2 - THE ARAL SEA BASIN: PAST, PRESENT AND FUTURE

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Abstract: The history of the Aral Sea Basin reflects many examples of pioneer accomplishments in developing water management. The situation that is taking shape in this region keeps on being the subject of numerous discussions and studies. Irrigated agriculture in the region has nowadays reached the turning point of its development and is undergoing turbulent dynamic changes, which differ deeply in the various countries and regions of the basin depending on specific political and natural environments. The analysis of the current situation permits identifying ways of survival under increasing water scarcity through introducing Integrated Water Resources Management (IWRM), which should be scientifically based as intended with this cooperative EU funded Project.

Keywords: Sustainable development, Hydro-ecology, Water resources conservation, Water saving, Water management, Irrigation.

Introduction

Water management and irrigated agriculture in the Aral Sea Basin are passing through a rather complicated period of political revival and economic transformation in conditions of independent statehood, transition to market economy, intensive impacts caused by internationalization and globalization processes, and efforts to elaborate new forms of state development. Given the specific features of the arid climate in this zone, the local demographic situation, the consequent critical role of water and respective transboundary relations, both water management and irrigated agriculture play a role of great socio-economic and ecological importance for the region. Though a large number of scientific and research works have been carried out in the region, integrated studies aimed at establishing the scientific grounds for efficient water

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resources use in irrigation, which is the major water user in the region with 80% of total water use, have only recently developed following an updated perspective.

Activities developed through the present EU cooperative research project are meant to be part of the first step along these lines of research, since they adopted up-to-date methods of modeling approaches that enable proper consideration of processes of water use, water delivery/distribution, as well as water and land productivity. Approaches include the adoption of Geographic Information Systems (GIS), namely coupled with Remote Sensing (RS) technologies, and Decision Support Systems (DSS). They allow considering how natural and technical resources and systems determine water demand and use taking into account their variation both with time and space.

The present book illustrates the results of the Project "INCO Copernicus ICA 2 CT 2000" and summarizes results of the efforts along these lines – thus forming the basis for a prospective implementation of Plan for Water Resources Use meant to harmonize water resources and agricultural production development with meeting water demands for Nature and Society. The objective of this article is to give the outline of available water resources to understand both past developments and the perspectives of development for the next 25-50 years, thus in an attempt to forecast future trends in the area. The article is based on various studies as those referred in the bibliography, as well as on numerous scientific and technical materials generated and made available through the Scientific-Information Center of the Interstate Commission for Water Coordination (SIC ICWC), particularly within the WARMIS and CARWIB programs.

Background on water management and irrigated agriculture in the Aral Sea Basin

One of the seven centers of ancient civilizations was located and developed in Central Asia (Fig. 1), its origin being contemporaneous with those in Egypt, Mesopotamia, India and China (III-II millenniums B.C.).

Having passed through such stages of development as brook, *keryaz*[*], dike-less and oasis irrigation, by the 19th century regional water management and irrigation received a powerful and new development due to involvement of Russian irrigation engineering, namely through engineers such as A.N. Kostyakov, V.V. Massalsky, and G.K.Rizenkampf, who worked in the region by that time. It was in this period that the first large-scale projects were initiated and start to be implemented, mainly the Hunger Steppe and Karakum Canal

[*] *keryaz* - water intake filter gallery

Fig. 1. Central Asia countries and Aral Sea Basin.

schemes, and the Choo-Talas and Amudarya delta development. During the Soviet times, a number of hydro-power projects were launched, which gradually got implemented from 1925 to 1990. Consequently, the region got an enormous technical and economic development associated to very large irrigation, hydro-power and water supply systems; but the Aral Sea, that used to rank the fourth in volume among the inland lakes, has actually disappeared from the surface of the Earth as a single water body (Fig. 2).

This makes necessary to reconsider the past development options and to find innovative approaches that reconcile water use development with environment and the maintenance of essential ecosystems. Figures reflecting the dynamics of water management (Table 1) evidence that huge economic and social problems are worsening, so adding to the environmental and ecological problems. Innovative approaches, largely overcoming those of technical nature, are therefore required for sustainable use of water and natural resources in the area.

Table 1. Water use dynamics since 1960.

Indicator	Unit	1940	1960	1970	1980	1990	2000	2004
Population	10^6	10,6	14,6	20,3	26,8	33,6	41,8	43,8
Irrigated area	10^3 ha	3,8	4510	5150	6920	7600	7896	8120
Total water withdrawal	km^3/year	52,3	60,61	94,56	120,69	116,27	105,0	102,0
Irrigation	km^3/year	48,6	56,15	86,84	106,79	106,4	94,6	93,0
water use	m^3/ha	12800	12450	16860	15430	14000	11850	11450
Water use	m^3/cap/year	5000	4270	4730	4500	3460	2530	2120
GDP	10^6 USD	12,2	16,1	32,4	48,1	74,0	27,5	34,4

July – September 1989 August 2003

Fig. 2. The Aral Sea is not anymore a single water body.

Water management and irrigation that developed in the region represented by 1990 a combination of up-to-date constructions and facilities, including unique pumping stations and canals (e.g. Karshy and Karakum canals, Djizak cascade), dams and irrigation systems utilizing advanced equipment of drainage and irrigation, and adopting integrated system of management (Hunger, Karshy and Kyzylkum Steppes) (Fig. 3), with outdated systems requiring renovation operating in almost one-half of the irrigated area with utterly poor water delivery and distribution.

This contradictory combination of good and poor, of modern and old, of up- and out-dated systems marked the irrigation and water management situation when countries in the Aral Sea Basin become the New Independent States. “Advantages” and “disadvantages” of this immense sector of the economy and nature management, which used to generate up to 40% of the whole GNP in the region, are reflected in strengths and weaknesses that became apparent during the subsequent phases of development (Table 2).

Fig 3. An irrigation canal in Hunger Steppe.

Table 2. Heritage of the Soviet Union.

Positive aspects	Negative aspects
• Immense water management infrastructure	• Neglect of public opinion and participation.
• Strict management and planning in water sector	• Lack of attention to ecological requirements
• High level of technical knowledge	• Administrative-command system
• Close cooperation among water professionals of various countries	• Inability to accept market mechanisms.
• Establishment of Basin Water Organizations (BWO)	• Absence of chargeable water use

The large infrastructures were governed by a strong administrative and water management hierarchy that adopted the “top-down” approach. When limitations were imposed to some water users while priorities were given to others, compensations inter-republics were adopted. Such immense infrastructure implied enormous operation, maintenance and development costs, which are absolutely maladjusted to the decentralized management required in a new market oriented environment where inter-sectoral competition, multi-level relations and egoistic aspirations from various water users and water management agencies produce a very different operation and management environment. Due to a weak economic basis during the transition period and at present, the former water management system became like a “colossus on feet of clay”, who has been failing to come to his senses for a long time. The advent of international expertise in the region and attention being focused on environmental and economic oversights of the former system, coupled with minor amounts of real donor support and controversial recommendations as to transition processes did not promote the formation of a new sustainable water management system adapted to the actual conditions of State‘s independence. Judging by the indicators in Table 3, there is an apparent decrease of water withdrawal and water use volumes during the transition period, which might be related to the observed decrease in total gross product in the whole region. However, these decreases in water withdrawals do not indicate improvements in the efficiency of water use in the region.

Table 3. Indicators of water availability in the Aral Sea countries (2000-2003).

Indicators	Countries of the Basin					
	Kazakhstan (Southern)	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan	Region
Population growth, annual rates (%)	1.22	0.96	1.54	3.48	1.44	1.95
GDP compared to 1990 (%)	69.4	37.5	30.9	116.1	70.1	69.6
Growth rates of GDP, annual average (%)	110.6	104.3	108.5	119.2	104	107.5
Total water withdrawal – relative to that in 1990 (%)	59.9	51.8	98.8	72.9	84.1	79.20
Annual water withdrawal ($10^3 m^3$/ha)	12.96	6.1	24.4	10.7	11.2	11.10
Water withdrawal per ha compared to 1990 (%)	67.3	50.9	100	52	82	75.53
Average agricultural production during 2000-03 (10^6 USD)	1952.4		755.4	2923.1	4225.7	
Average agricultural production (USD/m^3)	0.07		0.07		0.01	
Average water withdrawal (m^3/cap/year)	2262	1105	1607	3114	1929	1979.6
Total costs and capital investments in water management (billion USD)	1.05	0.45	0.5	2.2	3.63	7.83
Costs and capital investments in water management (USD/m^3)	0.19	0.11	0.04	0.12	0.08	0.09

Data in Table 3 also indicates that, although certain impacts on the decline of agricultural productivity for the last five years have been caused by price abatement on agricultural products, the situation in the various countries of the region has been evolving differently. According to the indicators shown in Table 3, positive trends in the development of water management in Kazakhstan and Kyrgyzstan are quite evident, whereas the situation in other countries has not improved yet. All economic indexes in Turkmenistan are evidently prominent, as well as in Kazakhstan.

The introduction of water charges in Kazakhstan, Kyrgyzstan and Tajikistan should be particularly emphasized, as these arrangements have already exerted visible influence on irrigation water use: the volumes of water intake and water use in these countries have been considerably reduced. All works regarding water delivery and distribution services, as well as the maintenance of irrigation networks within the territory of former collective and state farms, are now to be undertaken by Water Users Associations (WUA).

Differentiation of development trends in Central Asian states during the transition period has evoked discrepancies concerning the current state of water management and irrigated agriculture in various countries of the region (Fig. 4).

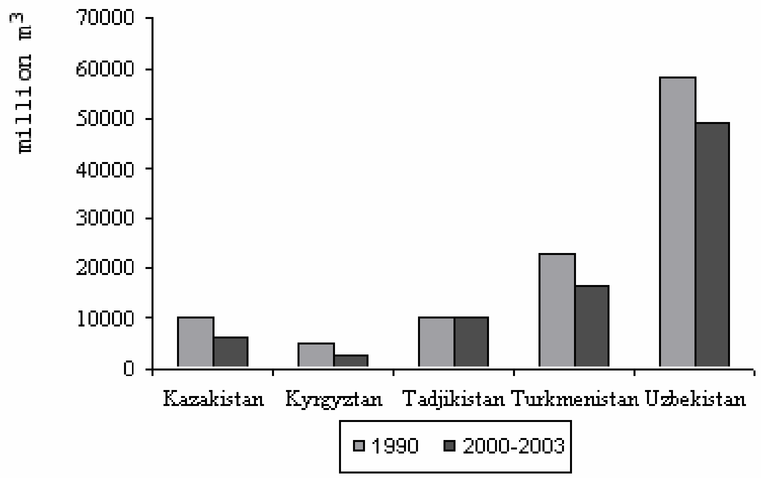

Fig. 4. Total water withdrawal by Central Asia countries in 1990 and 2003.

Simultaneously, there are some specific goals to be achieved that affect most of the states involved:

- Involvement of all countries in processes of privatization and re-structuring of water management in diverse forms, with irrigated farms varying in size from 0.2-1 ha in Kyrgyzstan up to 5–100 ha and even more in Kazakhstan;
- Maintenance of large cooperative and communal farms in some countries (Tajikistan, Turkmenistan, Uzbekistan);
- Implementation of WUA in all countries except Turkmenistan;
- General acceptance of IWRM as a general-purpose instrument meant to improve the effectiveness of water use;
- Neglect of drainage systems resulting in their deterioration, breakdown, increase in salinity of salt-affected lands, and decrease in crop yields and land productivity;
- Scanty capital investments for improvement of water application technologies and the rehabilitation and maintenance of irrigation systems.

There are some major discrepancies between water policies in Central Asian countries:

- Different approaches to the "*governance – management*" relation, which show up in various forms, mainly in the distribution of the generated income in the agricultural sector, between farmers and the State budget. When coupled with State subsidies in agriculture, it determines efficiency and motivation of farmers' activities, their and WUA's business solvency, and ability to invest money in land reclamation; the best situations are in Kazakhstan and Kyrgyzstan;
- The extent to which the State participates in reconstruction and development of irrigation and drainage systems and in supporting the WUA (the levels of such support are different in Kyrgyzstan, Kazakhstan and Turkmenistan);
- Change of perspective concerning water conservation and saving technologies and related provision of incentives;
- Promotion of public participation, capacity building and training of farmers and managerial staff of WUA and water management organizations (WMO).

The willingness of WMOs to analyze water use practices is of great importance. Formerly, during the 50-60 years of Soviet governance, the strict system of water management has been responsible for timely providing and guaranteed water delivery to large collective and state farms. Nowadays, thousands of small farm owners have found themselves at the very end of a long "staircase" of hierarchy, along which water decisions descend, passing through all the steps from the basin – sub-basin (national) level down to the WUAs and farmers (Fig. 5).

It is a long way, indeed, as the end-user is placed at the end of a chain of multi-step interests, caprices, and egoistic claims. Because the crop yield depends on the exactness of water delivery, i.e. at proper time and in the required amounts, and on the methods and quality of delivery, the staff of WMO and local authorities should have the farmers' needs in perspective, since these ones end up being dependant of several constraints.

It is commonly accepted that as long as water delivery services are provided in a stable and timely manner, with even and uniform distribution to the different applications, water users are satisfied with them. As to WMO, its performance is considered to be satisfactory if the volume of water withdrawn from the source does not exceed the amount of evapotranspiration of all crops by more than 20%.

The evaluation of the current situation concerning water availability and application was performed with data collected by SIC ICWC. In Table 4 water availability coefficients (WAC) relative to different hierarchical levels of water allocation are presented, and in Fig. 6 examples of data on water availability for vegetation along a few main canals are shown.

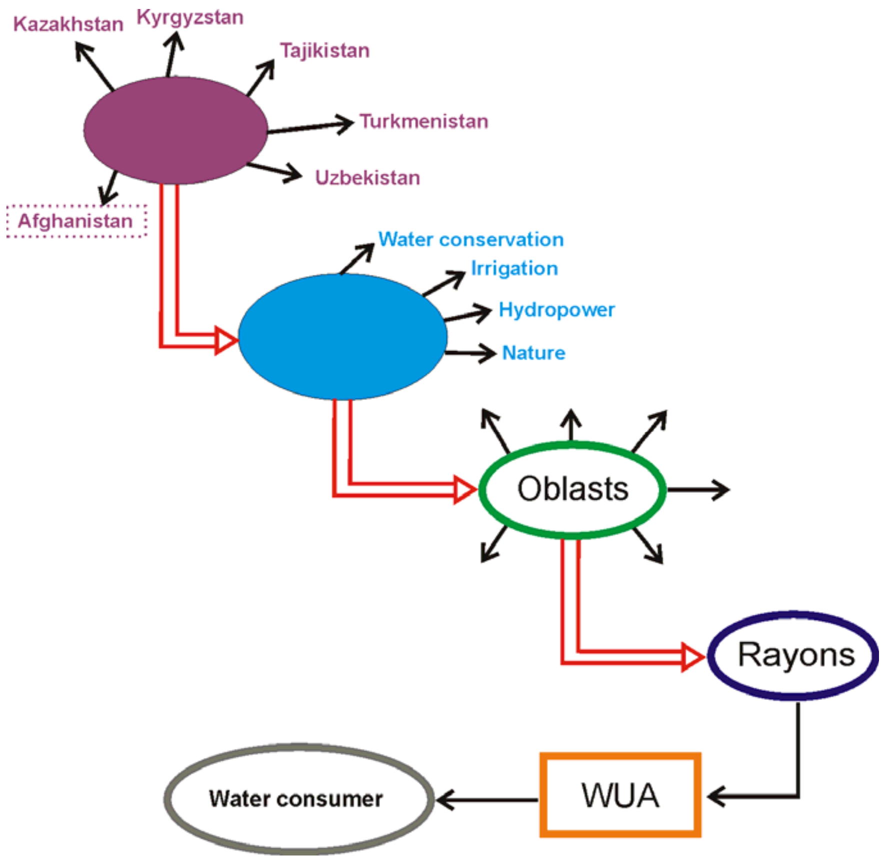

Fig. 5. From country policies to water user decisions.

Notably, there are situations where water delivery largely exceeds evapotranspiration, thus illustrating the poor water management that tolerates overuse side by side with scarcity, in both cases leading to crop yield losses. The major causes of this situation are:

- Outdated norms of water application based on use of indexes (obtained for an average year, average soil and hydro-geological conditions within the given area of water use) that fail to reflect real crop water demand;
- Water management issues concerning real water demand;
- Lack of adjustment of water application to actual conditions of a specific year, as the actual method considers an average year, average crop-pattern and average soil conditions and this is typical for both upper and lower levels of management hierarchy, thus Water use during a low-water year differs from average long-term water use and the latter from a high-water year by no more than 1200 to 2000 m^3/ha ;

Table 4. Water availability coefficients (WAC) at various management levels and various locations (2000).

State and Province	WAC at Province water intakes	WAC at farm outlets	Districts	WAC at District water intakes	WAC at farm outlets	Farms	WAC at farm level	WAC at field level
Kyrgyzstan								
Batkent	2.00	1.62	Kadamjaiy	1.79	1.39	Ak-Suu-Halmiton	1.19	0.92
Jalalabad	1.46	1.17	Bazar-Korgon	1.67	1.3	Tekdik	2.26	1.76
			Nooken	1.44	1.25	Taymonku	1.27	1.1
						Aral-saiy	1.35	1.17
Osh	1.28	1.02	Aravansaiy	1.08	0.84	WUS “Ak-Buura”	0.96	0.75
Tajikistan								
Sogdy	2.75	2.28	Dj. Rasulov	1.76	1.43	B. Hamdamov	0.95	0.77
			B. Gofurov	2.65	2.2	Samatov	1.1	0.89
						Bahrostan	2.09	1.69
Uzbekistan								
Andijan	1.43	1.06	Balikchy	1.34	0.98	Uzbekistan	0.89	0.65
						“Siza”	1.20	0.88
			Izbaskent	1.11	0.86	Uzbekistan	1.33	1.03
Namangan	1.18	1.01	Pap	1.51	1.30	Pap	0.77	0.66
			Mingbulak	1.28	1.09	Gigant	1.13	0.96
						Navoy	0.88	0.75
Fergana	1.24	1.03	Tashlak	1.61	1.30	Navoy	1.56	1.26
			Akhunbabaev	1.75	1.40	Niyazov	1.10	0.88
			Kuva	1.37	1.15	Navoy	1.06	0.89
Kyrgyzstan	1.58	1.27		1.56	1.25		1.42	1.115
Tajikistan	2.75	2.28		1.705	1.315		1.38	1.117
Uzbekistan	1.29	1.03		1.423	1.01		1.01	0.896

- Overestimated demands of water and high water application quotas, especially at upper and middle reaches, resulting in water scarcity at lower reaches and neglect of ecological demands of existing natural resources (deltas, rivers proper, etc.);
- Absence of water distribution systems managed by WUA and lack of uniform criteria on water use among users;
- Inability of WMO to monitor water distribution between water outlets and ensure equitable reduction of water delivery induced by water scarcity;
- Disregard of necessity to use differential approaches while determining water delivery terms in the process of water use planning;

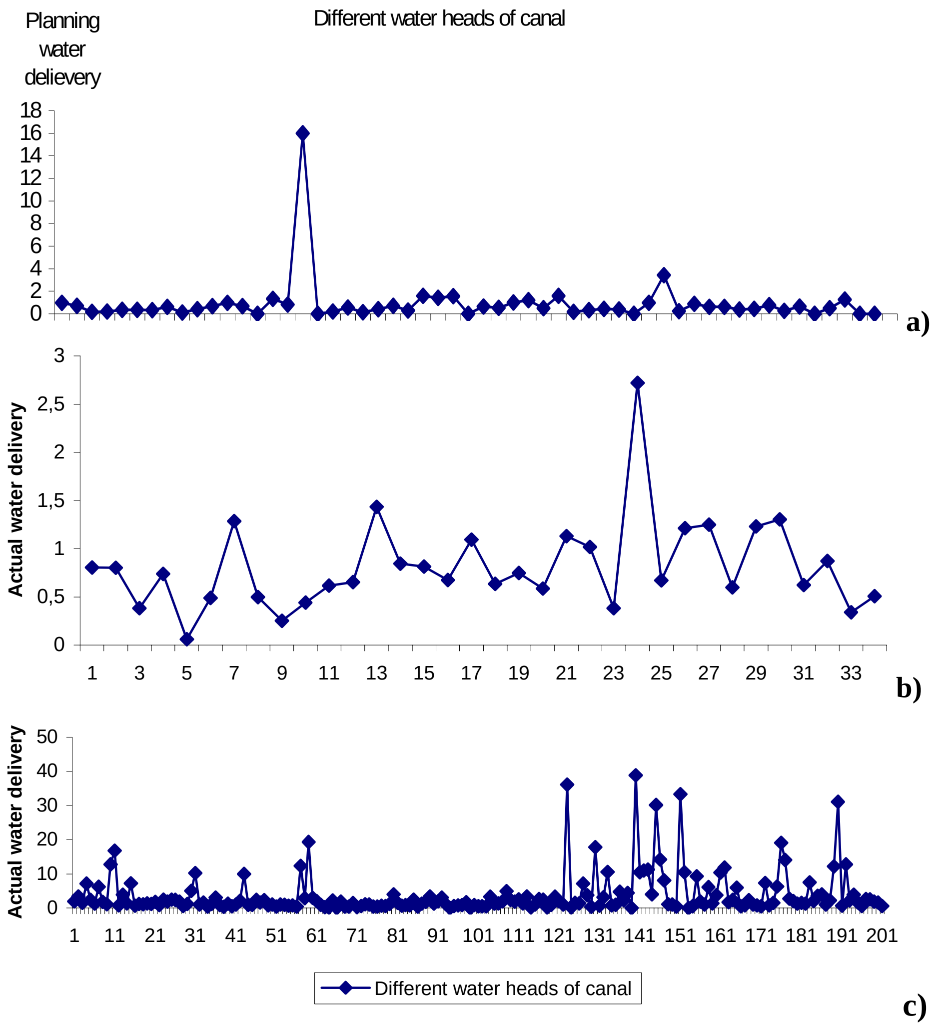

Fig. 6. Average values and variability of water availability for vegetation (2003) along: a) “Aravan Ak-bura” canal; b) “Khodja-Bakergan” canal; and c) “South Fergana” canal.

- Inability of water management professionals to apply mechanisms of effective participation in water delivery and use relative to different levels of management such as “farmer - group of users - WUA” and then “WUA – main canal”;
- Negligence by WMO staff of basic water delivery rules through second order distribution canals;
- Lack of tangible incentives that could induce farmers to save water and improve water use performances;
- Inadequate attention to systems maintenance and modernization;

- Insufficient attention paid to the use of alternative sources of water (return waters, aquifers, etc.).

Implementing principles of integrated water resource management (IWRM) throughout the region may solve the major part of these problems.

What will the region face in future and what can be done?

Even in its pre-independence period, Central Asian countries realized that the Aral Sea Basin had been approaching depletion of its water resources, and in this scenario plans were needed for a radical structural readjustment of regional water management and to determine additional sources of water.

As the economic recession arose following the disintegration of the Soviet Union, as well as the transition of newly independent states to market relations, governments and WMO responsibilities were lessened in terms of mitigating the acuteness of these issues. However, gradual recovery of the industry and agriculture, as well as the development and build-up of new branches of the economy, are beginning to create conditions that, in the short term, will lead to the progressive solution of the problems. It should be also noted that the society itself has been undergoing changes – public at large has been progressively demanding for a strengthening of environmental perception of natural resources and water demand and uses. A number of currently implemented projects, especially in Kazakhstan (recovery of the Syrdarya delta in the Northern Aral Sea) and Uzbekistan (GEF-“Sudochye”, NATO-“System of water bodies in Southern Priaralye”) require rather significant and strict ecological releases for the Amudarya delta - 8.5-10 km^3 a year - and for the Syrdarya delta - 4.5-5.5 km^3 a year (Dukhovny *et al.*, 2003).

A vision on future water resource’s use is reflected in a number of documents and works by UNESCO (1999-2000), GEF (1998 to 2001), and SIC ICWC (2002a, b). A recent assessment of future prospects has been made within the research of the global warming processes carried out by SIC ICWC (2002 to 2003). The latest results of these prognoses are stated below resulting from analysing three scenarios of development until 2020: the “maintenance of current trends” scenario (or “business as usual”), the “intermediate” or “neutral” scenario, and the “optimistic” scenario, which are briefly described below.

a) “Optimistic” scenario

- The region will be developing up to 2020 on a continuous improvement of integration processes that are presently being contemplated by all governments of Central Asian countries;
- Mutually beneficial joint use of all transboundary water resources, based on water conservation and common approaches to natural resources protection;
- Mutually beneficial development of the agricultural sector focused on regional division of labour with regard to most profitable crop specialization;

- Coordinated processing of production in agricultural sector and its infrastructure;
- Attainment of aimed potential water and land productivity;
- The population growth rate will slow down and decrease to 0.98% a year by 2020;
- The average annual growth of GNP will be 8-10% a year during 2000-2010 and 10-12% from 2010 until 2015, and not less than 7% in 2015-2020;
- The development of the power sector will be predominantly based on hydropower stations and joint construction of power facilities, with emphasis on ensuring sustainable production of ecologically clean electricity;
- Due to policies of water conservation pursued at State-level, it is expected that the water use for irrigation will reduce to 9400 m^3/ha, and the water use for the population will be also limited;
- Food production will be at the average level of 3500 Kcal/capita/day, with a diet where vegetables and fruits prevail;
- A significant share of GNP will be ensured owing to outrunning growth rates of industrial sector.

b) "Neutral" scenario

- Integration processes in transboundary water resources management will be under a developing perspective slower than for the "optimistic scenario";
- No provision for regional specialization in crop implementation nor coordinated process of production in the agricultural sector;
- Population growth rate will slow down less significantly, reaching 1.44% a year by 2010 and 1.23% a year by 2020;
- The GNP growth rate will be 2-4% a year;
- New lands development will be constrained, not only due to limited water resources availability and poor quality but also due to the lack of necessary investments;
- Taking into account that the given scenario presumes less significant economic development and limited financial resources for the introduction of water conservation and saving technologies in all sectors of economy, water use for irrigation will be 11000 m^3/ha; and the water use for the population will be also higher than for the optimistic scenario.

c) "Business as usual" scenario

- The development of the region will be influenced by the current trends in the use of transboundary water resources and by the ongoing processes in regional integration of the agricultural sector with regard to both production and processing of agricultural production. Major efforts of the countries will focus in resource conservation relative to local water sources;

- Under the maintenance of national development trends, there will be an increase of the disparity of income levels and in organizational/institutional arrangements in different States of the region, resulting in discrepancy in economic development among the aforementioned countries;
- Population growth rate will be 1.9% a year;
- The annual average growth of GNP will be 6-8% a year throughout the Basin;
- According to the current trends, water use for irrigation will be 12000 m^3/ha and will remain relatively high for the population;
- By 2020 there will be no substantial changes in irrigated land area.

Based on these three variants of development, considering that two sub-variants will implicate some sort of consequences regarding climate change, it can be concluded that by 2020 the region will be self-sufficient in terms of providing the population with its own food supplies and to achieve exports of its agricultural production. Some of the development variants stipulate formation of a certain water resources reserve.

In case of absence of active measures towards the management of the present situation, and if the current development trends are maintained, there will be no opportunity to allocate additional volumes of water to fit the needs of the natural resources.

According to the “optimistic” scenario, by 2015 the region’s food product *supply* will exceed the *demand* by 7% and the water resources reserve will be 13.2 km^3 a year, whereas for 2020 those items are 18% and 18.4 km^3 a year, respectively. Even within the “intermediate” scenario, a 6.4 km^3 water reserve is to be generated, although with lesser water and land productivity.

The results of this type of modelling (Fig. 7 and Table 5) show that the region will be able to survive using the current water resources only if the optimal development strategy is introduced. This strategy is based on the following assumptions:

- Equitable and reasonable utilization of joint transboundary water resources by all countries;
- Potential water and land productivity attainment by all water users (Nerozin, 2005);
- Comprehensive implementation of IWRM principles.

Table 5. Dynamics of water use and availability (Km^3) according the development scenarios considered.

Scenarios	1960	1970	1980	1990	2000	2005	2010	2015	2020
Total available water	136.6	136.7	125.0	130.3	117.0	124.8	122.3	125.5	130.2
"Business as usual"	64.7	83.5	120.7	116.1	104.6	106.2	106.7	107.4	108.4
"Neutral"	64.7	83.5	120.7	116.1	104.6	104.6	104.6	104.6	104.6
"Optimistic"	64.7	83.5	120.7	116.1	104.6	103.2	101.4	96.1	91.1

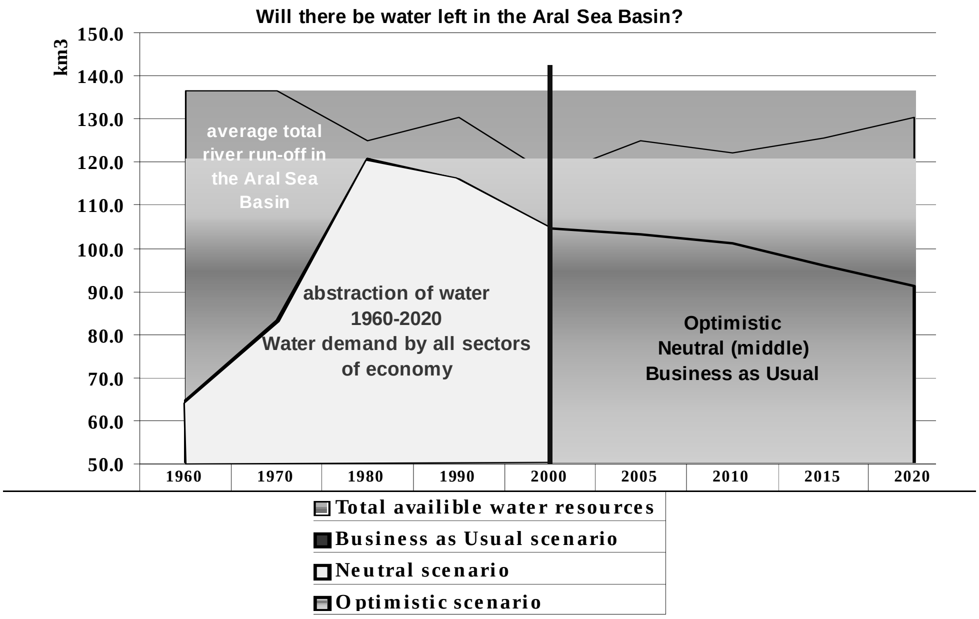

Fig. 7. Scenarios on water availability and use in the Aral Sea basin.

Integrated Water Resources Management

IWRM consists of a management system (in contrast to GWP's suggestion to consider IWRM as a process), which is based on reciprocity of all practicable water, land and other related resources (precipitation, surface flow, subsurface and return waters), within definite geographic boundaries. This system is designed to interlink various sectors of water use and nature management, hierarchical levels of water use and delivery, as well as to involve all water users in the decision-making processes, besides planning and financial support to meet the actual demands of Society and Nature in a sustainable way.

The IWRM system provides a steady basis for a joint organization that incorporates all stakeholders with the purpose of attaining specific objectives. The set of functions performed by this type of organization includes designing and improving proactive mechanisms of response to dynamic changes in water resources use and development, with special emphasis on continuous institutional self-improvement and progressive evolution. While the processes of self-improvement and self-evolution adjust themselves to environmental changes within the system, the initial objectives and main principles defined at the inception phase of formulating organizational framework will remain stable.

IWRM shall integrate:

- Planning and management of all water resources and demands, irrespective of water sources and sectors that use the resources;
- Issues of water quantity and quality;
- Water use allocation at upper and lower reaches;
- All stakeholders, including water users, WUA, WMO, natural resources users, local authorities, NGOs, and other decision and police makers, including their potential human and institutional resources and interests;*
- All levels of water hierarchy regulating water demands and supplies in the "down-to-top" mode;
- Water and land management, especially in the irrigation and drainage areas;
- Interests of Society (economics) and Nature (environment);
- Integration of costs, expenses and benefits at the level of water users/managers and the State/Society.

Proceeding from these deliberations, the following criterion for IWRM is considered: attainment of optimal water use productivity, but depending on specific socio-economic and natural constraints and taking into account the impact of human interventions within (and beyond) the basin geographic boundaries. The concept implies both direct and indirect costs, benefits and consequences.

This approach allows working out the scheme of interaction between levels of management hierarchy, based on an organizational structure such as in Fig. 8, which strictly maintains the vertical and transversal links of the hierarchy by managing its vectors:

- Participatory public governance engaging all stakeholders (e.g. Basin Public Council, WMO, WUA);
- Executive bodies (e.g. System/Canal Administration, WUA and WMO Boards).

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* Integration of interests concerning the Basin and each country is of great importance as they apply to transboundary water sources.

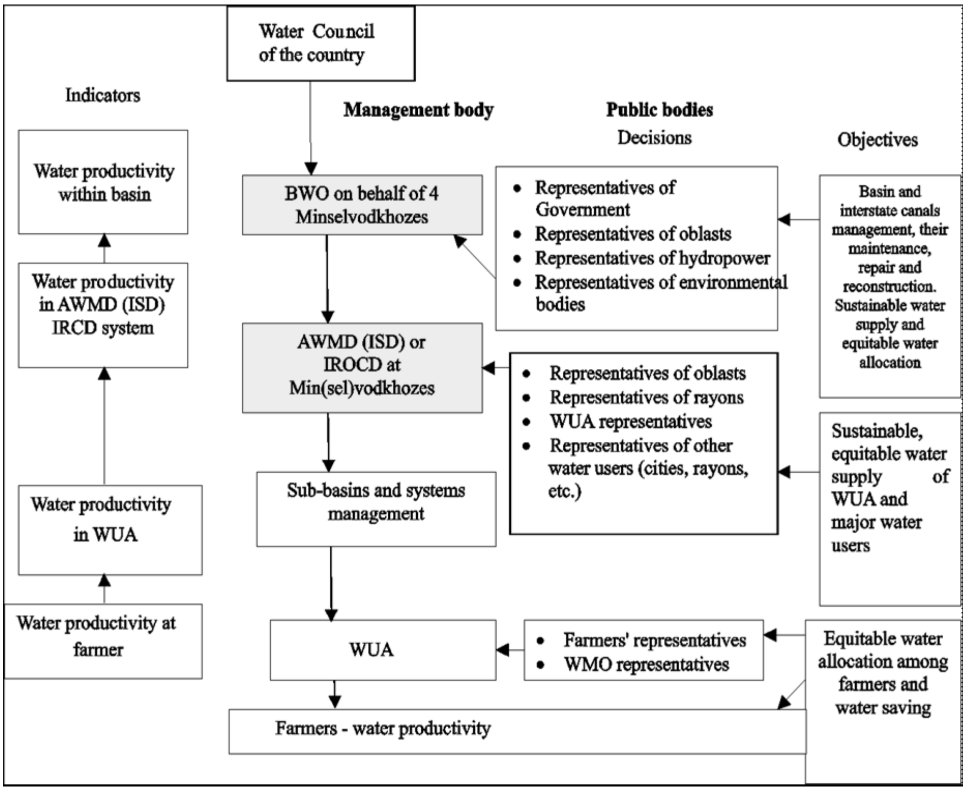

Fig. 8. An approach to IWRM.

Vertical coordination may be carried out through:

- Collective membership of the lower hierarchical level representatives in public/communal governing bodies of higher levels; and
- Flow of fees and payments for water use/services, and charges for water as a resource, as well as for land reclamation measures, carried out with application of relevant database, information systems, and sets of models pertinent to water/land resources and irrigation and drainage.

With the purpose of providing necessary scientific support for implementation of IWRM principles, SIC ICWC is developing capabilities to apply this set of management tools, including those based on GIS and RS technologies as reported in this book, thus enabling to numerically interlink various technical and economic parameters of water/land use and related evaluated resources. Models, as described in other chapters of this book, allow specifying resources availability and demands, and to identify the better ways to satisfy common needs of water users – stability and uniformity of water supply.

Along with the above stated, water management improvement needs some key instruments for promoting principles of regulation, which are based on technological innovations, institutional development and aimed at providing tangible and financial support to all actors. These problems still require additional research. The models considered in this Project constitute only a part of the general scientific and modelling knowledge base of IWRM, hopefully expected to get further development and support for implementation.

Conclusions

The vision of foreseeable future development in the Aral Sea Basin gives grounds for the assumption that the region is able to survive in terms of water resources availability until the end of the third decade of the current century - even operating under the actual obsolete irrigation and drainage network schemes – but only if unproductive water uses, water wastes and losses are minimized while the available water supply is stable and sustainable. It requires application of up-to-date IWRM principles and practical experience, based on a deep insight into interrelations between all elements of water management hierarchy. The pertinent tools and models introduced through the project as described in several articles of this book represent the inception phase of scientific substantiation of this system.

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