ICIWRM – 2000, Proceedings of International Conference on Integrated Water Resources Management for Sustainable Development, 19 – 21 December, 2000, New Delhi, India

Water use alternatives for the Bukhara region of Uzbekistan and water distribution in the Zerafshan river basin

ISKANDAR ABDULLAEV
Executive Director of Association of Uzbekistan for Sustainable Water Resources Development-Suvchi (AUSWRD-Suvchi), P.O. Box 4545, Glavpochtamt, Tashkent, 700000, Uzbekistan.

Abstract

The rationalization of water use for irrigation can be achieved through the optimization of water distribution between irrigation districts and water users. One of the basic steps in the rationalization of water use for irrigation is the optimization of water distribution for large water districts.

The distribution of limited water resources in the small river systems in the Aral Sea zone is problematic, because of the absence of water share agreement between countries, which were part of the Soviet Union and absence of the economical and environmental indices of water use in the region. One of these small water systems in Uzbekistan is the Zerafshan River system. The Zerafshan River begins in the Nurata-Turkestan Mountains of Tajikistan-Uzbekistan highlands. Its length is 500 km, and the average flow changes from 220-320 cubic m/sec at the headwaters, to 3 cubic m/sec where it ends. . In the past, the river flowed into the Amudarya River, but presently it ends in the Bukhara Oasis in southern Uzbekistan. The river provides water for 5 regions of Uzbekistan and a small part of Tajikistan. The Samarqand region of Uzbekistan receives 60% of its total flow, which is used for irrigation and domestic use. In the past Tajikistan captured 10% of average flow, but plans to increase the amount of water taken to the 25% in the future. The Kashkadarya region uses 3-5%, and Dzijjak region uses 2-3% of Zerafshan water, mostly for irrigation. The Navoi and Bukhara regions of Uzbekistan use the other 25-30% of water. The Navoi region uses water for irrigation and for cooling the Navoi power plant. The plans of Tajikistan to increase water withdraw from the Zerafshan River and continuously water shortage in the Samarqand region and the low efficiency of the water use in the lower part of the river requires analyzing and optimizing the water distribution in the Zerafshan river basin.

INTRODUCTION

Uzbekistan is situated in the Central South part of the Former Soviet Union (FSU) between Europe and the Far East and has borders with Afghanistan (south), Tajikistan (southeast), Kyrgyzistan (east north), Kazakhstan (north), and Turkmenistan (west south). It has the largest population of the four FSU Central Asian republics and is the third most populous republic in the FSU. Of its 21 million people, 60 percent live in rural areas.

Country's climate is typical desert continental and belongs to arid zone. Average rainfall ranges from 176 to 302 mm. Total area of Uzbekistan is 447,000 square kilometers of which 4.22 million hectares were irrigated areas in the 1999 (41 percent of arable land was under cotton, 32 percent grain crops, 11 percent fruits, 4 percent vegetables, and 12 percent was used for other crops). Only 10% of total water consumption Uzbekistan are

forms in the its territory, rest of water uses from the interstate rivers. The Zerafshan River flows from the north part of the Tajikistan to the Uzbekistan, where has 560 000 ha irrigated lands.

The water quality in the upper basin of the river is very good. In the lower part of river (in Bukhara region, table 1) water is polluted by agricultural chemicals from irrigated lands in the upper and middle part of basin. It does water not useful for irrigation in the lower part of the basin and mostly river water flows to the low lands.

Table 1. Concentrations of various chemicals in the water of Zerafshan river in the upper and lower parts, mg/l (Abdullaev, 1996).

Objects	H	TDS	Chloride	Sulfate	Ammonium	Nitrates	DDT	BHC	Lindane
Maximum Contamination Level	7	1000	250	350	0.5	0.05	-	-	-
Samarqand region Zerafshan river	7.6	960	220	290	0.6	0.2			
Bukhara oasis Zerafshan river (Shafrican water distribution system)	8	2571	325	879	1.6	1.4	0.034	0.029	0.054

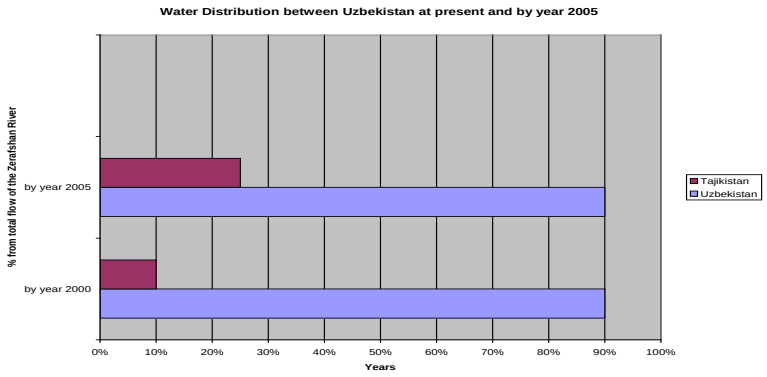

Figure 1. Present and future (possible water distribution between Uzbekistan and Tajikistan in the Zerafshan river basin.

Middle part of Uzbekistan and northern Tajikistan shares the water of the Zerafshan River, and it forms in territory of Tajikistan. If Tajikistan increases its water use in the future, Uzbekistan will need to reduce its water use (figure 1). For preventing possible conflicts must sign the water agreement between Uzbekistan and Tajikistan. The major principle of the water distribution could be demography. In the basin of the Zerafshan river from Uzbekistan side lives 6.0 million population and population growth rate equal to 1.4-1.6%, from the Tajikistan side 1.5 million people and population growth is 2.1-2.3%. It means Uzbekistan can have share 75%, instead of 90% nowadays and Taji-

kistan can have 25% of the Zerafshan River flow. For improving the water use and for decrease the water withdraw from the Zerafshan river basin up to 15% for Tajikistan Uzbekistan needs to set up the efficiently water use criteria for its regions.

The Samarqand region of Uzbekistan is one of the fastest developing parts of the country and plans to increase its water use from the Zerafshan by 85% by 2010(Design Institute, 1996). The Zerafshan River is only one-water sources for this region (figure 2)

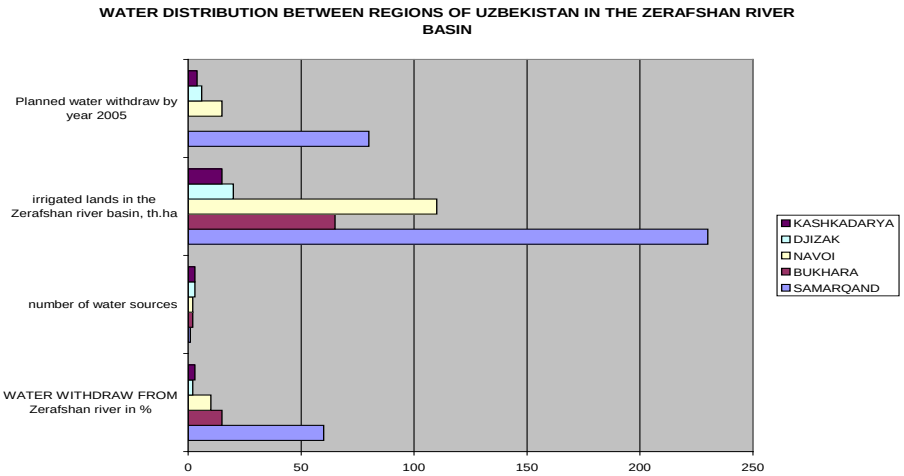

Figure 2. Zerafshan-river distribution between regions of Uzbekistan.

The optimal water distribution in the river basin requires the analysis of the current water use in the different regions of river basin. In this paper gives analysis of water use in the lower part of the Zerafshan river basin- in the Bukhara oasis. Water use in the Djizak and Kashkadarya regions are not analyzed, because this regions receives only 5% of total flow of water from the river, and this could be reduced to zero without any serious water shortage in these regions. Water use in Tajikistan is also not included in this discussion, because of the scarcity of water use data.

In the Samarqand region 45% of water use is for domestic and industrial purposes, with the remaining 55% will be used for irrigation. By 2010, 65% of river water will use for domestic and industrial purposes (Design Institute, 1996). The river water use efficiency in the region is 75%, which is one of the highest in the Uzbekistan (Design Institute, 1996). Of the river water arriving in the Navoi region, 25% is removed for industrial use and 40% for irrigation, with the remaining 35% of Zerafshan water flowing directly to the Bukhara region. The Navoi region also receives 2-3 cubic km annually of water from the Amudarya River, through the Amu-Bukhra Canal. For drinking water, the Navoi and Bukhara regions receive high-quality water from mid-Zerafshan, via the Domakhodja – Navoi-Bukhara pipeline, which transports 1.0 cubic km/ year of water (Table 2). The Bukhara region receives 15% of its total water withdrawals from the Zerafshan River, including 0.6 cubic km of drinking water from the pipeline Indeed, Bukhara uses up to 20% of the total of all of the Zerafshan river water. The most water

institutions of Uzbekistan excluding the Bukhara oasis from the water users of the Zerafshan River. Indeed in 1995-99, 237 M cubic km annually of river water was used for irrigation in the upper part of region, accounting for 20% of total water resources of Zerafshan River that flows into the Bukhara region (UzbekHydromet, 1999). During the last 15 years, more than 800 $Mm^3$of Zerafshan River water has also flowed through the drainage canal systems into natural depressions, creating the Karakir and Mahankol drainage lakes.

Table 2. Water uses in Samarqand, Navoi and Bukhara regions of Uzbekistan.

Regions	Total Water Use (Mm^3)	Water use from Zerafshan River (Mm^3)	Ground Water (Mm^3)	Water use from Amudarya River via Amu-Bukhara Canal (Mm^3)
Samarqand	5308	4730	578	-
Navoi	3642	1200	342	2100
Bukhara	5150	1600	550	3000

The structure of water use in the three regions is shown above. It is estimated that that the Bukhara region can reduce its water use from the Zerafshan by up to 1000 Mm^3 through the application of three alternatives to improve water use efficiency in the region. (1998, Abdullaev and etc.).

WATER USE ALTERNATIVES FOR THE BUKHARA REGION

The Bukhara region uses water from Zerafshan River, Amudarya River and ground water resources. Water use alternatives include the maximization use of water from any one of these water sources. The criteria chosen for the optimization of water distribution for the region are based on economic and environmental indices. Table 3 presents the distribution of water under these three alternatives.

Table 3. Water use alternatives for the Bukhara region (Mm^3).

Water use Alternatives	From Amudarya River	From Zerafshan River	From ground water and drainage water	Total water use
Alternative 1: Maximum water use from the Zerafshan River	3000	1600	500	5100
Alternative 2: maximum water use from the Amudarya River	4000	600*	500	5100
Alternative 3: maximum ground water and drainage water use	3000	600*	1500	5100

*- Drinking water trough Damohodja- Bukhara pipe system.

Water use alternatives were adopted by analyzing the water management system of the Bukhara region. The first alternative had been used in the past in the Bukhara region, before increasing the amount of water taken from the Amudarya. The second alternative is currently in use, but withdrawals of the water from the Zerafshan under this alternative will eventually drop to 600 Mm3, which consists only of the withdrawals for drinking water from Bukhara -Damohodja pipe system. The third alternative is to increase the reuse of drainage water and ground water use. The criteria's for choosing the proper alternative must include the consideration of the price of water and the environmental impact to river system caused by water withdrawals from the Amudarya.

The water from the Amudarya is the most expensive because of the energy use required by the 7 pump stations used to bring water from the river to region, and because of the operational expenses of the 250 km long canal. The price per unit of water from the Amudarya changes with the volume used; for less than 1 cubic km the price is high; between 3.6 –4.0 cubic km water price declines. At these volumes pumping stations and canal works operate at their highest efficiency and use less electrical energy. However, beyond 5 cubic km, the price of 1 cubic km of water again begins to increase, as the operational and energy cost once again increase at these larger volumes. The environmental index includes impacts to the river system caused by water removed from the river as well as irrigation drainage return flows into the river (1998,Abdullaev). The index is graded from 0 (min) to 12 (max). The effect increases with increasing water use, and with increasing the water use there is a concurrent increase in drainage water return flows into the river. Table 4 shows the environmental effects of the three alternatives.

Table 4. The main indices of water use alternatives.

Water use alternatives	Water withdrawals from the Amudarya (Mm3)	Drainage Water (DW) formation (Mm3)	Possible volume of DW, which will flow into the Amudarya (Mm3)	Price of 1 cubic m3 water from the Amudarya (cubic m/$)	Environmental effect (grades)
Alternative 1 Maximum water use from Zerafshan river	3000	1300	800	0.35	3.5
Alternative 2 Maximum water use from Amudarya river	4000	1800	1100	0.38	5.0
Alternative 3 Maximum ground water and drainage water use	3000	1300	0*	0.35	2.0**

* Under this alternative drainage reuse will reduce return flows into the Amudarya to zero.

**- The reduced drainage inflow will reduce the environmental effect by 1.5 grades under this alternative.

RESULTS AND DISCUSSIONS

Economic and environmental analysis is very important for the Aral Sea basin, where the environmental problems are very real and the economic situation is difficult. The above analysis has showed, that the first and third water use alternatives satisfy the least cost economic criteria, the price of 1 cubic m water is lowest, at $ 0.35/cubic km. From the environmental point view, the third alternative is optimal, when environmental effect less than all other alternatives. Also, the main goal of this analysis, to discuss how to reduce the water from Zerafshan River for future water use in Samarqand and Tajikistan is achieved under this alternative. Only one cubic km of Zerafshan water, or 600 Mm^3 of water, will continue to be used to provide drinking water for the Bukhara oasis. Water use for the Amudarya River will also be optimized through improved reuse of drainage water in the region, which also will decrease pollution of the river and the environment. More than 300 drainage wells situated in the upper and middle part of the Bukhara region, are capable of providing annually 12.cubic km. Approximately 80% of the water from these wells are of a high enough quality to be used for irrigation (Abdullaev and etc., 1998).

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