine or mechanism, construction or production process without information on its current status, available resources, interrelations of its components etc. It is also important to know the future needs and to be ready to meet future requirements to avoid failures in operation.

Much more information needs to be provided when we deal with water management. Mistakes in water management threaten not only to damage sufficient water supply but also to cause floods, droughts, and diseases, loss of crop yield, famine and many other hardships and even disasters. Nevertheless, a well thought-out information management system (IMS) should be the backbone of IWRM under all the diversity of interrelations with the outer world. Lets us look at Figure 1 given in the preface. We see all-round links of water resources, on the one hand, with different factors and effects, which are far from complete presentation, but, on the other hand, with impacts of outer and inner factors on state, regime, available resources, and quality of water and all water-related aspects. It is understandable that it is quite difficult to establish the information management system including directly all necessary entities due to the need to set data of both temporal and spatial measurements. Therefore, in the process of establishing the information management system (IMS) for IWRM it is necessary to stick to specific rules and principles. An attempt to formulate these rules and principles are made below.

1. The IMS is formed as a structured storage in which data is arranged in major data sets of thematic information. The following data sets, most often, are represented: “Water - Resources”, “Water - Consumption”, “Social Environment”, “Land Resources”, “The Environment – Biodiversity & Bio-Productivity”, “Climate”, “Infrastructure”, “Hydropower”, “Irrigation & Drainage”, “Water Supply”, “Industry”, “Micro-Economy” and so on. A series of data sets may be different depending on the specific character of IWRM.
2. The IMS is built up for three time periods: retrospective, current information, and outlook. A retrospective series length depends on the set of planned tasks of management and analyses. It is recommended to include all hydrological and climatic data over the whole length of existing series of observations, since forecast, recurrence assessment or calculating the probability of emergencies provide more reliable results if there is longer series of observations. It is important to have additional series of observations related to the status of land resources, vegetation cover, and soil fertility, however, taking into account more smooth changes of their characteristics, it is not necessary to store in the IMS data of each year, but, for example, to store averaged data over each 5-year period or even decade, if series of observations are long enough. It is desirable to have the socio-economic indicators, at least, over last 25-30 years, since the length of retrospective series specifies the reliability of socio-economic analysis and forecasts. Taking into consideration the long period of implementing water management projects, their efficiency assessment for prospect should be made on the basis of retrospective series of observations, the length of which exceeds the planned period, at least, one and a half or two times.
3. Current time series for a planned year, usually, have daily intervals, but in some cases one-hour intervals may be required. After certain time, these daily data series can be either annihilated or aggregated and archived. Retrospective or long-term time series can consist of the series of 10-day or monthly average data.
4. Spatial location of objects is contained in the IMS in the form of GIS thematic layers (Geographic Information System) that allows to set position data in absolute coordinates and to link IWRM interacting components over area or linearly, and this is very important for solving many practical tasks of management and planning. For example, only with a help of the GIS, the detailing of forming snowmelt runoff depending on land gradients, soils, precipitation etc. is possible. Information on soil conditions, hydro-geological cross-sections, crop patterns and other components is the reliable basis for calculating water requirements of irrigated areas. The GIS allows to link return water formation with an area affected by the drainage network and with water supply over this area, as well as to set the source zones of different pollutants.
5. A set of models that allows analyzing various operational and emergency situations and making forecasts should be provided for in the frame of IMS. A legislative base of planning, operational management together with O&M regulations and rules of controlling different functional components should be a special part of the IMS. This part of the IMS is included into the database (DB)
6. Various data and indicators necessary for solving IWRM operational and long-term tasks related to developing information data sets, mentioned in Para 1, and the GIS (Para 4) should be specified by managers of the IMS in co-ordination with technologists and governmental bodies.

Establishing the Information Management System provides for the following target activities:

- Establishing database on all operational processes, including annual and long-term planning and operational water supply and distribution;
- Water quality monitoring and management;
- Analyzing and adjustment of the water management process;
- Providing the transparency of water management and trust among water users;
- Assistance to water users in economical water consumption and achieving its potential productivity;
- Preparing the analytical reports for improving management methods and informing decision makers and stakeholders; and
- Assessment of current trends and adjustment of the water use strategy; and so on.

In Central Asia, the first steps in establishing the IMS for IWRM were done. In particular, under financial assistance of Swiss Development Cooperation, the regional information system CAREWIB, which serves stakeholders in the Aral Sea basin at the interstate level, was created by SIC ICWC's specialists. Another example of the established IMS aimed at servicing stakeholders at the levels of irrigation canal, WUA, and selected farmers is the IMS of the IWRM-Fergana Project that contains the database for pilot irrigation canals. Finally, the IMS aimed at long-term planning and improving water management practice, by example of water management in Chirchik River Basin (sub-basin of the Syr Darya River) was established in the frame of the RIVERTWIN Project. Detailed description of above projects can be found at website: www.cawater-info.net.