Harmonizing water use for irrigated agriculture and ecosystems sustainability in Central Asia

Vadim Sokolov[a1], Ivan Sokolov[b]

[a] Scientific-Information Center of the Interstate Commission for Water Coordination in Central Asia, Uzbekistan; [b] Moscow Academy for Finance and Industry, Russia

Key words: Integrated water resources management, Ecosystem approach, Drainage basin, Ecologically permissible water abstraction, Ecological and sanitary flows

Environmental aspects of IWRM could be implemented in two directions: to minimize harmful impact of land use for irrigation to water resources, and to meet specific water requirements of eco-systems. From the ecological point of view, the main features of water are high mobility and ability to dissolve different chemical components. A key for stability of natural and anthropogenic cycles is negative impact minimization of interacting rivers (sources of water) and territories in use for irrigated agriculture, as well as the interaction of surface and ground water, blue and green water.

To provide environmental sustainability over the river / drainage basin, specific criteria proposed under which such interrelated factors as water quality and accumulation of pollutants over areas under irrigation use are linked up. In other words, the criteria of well-being in the drainage basin could be formulated as follows:

- A pollution load from the area under irrigation to affected ecosystems should not exceed the permissible (agreed) concentrations. Trends of accumulation of toxic pollutants should be negative - there should be observed gradual reducing of pollution over the irrigated area in time-scale.
- Concentration of contaminants in water sources over all zones within drainage basin, from upper stream to delta, shall not exceed the maximum permissible concentrations for all water users utilizing water from these water sources.
- Anthropogenic pressure to eco-systems over the catchments should not exceed the optimal limits that ensure maintaining of their biodiversity and bio-productivity.

An another important issue is consideration of ecological requirements for water resources, when we keep in mind the requirements of eco-systems as source for water supply and basis for flora and fauna sustainability. It is important not only to preserve natural spices and objects, but also to keep their natural attractiveness for humanity.

In compliance with the IWRM principles, water and land resources within catchments should be considered as components of joint use, management, conservation, and development. Responsibility and duties should be distributed among variety of water users at different hierarchical levels aiming regulation of water demand and use to provide sustainability of the natural potential as well as preventing its reduction by time. Based on those considerations, available water resources within the basin have to be considered in their interaction with economic activities, but with some properly regulated limitations for use of water, land, and reclamation measures in order to ensure sustainable development.

On the basis of the legislation, regulations, and agreements, the Government assumes the responsibility, with the assistance of its conservancy agencies, water management

[1] Corresponding author. E-mail: vadim@icwc-aral.uz

organizations and public mobilization, to monitor ecological and sanitary flows and the norms on preserving natural streams.

Water resources management could be based on the ecologically permissible water abstraction (EPWA) to prevent the irrevocable water consumption. When this level is exceeded (such a situation took place in the Aral Sea basin), water consumers would make their contribution into the joint compensation fund as a payment for excessive use of natural resources and implement mitigation measures. For example, in the Aral Sea basin, this permissible level of total annual water abstraction from rivers is about 78 km^3 against the present water abstraction of 97,2 km^3 (2009), and 123 km^3 in the past (1990)! If each country which exceeds the ecologically permissible quota for water abstraction, it will make proper contribution into the joint fund, then opportunities for improvement of environmental conditions within the basin will arise.

Table 1 presents the principal figures for assessment and comparison of the EPWA and real water withdrawal (RWW).

Table 1. Indicators of actual water use in comparison with EPWA

Indicators	**Country**					**Aral Sea Basin**
	Kazakhstan	**Kyrgyz Republic**	**Tajikistan**	**Turkme-nistan**	**Uzbekistan**	
Population, million inhabit.: 1960 2009	 1,3 3,1	 1,0 3,1	 2,05 7,6	 1,55 5,04	 8,2 28	 14,1 46,84
Ecologically permitted water abstraction (EPWA), km^3/year	10,2	5,5	11,4	18,5	32,4	78,0
EPWA, m^3 per capita : 1960 2009	 7,846 3,290	 5,500 1,774	 5,560 1,500	 5,484 3,671	 3,951 1,157	 4,823 1,665
Real Water Withdrawal: (2009):						
km^3	7,25	2,2	13,5	23,6	50,7	97,2
m^3 per capita	2,324	714	1,775	4,615	1,826	2,082

The Figure 1 presents the visual picture of the water withdrawal variations in the Aral Sea Basin during last five decades.

We are suggesting combine the following approach for water allocation in the Aral Sea Basin:

- the water withdrawal of the riparian countries at the level of 1960 (EPWA) will keep as a guarantee part of transboundary water resources free of charge;
- the part of real water withdrawal above the ecologically permitted level should be paid by the each country to the common regional Fund of the Aral Sea Basin, because it caused the proper “harm” in the environment situation;
- share of the each country within the difference between EPWW and RWW could be estimated on the base of agreed by riparian countries criteria. There could be suggesting quotas with account degree of water consumption in comparison with potential productivity of water.

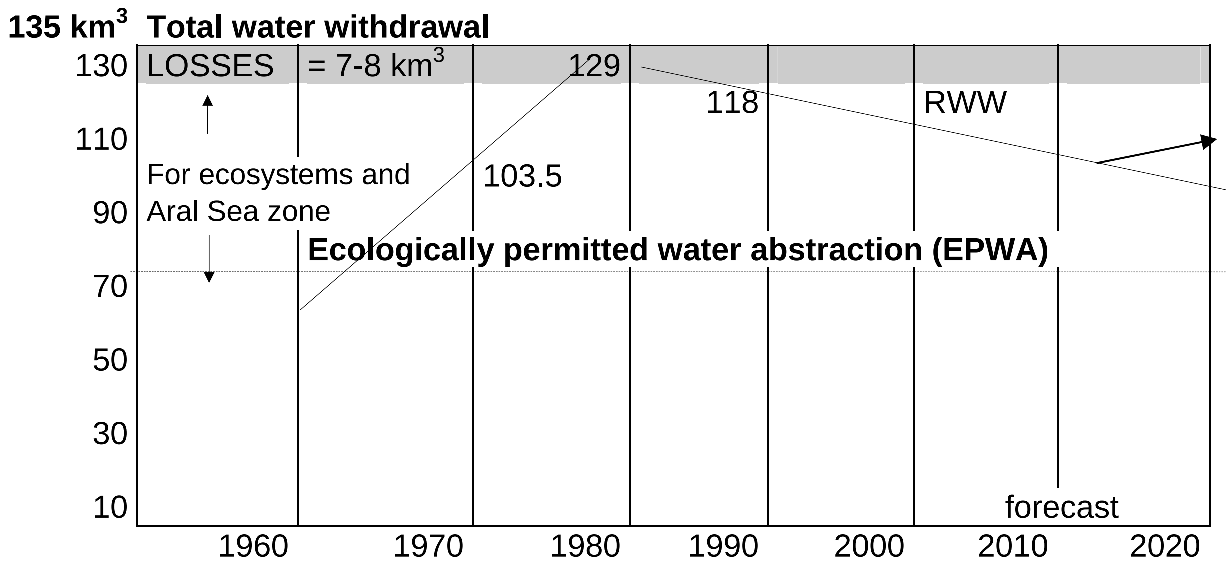

Fig.1. Dynamics of Total Water Withdrawal in the Aral Sea Basin in Comparison with the Ecologically Permitted Water Usage

Each state bears the cost for the formation and distribution of water resources in proportion to the volume of water used by the national economy and resources in proportion to the effect received from use of the resources. Each state pays the difference between the average cost of water, established for the basin on the international level, multiplied by the intake volume and cleared cost, which the country bears for independent participation in river management.

Other principles could focus on providing incentives for water conservation, improvement of the ecology of the basin and uniform water resources distribution, for example:

- Payment for water withdrawal from transboundary sources at the price of so-called "final cost" in order to establish a fund supporting the maintenance of water management network and a fund supporting the international development of water resources in the Basin. In this case, related environmental damage could be incorporated into the cost of water paid by each the country above the "final cost."

- Equal sharing of the maintenance costs of interstate water organizations and additional charges for the basin water supply beyond the agreed upon quotas for "equitable and justifiable water use in the Basin".

In any case, the system of water charges and cost allocation at the interstate level should be correlated with the right to use the common transboundary water basin through justified sharing as it was proposed above.

Looking to the figure 2 anyone can understand the roots of the recent water related problems in Central Asia. Stochastic variability of the natural river flow creates two externalities for humanity. From one hand, there is a risk of floods in the years (or periods) of high water. From another hand, during dry periods there could be observed critical scarcity (deficit) of water for uses. When humanity understood these problems – the big dams were constructed to regulate river flow in the water reservoirs behind dams. The multi-year flow regulation permits to minimize risk of floods and optimize water availability for different uses, and in the first turn for irrigation.

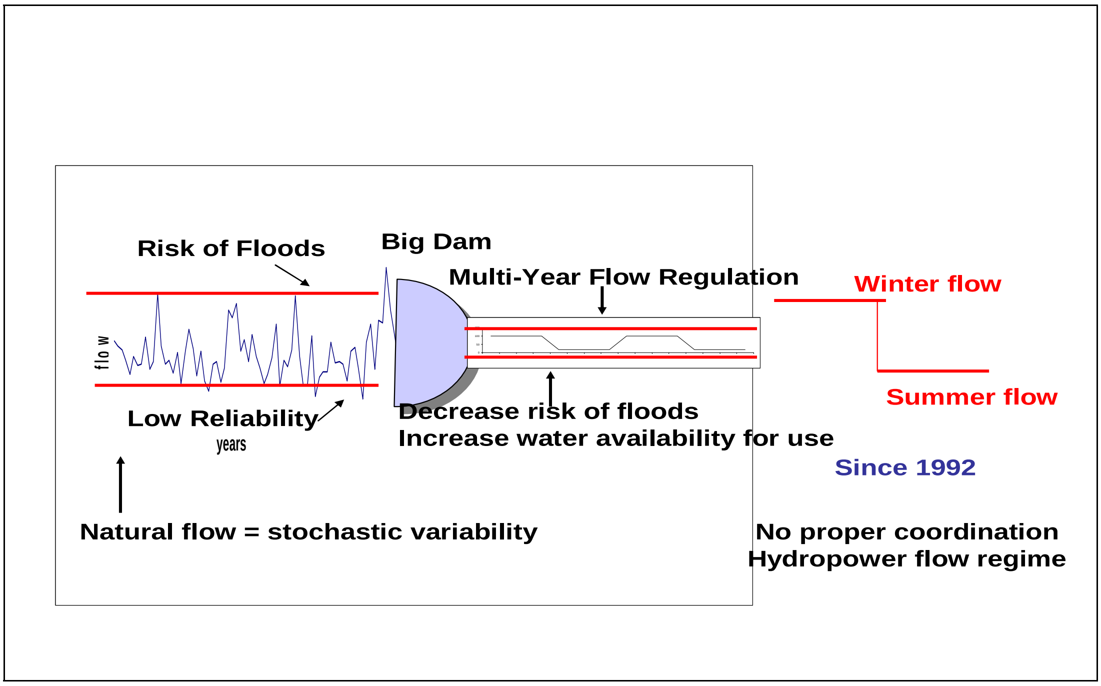

Figure 2. Evolution of river flow transformation under impact of water development

During the Soviet period, federal government constructed in Central Asia water infrastructure and allocated water resources in order to maximize water supply for irrigated agriculture. This policy brought some economic benefits and social stability to the region, but it also resulted in environmental challenges (as shown above). The key water management institutions were the republican water ministries, which effectively managed water allocations and development projects, and today remain the foundation for interstate water management (with some transformation by status and authority). For operative water management along two main rivers in 1986-87 two Basin Water Organizations (BWOs) for the Amudarya and Syrdarya rivers were established. The federal Soviet government conducted compensatory schemes to regulate trade-off between republics concerning agriculture, energy and other sectors. Thus, on the basis of multi-year regulation of river flow there was not any serious competition for water among the republics.

As the USSR collapsed, and with the creation of the five independent states, the big number of former domestic river basins were now transboundary and water had been turned into a source of potential interstate disputes that had not only environmental, but also political and economic implications.

During the Soviet period, the Aral Sea Basin was managed as an integrated economic unit. Economic priorities, defined by Moscow, dictated that water was allocated to optimize agricultural production and provision of hydroelectricity was a second priority. With independence the integrated economic system broke down. Each country began to redefine its own economic priorities. They became acutely aware of their resource inputs and outputs and it became evident that their respective goals conflicted regarding water usage (by volume and by schedule). Uzbekistan and Turkmenistan wanted to intensify agricultural production for which they were heavily dependent on water for irrigation. Yet, the majority of the water sources originated outside their borders. Kyrgyzstan and Tajikistan, meanwhile, would like to utilize water for electricity production and also expansion of agriculture. The scene was set for intense competition.

As it shown in the Figure 2, the energy regime of river flow, which is keeping by upper stream countries since 1992 again returned back to reality risk of floods in winter season and water deficit in summer season.

For preservation of rivers and water bodies as natural ecosystems, release of water from reservoirs and keeping flows along the river should not be less in summer and more in winter than mean annual runoff (that should be specified based on observed long-term flow series). The following ot this rule can prevent transformation of rivers into drains. Water requirements of ecosystems in deltas and estuaries should be specified taking into consideration their bio-productivity.

Environment aspects should be included into IWRM plans at the level of basin. This includes: (i) rehabilitation of impacted natural landscapes due to water erosion, waterlogging, and deforestation; (ii) regulation of excessive abstraction and use of local water sources; and (iii) inventory of sources and zones of pollution, and their monitoring and localization.

The interrelation of surface water, groundwater, and drainage waters is a very sensitive aspect for water and land reclamation management because excessive water use for irrigation results in not only losses and deterioration of water as a resource, but also in land degradation and soil fertility losses. The incorrectly designed drainage systems will lead to mobilization of vast volumes of salts from lower stratums. In addition, unevenness of irrigation and drainage results in increasing water losses and non-uniform crop yields over irrigated area. In order to overcome those shortcomings, it is necessary to enhance land reclamation services, to equip them with relevant facilities and instruments, to introduce GIS and remote sensing methods for monitoring and evaluation of land conditions. It also could be noted that land salinization and waterlogging are main factors decreasing crop yield and water productivity in Central Asia, because there observed reduction in crop yields, but total water consumption is increasing.

A key objective is to achieve the potential water productivity based on “the quotas for water consumption and application of advanced methods for water use” or “the promising level of technologies in all water-consuming sectors.” Practical findings of some projects (the WUFMAS, Best Practice, IWRM-Fergana etc.) implemented in the region over the past two decades demonstrate that it is quite substantively to achieve potential water productivity.

The case of the Syr Darya basin

The Syr Darya is the second most important river in Central Asia. Its length is 3019 km, with a catchments area of 219 thousands km^2. A feature of the basin is the division of its territory into three main zones of surface runoff: (a) the zone of flow formation (upper watersheds in the mountain areas), (b) the zone of flow transit and its dissipation, and (c) the delta zones. As a rule, there is not a significant anthropogenic changes in the zone of flow formation, but due to construction of big dams and water reservoirs on the border of this zone, the downstream run-off regime is changing significantly. Within the zone of flow transit and dissipation the run-off and the whole hydrological cycle are changing in consequence of interaction between rivers and territory. This interaction is characterizing by water withdrawal from river to the irrigated and urban areas, and disposal of return flow to the river with salt and agricultural chemicals. The total amount is comprised of about 95 % of drainage water and about 5 % of untreated domestic and industrial wastewater. The large percentage of drainage water demonstrates that local irrigation actually consumes only about 45-50% of total withdrawals. The poor quality creates limitations for the re-use of drainage water, especially for irrigation. Only about 15% of total return flows are re-used and more than 55% returns to rivers. About 30% end up in natural depressions, from which the water evaporates. The total water use within the basin is in 1.6 times more than renewed surface water resources. Thus, it is classical example of closed hydrological basin in the arid climate.

Coherent analytical tool for evaluation of alternative strategies for water and salinity management in the short, medium and long-terms for basin scale is water budgeting. Its application avoids the danger that partial solutions will be adopted and to ensure balanced approaches to the management of water quantity and water quality (especially of salinity), taking into account the following considerations:

- The assessed water management options should accommodate the present and possible alternative future water demands - in both consumptive and in-stream uses. The potential contribution of water savings programs, future environmental and other needs, seasonal, annual and inter-annual operating issues should be taken into account in the light of agreed allocations of water between the riparian states.
-
- With respect to salt management, the assessed options should accommodate the interactions between river and irrigated lands/ urban areas, between surface water and groundwater.

The coherent alternative combined water and salinity management options for basin level could be constructed and tested using water budgeting. The options were specified for the short-term (2015), medium-term (2020) and long-term (2025), reflecting alternative macro-economic and sectoral development perspectives with the following considerations:

- For the short-term, used actual operating rules and water management practices (but supported by complementary incentive mechanisms) broadly appropriate to existing reservoir, conveyance, utilization and disposal systems under investment programs that are consistent with continued economic and financial stringency.

- For the medium-term, revised operating rules and water management practices for feasible new combinations of reservoirs and water conveyance, utilization and disposal systems under investment programs consistent with stabilized and steadily expanding macro-economic conditions.

- For the long-term, perspective operating rules and water management practices for alternative combinations of reservoirs and water conveyance, utilization and disposal systems under investment programs consistent with tackling the major problems associated with the sustainable basin development.

Table 2. General Water Balance of the Syr Darya River Basin, in million m^3

Basin Water Balance components	2009 actual	2015	2020	2025
I. Income Components				
1. Renewed surface flow	28200	40500	40500	37500
2. Total ground water abstraction	3760	3855	4110	5320
3. Formed return waters (total)	9900	10000	9600	9100
4. Water transfer from outside the basin (Zerafshan)	700	500	500	500
5. Multiyear stock depletion	1500	-	-	-
Total income	44060	54855	54710	52420
II. Outcome Components				
1. Accumulation of perennial stock in reservoirs	-	6000	5000	5000
2. River flow losses	2400	2600	2800	3000
3. Damage to surface flow by ground water abstraction	1200	2400	1600	2100
4. Water pumped by vertical drainage disposal without use	500	550	500	650
5. Surface water total use for all branches of economy	28300	30000	33000	35000
6. Losses in irrigation system	5600	6500	5500	5500
7. Drainage water reuse for irrigation	1650	2050	2350	2500
8. Return water disposal to the Northern Aral and wetlands	1700	2000	1900	1600
9. Release to Arnasai depression from main river channel	1810	1500	1500	1500
10. Inflow to the Northern Aral from the main channel	2700	3000	4500	4500
Total Outcome	45860	56600	58650	61350
Balance discrepancy (I - II)	-1800	-1745	-3940	-8930

There were tested options , which reflect regional and national goals and objectives are more or less realistic in terms of macro-economic and sectoral prospects. The water budgeting is a powerful tool to analyze the impacts of the proposed options with view to checking the consistency of the overall physical impacts and presenting systematic justification for the proposed water policies. As it follows from the table 2, proposed options not match with available water resources in the Syr Darya basin. The water deficit will increase, if we will not change the general water development strategy.