20 - FUTURE TRENDS IN WATER MANAGEMENT FOR CENTRAL ASIA

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Abstract: The concept of "sustainable development" presumes having in place a combination of four major resource potentials: natural, productive, financial and human. They continuously interact in dynamic relations driven by forces within three major frameworks: the political system, that determines *governance*; the social environment defining the *socium* context; and the system of *management*. The way in which they interact as a result of the acting driven forces determine how resources will be preserved and, ultimately, whether there will be enough water for life-support in the countries of the Aral Sea Basin. In order to lay down a possible survival strategy for the region an analysis is needed, even if a rough one, with regard to the status of each resource potential in each country and in the whole region, and then to outline what has to be done for strengthening these resource potentials and ensuring the sustainability of the water sector in Central Asia. In addition, the paper discusses how integrated water resource management could be implemented in the region and stresses the need for public participation, new societal attitudes relative to water, education and training, new institutional building and a renovated role of the State. A perspective for further use of tools developed in the project is also presented.

Keywords: Aral Sea Basin, Sustainable development, Natural resources, Human resources, Governance, Public participation, Irrigation, Agriculture, Water scarcity.

Introduction

Long-term sustainable evolution of any territorial entity – let it be a country, a region, the river basin, a province, or a county - is determined by the existence and development of natural, human, productive and financial resource potentials within that territorial habitat. As previously shown (Dukhovny, 2004), nature and paramount intellect that built-up civilizations after thousand years ago has

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created contemporary humanity as a combination of nature and "*socium*", i.e., the community of "homo sapiens". The initial primitive society was a combination of *natural and human resource potentials* originated at the very beginning of human history and then evolving in interaction and inter-relation with various gradually maturing forms of social organization. The *productive resource potential* started as its derivative, first in the form of wooden plows, spades, potter's wheel, and then manufactories, mines, plants until nowadays huge industrial conglomerates and monopolies. The emergence of money as a means of exchange and trade with development of productive and human resource potentials resulted in creating the *financial resource potential*. Thus, at present, the sustainability of any territorial entity is determined by the existence and development of these four resource potentials (Fig. 1).

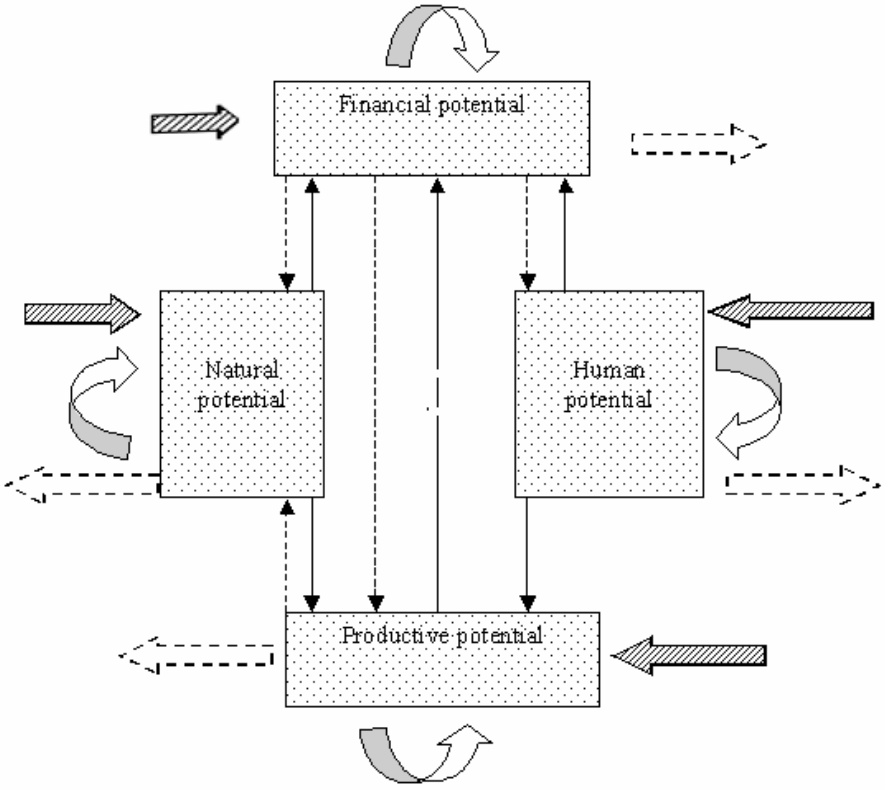

Fig. 1. Scheme of interactions between resource potentials aiming at sustainable development considering internal fluxes as well as fluxes from and to the exterior.

Productive and financial resource potentials are results of the development of natural and human resource potentials. The development of any territory has been achieved owing substantially to the capacity for changing non-renewable

natural resources into productive and financial resource potentials as well as due to employing renewable natural and human resources in a balanced way.

Increasing the productive resource potential through the process of development enhances the financial resource potential while increasing the latter contributes to the augmentation of the productive resource potential. Similar assumptions pertain to favouring the interactions between human, productive and financial resource potentials in such a way that they should be conducive to cross-feeding their capacities, thus mutually strengthening themselves. Concurrently, a well-balanced use and rehabilitation of renewable natural and human resources must be ensured; together with rational use of non-renewable resources. If interactions between these various resource potentials are reasonable and well-balanced, thus favouring their mutual enrichment, then the resulting balance in enhancing their own capacities is positive. The reproductive abilities are therefore secured with regard to the recovery of nature and ecosystem components through self-adaptation of natural conditions, to the development of the human resource potential with societies improving themselves and for the generations to come, to the augmentation of the productive resource potential where existing activities bring forth new ones, and enhancing the financial resource potential since money makes money.

The import-export balance of the human resource potential, i.e. the balance between brain draining and the engagement of skilled specialists, is of great importance, mainly for large territorial entities as countries and regions, similarly to the financial import-export balance referring to loans, credits, donations, subsidies, or the outflow of capital, both legal and illegal. The productive resource potential can also be exported or imported through transactions of raw materials and semi-finished goods or the importation of manufactured, agricultural and transportation equipment, for example. Even the natural resource potential, especially water, can be exported or imported by reallocating water resources or by adapting external fauna and flora species to non-climax regions.

Relative to the five countries of Central Asia, which share the Aral Sea basin, mainly the Amudarya and Syrdarya rivers (Fig. 2), some common development features may be currently considered as explained below:

All countries of the region, thought to a different extent and along various lines of development, have significantly lost their productive resource potential as a result of privatization performed without adequate fairness, social justice, or economic efficiency. It turned out to be just plundering of productive capacities that had been accumulated for decades. In addition, the decrease in productive resource potential is related to disregard of needs to rehabilitate the productive systems and avoiding their depreciation and disrepair through capital and technological investments and, moreover, by enhancing the human capacities.

Major efforts of governing bodies have focused on developing those industries that utilize the non-renewable natural resource potential such as oil, gas, and minerals, but neglecting approaches that could counter-balance the withdrawals of resources by assuring alternative activities or investments that compensate for damages and build-up for future generations. In some places, the extensive extraction of hydrocarbon materials permits obtaining tremendous profits but with scanty shares allotted to sustain reserves and maintain adequate output. As a result, the latter has been gradually decreasing, thus calling for an urgent need for advanced development of survey and technological works with the purpose of utilizing unexplored and yet inaccessible reserves. Only in two CIS countries a more sustainable approach is evidenced.

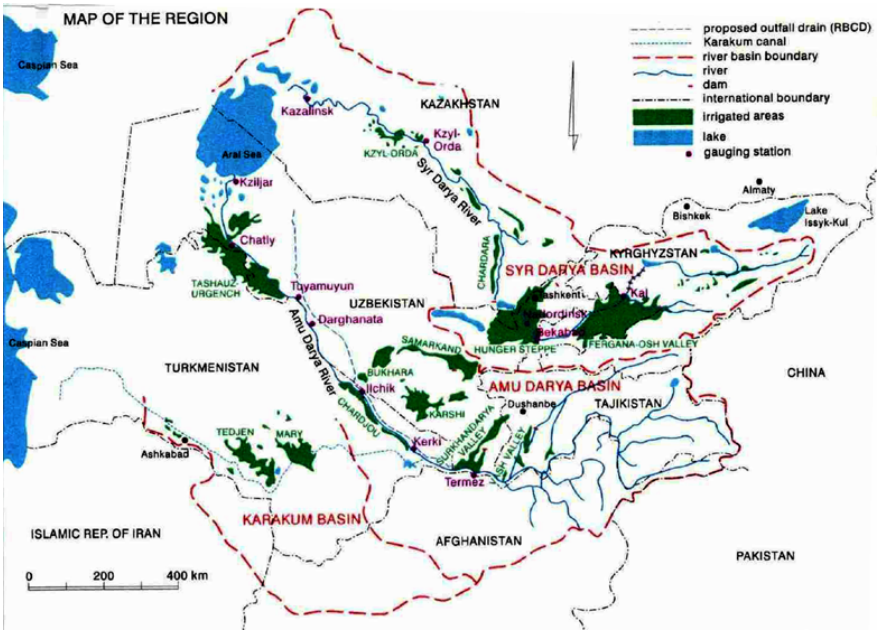

Fig. 2. Central Asia countries, Amudarya, Syrdarya and the Aral Sea basins.

An extensive outflow of skilled people, especially from industry, science, and managerial entities, coupled with changes in the system of teaching, education and public health, have deflated the human resource potential of the region as a whole. However, a large local labour force is engaged in a kind of "seasonal work" out the region, which provides for unofficial and non-registered inflow of capital, which contributes for the current regrowth of the financial resource potential in the region. (According to the informal assessment by B.B. Bolotov, Deputy Chairman of the State Committee for Planning of Tajikistan, hundreds of thousands of local people working in the Russian

Federation generate an inflow of funds for the republic that amounts for not less than half a billion of US dollars per year).

The human resource potential is affected by some dangerous trends in development related to the redistribution of personal income, that used to be more or less uniform during the Soviet rule: the coefficient of income inequality, ratio between the incomes of the 10% most wealthy and the 10% of most poor did not exceed 15-20 while nowadays it has grown exponentially and is now different by two orders of magnitude. Consequently, the social unbalance is great, the motivation to work diminishes, the degree of dissatisfaction grows up and the potential for confrontation between "the rich" and "the poor" gathers momentum, all this destroying or deteriorating both the productive and the human resource potentials.

The questions identified above affect agriculture and the rural world in the Aral Sea Basin but some other aspects need to be considered relative to agriculture and water management in the region, mainly:

- Loss of land productivity due to increased salinization, waterlogging, land abandonment, and neglect of technological requirements in land cultivation;
- Loss of basic assets that have been created in construction industries, production of building materials, and in plants of regional significance, amounting to billions of US dollars;
- Deterioration and breakdown of agricultural and construction machinery and operational equipment, thus leading to a huge deflation of the productive resource potential needed for reconstruction and development. 20 years ago, the region had the capacity to construct up to 3000 km/year of horizontal subsurface drainage and several thousands kilometres of canals per year, to produce not less than 2 million m^3/year of precast concrete, to carry out operational land levelling of almost 1 million ha/year, harvesting with adequate machinery about 30% of cotton yield while in some provinces up to 80%. At present, figures look to be ridiculously or just wrong: subsurface drainage is reduced to not more than 10 km/year; canals are no more under construction; precast concrete corresponds to only 100 thousand m^3/year; not more than 10% of cotton yield is harvested by machines; and there is no machinery available to carry out land levelling;
- The human resource potential referring to the water sector has suffered disastrous impacts: the average age of specialists increased to above 50 years; there is a lack of qualified personnel in several areas, namely those referring to new technologies; there is a loss of professional experience in cultivating the land due to drifting of skilful teamsters towards private small businesses;
- There is an enormous cut in funding by more than 10 times in operational costs needed for water management and maintenance of irrigation networks, not to mention almost full suspension of funding necessary for agriculture

and water management development. Moreover, covering irrigation operational costs through payment by the users is not possible because farmers' incomes are reduced and the agricultural sector is generally under-funded.

The situation as described above is not the price to be paid for the political change. But this increased the vulnerability of these countries to the rapid and dramatic changes in world's economy and globalization.

Trends in water management

Sustainable development is determined by the ability of mankind to keep a balance between the natural, human, productive and financial resource potentials and to ensure that they interact in a positive way. Achieving this purpose requires:

- Existence of monitoring and information systems that provide decision makers with reliable data on processes relative to the dynamics of development, and support decisions based on knowledge relative to trends involved, direction of changes and impacts of measures to be taken or when not taken;
- Consideration of nearly unlimited opportunities of technical progress and improvements of intellectual capabilities of human beings;
- Identification of existing limits for the natural resource potential for self-rehabilitation and, thus, about measures that favour re-establishing the respective dynamic balance;
- Understanding of interdependencies and interactions between the natural, human, productive and financial systems and the respective potentials, as well as about the framework to properly mobilize them;
- Knowledge and related implementation of measures to achieve the potential productivity of natural resources systems, as well as and for sustained growth of that productivity owing to progressive dynamics of human society's advancement;
- Implementation and enforcement of mandatory regulations, rules and norms of behaviour common to all members of the society, when designed to ensure a reasonable utilization of the four resource potentials in the interests of the society, not only in certain areas or countries but the society as a whole.

Each of the above mentioned resource potentials incorporates a multi-dimensional and diverse set of components (Table 1) that are apt to change in terms of contents and degree of completeness depending on the dynamics of development; however, the balance between major elements must be retained.

Each of the referred components of the resource potentials is under a process of continuous dynamic changes, some of them negative: for the *natural resource potential*, processes include land degradation, depletion of mineral resources, and climate change; relative to the *human resource potential*, processes include changes in birth rate, mortality, population growth rate, modification of human needs and aspirations, and brain draining, as well as; concerning the *financial resource potential*, questions include the depletion or deficit of funds, assets and reserves; the *productive resource potential* is affected among others by the obsolescence of fixed assets, less adoption of technological progress, education and professional training, as well as due to impacts caused by other resource potentials.

Table 1. Components of the natural, human, productive and financial resource potentials that support sustainable development.

I. Natural resource potential 1.1. Climate 1.2. Water 1.3. Land 1.4. Mineral resources 1.5. Fauna 1.6. Flora, etc.	III. Productive resource potential 3.1. Industry – works 3.2. Agriculture 3.3. Transport 3.4. Communication 3.5. Informatics 3.6. Roads 3.7. Power system 3.8. Construction 3.9. Water management 3.10. Business climate 3.11. Priorities, etc.
II. Human resource potential 2.1. Population - size 2.2. Mode of life 2.3. Traditions 2.4. Education 2.5. Public health 2.6. Culture 2.7. Religion 2.8. Science 2.9. Public associations	IV. Financial resource potential 4.1. Funds reserves and resources 4.2. Gold and valuables 4.3. Money 4.4. Loans 4.5. Fixed assets 4.6. Tariffs, dues and fees 4.7. Taxes, tax remissions 4.8. Subsidies

Interrelations among these resource potentials (Table 1), their driving forces, trends of development, and effectiveness of such interrelations are therefore determined by three major domains of human activities and the society:

- *The political sphere*, that establishes the system of state control, i.e. the executive power of government, legislation, legal regulation and judicial norms, coupled with the system of public control within the civil society, which define the *governance system*;

- *The social sphere*, which sets the conditions for forming specific internal social environments and to define the vision of any society regarding its own development perspectives, so defining the *socium system*;
- *The management sphere*, that develops methods, means and organizational principles of management, works out the system of monitoring, data collection and control, and that superintends on the dynamics of the evolving development processes, which consists of the *management system*.

In other words, the sustainability of the development focusing the person and the society is determined by:

- The viability and legitimacy of the political sphere (*governance*);
- The social environment characterizing the *socium* system, which is formed under the influence of the governance and through the development of all development resources, especially the human one;
- The system of *management* that is established and implemented on the basis of the previous two, and that impacts the sustainability and effectiveness of resources' use and how capacities for development originate new ones.

The term "sustainability" should be understood as an uninterrupted dynamism of endogenous and exogenous factors determining how development potentials are evolving, including for the generations to come.

In water scarce regions (Pereira *et al.*, 2002), water is the most important component pertinent to all development resource potentials, because:

- It is a main resource component of the natural resource potential;
- Its availability is paramount for achieving the human and productive resource potentials;
- It conditions the application of the financial resource potential;
- It is a supporting component in human, natural and productive resource potentials; and
- It constitutes a bridge interrelating all development systems.

Water is indispensable for the sustainability of the natural resource potential. First, the climate is a determining factor of water availability and its fluctuations cause impacts on water use, water resources dynamics, occurrences of floods and droughts; however, water bodies, including the artificial ones, exert certain influence on climate. Second, the existence of water bodies and the regimes of the water and aquatic systems determine the specific landscape, including the resilience of fauna and flora. *Equilibriums* can only be ensured if ecological demands for water are met within the river basins. The case for the Aral Sea has not to be repeated and constitutes a main challenge for all countries in its basin. To sustain such demands, definite political will and governance are needed: governments must establish a strict order of compliance with pertinent

international agreements and national legislation and regulation, and set up appropriate constraints on water use and mechanisms of monitoring and control.

Role of governance

The most important function of *governance* is then to exert influence on the attitude of the society aiming at establishing such a social environment that could make that citizens, from early childhood and through all stages of education, be capable to abstain from intervening in natural processes and respect the integral value of water; to a certain limit, this corresponds to retrieve the traditional attitude of the people regarding water and the social environment that used to exist in the past, which were lost during the Soviet rule and still fail to be reanimated at present when market relations push to the recognition of the economic value of water in detriment of the social, environmental and cultural values.

The importance of *governance* in water resources use and development becomes apparent while meeting demands of natural ecosystems. Moreover, the role of water governance is of great importance in provoking and regulating the mutual reconciliation between natural and other resource potentials. The human resource potential incorporates such components as population dynamics, modes of life, traditions, levels of education, knowledge, and public health. All of them determine the attitude of governments and the general public relative to water resources use, development, conservation and maintenance. This attitude pattern also depends on the political orientation of the society, its moral principles and legal framework.

The social environment in the five Central Asian countries, though having cultural and political distinctions, generally still lack aspiration to propagate water conservation and water saving technologies, to retrieve ancient (prior to the Soviet rule) traditions of participatory approach to water management and governance. A specific deficiency, which is nowadays common to most societies, is the disregard of water issues by the sphere of education, and the necessity to develop special water oriented information and educational programs; however, nowadays efforts have been undertaken along these lines and there is the hope to receive some relevant assistance from donors with these objectives. There is a great need for reinstatement of prestige that all water related activities used to enjoy in the old days: in terms of social authority, *mirabs*[3] used to occupy the second, sometimes the first level of the official governmental hierarchy, after *vizirs*[4] and senior mirabs. For example, Alisher Navoy, a famous medieval poet and statesman used to hold these positions concurrently. Nowadays, a university graduate majoring in irrigation does not

[3] *Mirab* – is a public and communal functionary who was responsible for water management in Central Asian region prior to the Soviet rule
[4] *Vizir* – a prime minister in medieval Central Asian countries

enjoy popularity; the same happens for functions of water managers. The challenge is to reinstate social attractiveness of the profession. But reviving that prestige does not mean to return to old times but to recreate the understanding of the role of water management in water scarce regions.

Achieving the productive resource potential is responsible for the largest water uses and exerts most noticeable impacts on the resources, including in terms of creating water stress to riparian ecosystems. In order to sustain effective water use for production purposes, an explicit country water policy is required stipulating such arrangements as subsidies to the water sector, support to water management, regulation of activities carried out by water managing entities, including their relations with water users. The attitude of the State regarding the implementation of integrated water resources management (IWRM) principles is highly important, as well as concerning improvements of water use systems, compliance with set norms of water resources use and application of incentives aimed at higher water use performances. The State governance should ensure the establishment of appropriate institutional basis for implementing IWRM, transparency of water policies, and elimination of command administrative pressure. This kind of State support to rational water resources utilization and development is essential to create a proper framework for effective management and social environment enabling community participation (Fig. 3).

The role of governance is critical for creating effective management infrastructure designed to perform control over water use and to manage water demand. To implement this, the system needs application of pertinent financial, modelling, legal and technical instruments – including introduction of block systems of payments for water use, incentives for water saving, installation of water measuring equipment and establishment of Extension Services providing support for water users. There are not many case studies following this pattern in the region, though it should be noted that introduction of routine charge for water in Kazakhstan, Kyrgyzstan and Tajikistan has already resulted in significant volumes of water resources conservation.

Role of the Society: public participation

The abandonment of the administrative water management approach based on the “top-down” chain-of-command typical for the governmental system of the former USSR, and the transition to a market economy followed by the emergence of an immense number of independent water users require a radical enhancement of public participation at all levels of water resources management.

At the lower organizational levels of irrigation and water supply, management can be undertaken by water user associations (WUAs/WUF) or by communal and non-governmental organizations, whereas at higher levels, such

as the main canal, large system, or the basin, appropriate institutional arrangements are necessary to combine the State's and other stakeholders' efforts aimed at improvement of water resources use. These include Basin Committees at the basin level and Irrigation System (or Canal) Committees at the canal level. Such institutional changes have already gained a momentum in the region, but the pattern is different in various countries. Thus, a lot of efforts are to be undertaken with the purpose of involving public at large in reforming water management supported by the State and initiated by water professionals; neither the State nor the Society can identify these needs without the expertise of water professionals.

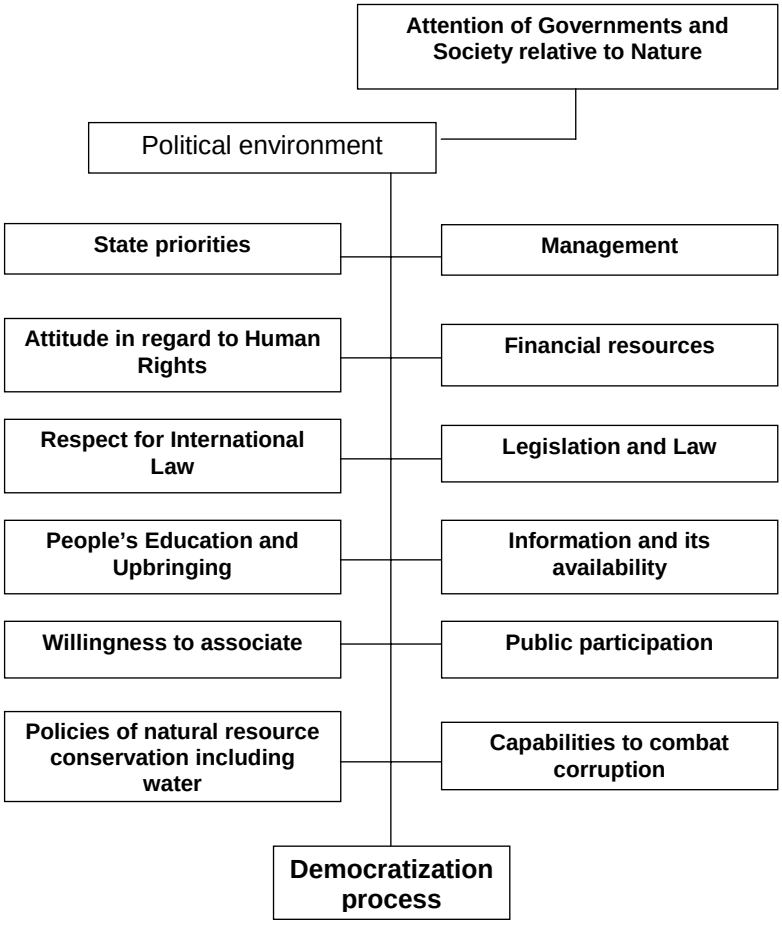

Fig. 3. Conditions for natural resources preservation and sustainable water use.

The Society needs engrafting of a water partnership spirit, a new attitude in valuing the water, respect to this natural but limited resource, and appropriate

and effective forms of public participation. This is also a part of the democracy challenge.

IWRM as a mechanism of management

IWRM is designed to incorporate such interlinked components of integration as action, control and harmonization of multi-level, multi-sectoral, multi-purpose water use processes, which meet versatile interests of stakeholders. This mechanism includes several instruments:

- Institutional – basin and hydrographic approach to water management combined with active participation of water users;
- Legal – advocacy of every water user's rights for equitable, reasonable and guaranteed water delivery, provided that certain commitments are carried out;
- Technical – water resources conservation and saving technologies as the basis for achieving minimal productivity of water and introduction of an Extension Service network;
- Managerial – with control over the water resources, the infrastructure and the water demands;
- Informational – transparency, availability and feasibility of projects.

On going initial efforts to implement this approach within the "IWRM – Fergana Valley" project (SDC – IWMI – SIC ICWC) prove its practicability.

The future of river basins

Though we conceive the Central Asia region as a single whole, it should be noted that five dissimilar transboundary water countries are to be addressed to (in future they can be six keeping in mind that Afghanistan also is part of the Aral Sea basin). They have absolutely different conceptions, trends, potentials and priorities of development, as well as specific nature of political leadership and social environment.

In 1990, all Central Asian countries – the former republics of the USSR – had approximately a similar index of productive, human and financial resource potentials, whereas at present the newly independent states have enormous differences as to the economic, social and political spheres (see Chapter 2). This can be clearly proved by the example of Kazakhstan and Tajikistan policies of capital investments in water management. Considerations concerning governance and use of resource potentials (productive, natural and financial) determine specific features of natural resources development. Lack of hydrocarbon fuel entails priorities of hydropower generation for Kyrgyzstan and Tajikistan. Limited capacity for development of new irrigated lands coupled with immense demographic pressure in rural areas justifies the intensification of

irrigated agriculture – the major producer of national welfare in Tajikistan and Uzbekistan – to meet public and private economic interests.

It is now evident that, in order to survive, the region should improve not only the technical level of its own water resources use, but reconsider the system of this natural resource management. Due to poor management, water losses and decline of water productivity in various sectors of water use considerably exceed the technical water losses in river channels, irrigation systems, and at farm and field levels.

The major objective of management is to achieve guaranteed and stable water delivery to users at proper time and of good quality, concurrently meeting demands of Nature for water and, in case of water scarcity, to secure uniform and equitable water supply. But this seemingly simple objective requires immense efforts to improve the current system of management.

In order to improve the system of management at the basin and interstate levels, the following activities must be carried out:

- Accurate annual, seasonal and on-line forecasts of river flows, and provision of national and basin water management entities and major water users with information on the current rivers discharges;
- Elaboration and legal implementation of rules designed to ensure reservoir management under normal (average water availability) and extreme situations (floods and droughts);
- Elaboration and legal implementation of rules designed to regulate water allocation and distribution between Central Asian countries, and to ensure appropriate interaction between regional and national organizations with regard to concerted amounts of water withdrawals from transboundary rivers;
- Involvement of water users in river basin management through establishing Basin Councils, which can be subsequently transformed into entities of "hydro-ecological management";
- Formulation of commitments to be implemented by regional countries with regard to joint funding of regional and basin arrangements designed to provide hydro-meteorological services, maintenance of flow formation zones, coordinated water resources management and protection, development of joint projects stipulating compensation of costs allotted for repairs, maintenance and modernization of water facilities having regional significance.

Proceeding from specific flow characteristics of the Syrdarya and Amudarya rivers and their strong dependence on volumes and time-profile of return flows, special emphasis should be placed on management of transboundary return flows by monitoring their formation regimes, dependence on water delivery practices and other factors such as salt and other pollutant contents, and

controlling over their releases and use. Accurate forecasts should be made with regard to amounts of return flows and volumes intended for use both at locations where they are created and where they are discharged into the major rivers.

An important aspect about the use of return flows is their storage for the purpose of watering wetlands and supplying lakes in the delta systems of the Syrdarya and Amudarya rivers, so to sustain fishing productivity of such water bodies as Solyenoe, Dengizkul, Arnasay, Aydarkul, Sarykamysh and Mejdurechensk lakes. To ensure this, pertinent rules, provisions and regulations must be prepared considering the necessary ecological releases to meet environmental demands of river channels, flood plains and deltas.

Much is to be done for arranging appropriate interrelationship between power generation and irrigation demands. In addition to provisions stipulated in the Agreement of 1998, a new institutional tool has been given consideration to – the establishment of a Water-Power Consortium, with relevant financial and economic mechanisms of tradeoffs between the water and power sectors.

Water users must be involved in the basin level management. Two Basin Water Organizations (BWO) – "Syrdarya" and "Amudarya" - have been operating in the region for 15 years. At present these regional bodies have been gradually improving their technical capacities (e.g. SCADA systems, advanced hydrometrical equipment). But activities carried out by these BWOs still retain purely professional nature within limited teams of experts, lacking transparency and information availability.

The establishment of Basin Public Councils attached to the BWOs should facilitate the creation of an environment enabling equitable water allocation, accessibility and transparency of management, and information exchange between major regional stakeholders. Such transboundary public entities should include representatives of all provincial governments, large hydropower stations, irrigation systems, nature protection agencies of adjacent countries, especially in delta areas. The Basin Council members should give consideration to expediency of transforming basin water management into more integrated management of basin natural ecosystems, involving all stakeholders in the process of decision making and attracting financial support to the basins.

Basing national water policies on governance and new attitudes of the society

Though the region has evidently approached the threshold of water scarce region – 1700 m^3/capita/year – governance and society have not yet gained proper insight into such development. The younger generation of citizens, who will become leaders in 20-30 years, should be brought up and prepared to utilize water in a frugal manner and to save this most important natural resource efficiently, since at that time there will be only 1200-1300 m^3/capita/year of

available water. Water conservation and saving are essential to cope with water scarcity (Pereira *et al.*, 2002). Therefore, a primary task of Central Asian states is education of children and teenagers in the spirit of ancient traditions, respectful attitude to water as sacred bounty of nature, thus creating conditions to effectively implement water conservation and saving. Such skills must be inculcated from early childhood. The generations to come must be able to manage irrigated lands in a productive manner. Retrieval of ancient traditions of setting a priority to water resources development in the region, engaging outstanding water managers to work in state governing structures (like it used to be in days of Al-Khorezmi and Navoy) could assist in organizing appropriate water governance and policy appropriate to the new times and not just reviving old traditions.

Appropriate water policy is based on comprehension of finite nature and dynamics of water resources as well as on water conservation and saving issues. Among others (Pereira *et al.*, 2002), the following arrangements may contribute to appropriate water policy implementation:

- Development of legal and institutional basis for implementation of IWRM;
- Involvement of water users in management;
- Development of incentives for water conservation and water saving practices;
- Capital investments in development of water sector;
- Creation of infrastructure and extension services necessary for efficient water use;
- Organization of a widespread network of water-oriented training and professional development.

Building-up of IWRM in a country should not be confined to management based on hydrographic and hydrologic principles, as some water managers may conceive. The main task to be addressed while introducing IWRM is to conduct social mobilization of water users and staff-members of water managing entities through exercising participatory approach while engaging them in activities carried out by WUA, Canal Committees, Irrigation System Councils, and national Water Management Councils.

These new organizational forms of stakeholders' participation should not be transformed into an appendage of the State water authorities: they are meant to acquire independent self-sufficiency in terms of organization, financing and management. There are many successful examples on that score around the world (Abernethy, 2001), mainly in developed countries where funding opportunities are rather significant and the State participates in public associations in the capacity of the major partner with sufficient share of resources input (Correia, 1997; European Commission, 2000).

As to the regional indigenous forms of public participation in water resources use and management, there are also enough positive traditions dating back to ancient Turkistan that regulated such socio-economic and cultural institutions as *mirabs* and *aryk-aksakals*[5]. They were responsible not only for equitable and reasonable water allocation, delivery and control over water resources conservation, but also to organize tangible contribution of users to all operation and maintenance arrangements, construction and repair works in the form of *khoshars*[6], collection of charges and, in case of money deficiency, mandatory contribution in kind by inputting materials, draft cattle, etc.

The current task of participatory water management is to gradually shift responsibility for planning, equitable water distribution and water delivery from the State water authorities to water users themselves. The number of water users in each irrigation system and canal reaches several hundreds and in some WUAs, for example in Kyrgyzstan, there are thousands of water users. It is clear that active participation of farmers is necessary to arrange managing groups within WUAs along every canal, and to organize the water delivery schedules and coordinate among users and managers, mainly to provide for equity between head- and tail-end canal users. Only such participation makes water delivery stable, sustainable, uniform and timely produced. Moreover, the farmers themselves, having organized communal self-control over efficient and controlled water use by each WUA member, will prevent non-equitable water distribution, thus, promoting conditions favouring water saving, ensuring water availability for all users, and concurrently reducing financial load on water management.

The harmonization of different interests pursued by water users and water management agencies is very important for achieving coordinated issues on water saving and conservation and efficient water use. Appropriate national water policy and national water management tools are of great importance on this respect. Under the current free of charge water use in Uzbekistan, neither water users, nor water management agencies are interested in water resources conservation or having reciprocal commitments as to water delivery. After chargeable water use was introduced in Kazakhstan, Kyrgyzstan and Tajikistan the direct interest to prevent overuse has emerged from the water users with the purpose of reducing irrigation costs. Such interest increases when penalty provisions are applied for overuse, especially if the amount of such penalties is collected according to a progressive scale. However, water management agencies may be interested in delivering more water to users if direct payments for water are set, which is a contradiction to be avoided.

The solution of this problem may be found through introduction of regulations under which both water users and water agencies are mutually

[5] *aryk-aksakals* – senior supervisors of distribution canals at the community level
[6] *khoshars* - communal collective mandatory works

interested in improving water productivity, for example giving a prime to specialists and responsible for operation of a system when the service provided contributes to attain a given threshold level of water productivity. Another solution might be the introduction of financial compensations to water management agencies for saving water to be made available for other uses at the State expenses similarly with what happens in regions as California where saved irrigation water is paid by the downstream municipal users. This approach significantly facilitates the interest of users and water management agencies in application of advanced technologies.

Issues in the irrigation domain

The results of the research project presented in this book refer to several technological issues in the irrigation domain: methods and models to compute crop water and irrigation requirements, models to create, analyze and base irrigation scheduling programs, GIS and remote sensing tools, surface irrigation models and field techniques aimed at improved farm irrigation performance, decision support systems (DSS) combining these models and databases to be used at various scales, including the farm and the water distribution scales. Research performed aimed at adapting or developing the model tools and at developing the DSS to be used in future. The great challenge is to implement these tools in the practice and to develop the inherent auxiliary tools that should make easy to accede and use them.

In this perspective, in a parallel project, it is foreseen the large-scale implementation of the Field Certification System (FCS) in irrigated agriculture. It requires adaptation throughout the irrigated areas, further development of its toolbox and provision of widespread training of an extension network for dissemination of relevant practices to be adopted by water users and technical staff that can obtain personal benefits from such innovations.

At present, the following stages can be considered with regard to the large-scale implementation of these innovative approaches:

- Characterization of fields and farms, which is based on the recognition of relevant soil characteristics with application of remote sensing and GIS technologies, including the focus on identifying causes of non-uniformity of crop yields and low yields. This will enable farmers and advisers to assess current land and water productivity, and elaborate short,-medium- and long–term measures designed to further achieving the potential land productivity;.
- This activity should be followed by adopting the WINISAREG model to simulate and select appropriate irrigation scheduling, including its GIS version, GISAREG. This may produce more adequate irrigation norms and schedules on base of actual climate data;
- With help of the DSS SADREG, which is aimed at selecting the best surface irrigation practices, mainly relative to improvements in the furrow irrigation

systems now commonly used, in combination with ISAREG generated irrigation scheduling practices. Criteria for selection are user defined and comprise irrigation performance, environmental and economic attributes;

- In order to better combine farm and delivery system objectives, the DSS SEDAM, also operating in a GIS base, may be used to generate scenarios of irrigation demand and delivery. At present, it is useful to analyze and support decisions on the main directions of change. In a later phase it has to be modified to operate in real time and therefore support canal management decisions. This implies coupling SEDAM with the hydraulic and delivery simulation model described by Dukhovny and Tuchin in Chapter 17;
- Tools as above may support the activities of WUAs, particularly water delivery plans and advise to farmers, as well as supporting the interaction between WUA and Water Committees of Canals;
- Installation of SCADA systems on canals of first order and equipping outlets to distribution canals and on-farm irrigation distribution systems with measuring devices with the purpose of conducting accurate accounting of water use and delivery;
- Concurrently, training for WUA water specialists and users should be organized on methods for using and exploring the models referred above, making good use of devices serving for control of water deliveries, and to upgrade their activities;
- Establishment of extension services at the level of WUAs or irrigation systems, which are meant to serve as a basis for introduction of innovation through demonstration sites and network of experts, providing farmers with systematic assistance in order to adapt and adjust innovations to specific local conditions; apply fertilizers and chemicals in agreement with agricultural needs and in agreement with environmental requirements; select the well-adapted crop varieties; combat agricultural pests and diseases; carry out marketing, and to develop recommendations on optimal strategies for land and water use;
- Creation of reliable drainage background as the basis for managing salt and water regimes of soil, particularly basing upon the knowledge resulting from several decades of drainage in Central Asia;
- In addition, because the rates of decrease in land productivity in Uzbekistan for the last 25 years are about 5% in Fergana province and up to 30% in Karakalpakstan, to improve the situation there should be created conditions to augment investments for maintenance and rehabilitation of drainage.

Adaptation of these tools should be ensured through training, designed for professional development of senior and middle levels of water management personnel, so that they could conceive the essence of necessary interactions at all levels of the water management hierarchy in providing stable water delivery to the end water users. Training of specialists engaged in Canal and Systems

Authorities is to be aimed at application of proposed modelling techniques and water distribution regulations. Training of WUAs' specialists is to be focused on mastering computer skills and information technologies adapted to their level. Training of farmers and agricultural workers should be oriented at issues closely related to crop irrigation practices.

Conclusion

The situation in Central Asia countries calls for further advances in water management that should support the nature, human, productive and financial resource potentials for sustainable development. This implies recognition of these resource potentials and adaptation of the governance, *socium* and management systems to existing problems, mainly those relative to water. Regarding this resource, further efforts to develop modelling and technical tools are required, as well as their implementation when they become available for the irrigation sector. These are a step further in implementing IWRM principles. However, a priority is public participation, institutional building, education from child to all levels, and improved intervention of State authorities.

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