GROUNDWATER USE IN IRRIGATED AGRICULTURE IN AMUDARYA RIVER BASIN IN SOCIO-ECONOMIC DIMENSIONS

These research results a part of INTAS 1014/1003 Project

Askarali Karimov[1]
Dilshod Bazatov[2]
Jusipbek Kazbekov[3]
Shavkat Rakhmatullaev[4]

ABSTRACT

The paper analyses groundwater resources use in socio-economic context in Amudarya River Basin. The paper discusses present extent of groundwater resources use and special focus is on agriculture, livestock use and small farmers in their homegardens. Institutional and social pattern of groundwater resources use, allocation, monitoring and distribution are other aspects that reviewed. After the collapse of former Soviet Union with its old water resources management mechanism and infrastructure, new underdeveloped systems are being practiced over Amudarya River Basin. Many assessment reports haven't considered Afghanistan in their analysis for water allocation. In Afghanistan, after the end of civil war, irrigated lands are being expanded and the share of groundwater use is increasing too according to the recent reports and assessment projects by international institutions and local scholars.

Local farmers use water from boreholes and wells for their water supply systems in order to range livestock and grow crops for sustaining their livelihoods. For example, in Afghanistan karezes (traditional groundwater extraction structure) are widely documented as main extraction methods. Many farmers and settlements use different water extraction mechanisms for withdrawing water. Some drill new boreholes and some renovate old wells. Majority of locals does not have access to machinery pumps and do not have funds for purchasing or renting such pumps for practicing irrigated agriculture.

[1] Extension Associate, Texas Cooperative Extension, Texas A&M University System, 2401 East Highway 83, Weslaco, TX 78596, USA
[2] Professor, Hydraulics Department, Professor at Hydraulics Department, Tashkent Institute of Irrigation and Melioration (TIIM), 39 Kari-Niyazov Street, Tashkent, 700000 Uzbekistan
[3] Director of the Hydroinformatics and Water Resources Training Center, TIIM, 39 Kari-Niyazov Street, Tashkent, 700000 Uzbekistan
[4] Water Resources Specialist at HWRTC, TIIM, 39 Kari-Niyazov Street, Tashkent, 700000 Uzbekistan

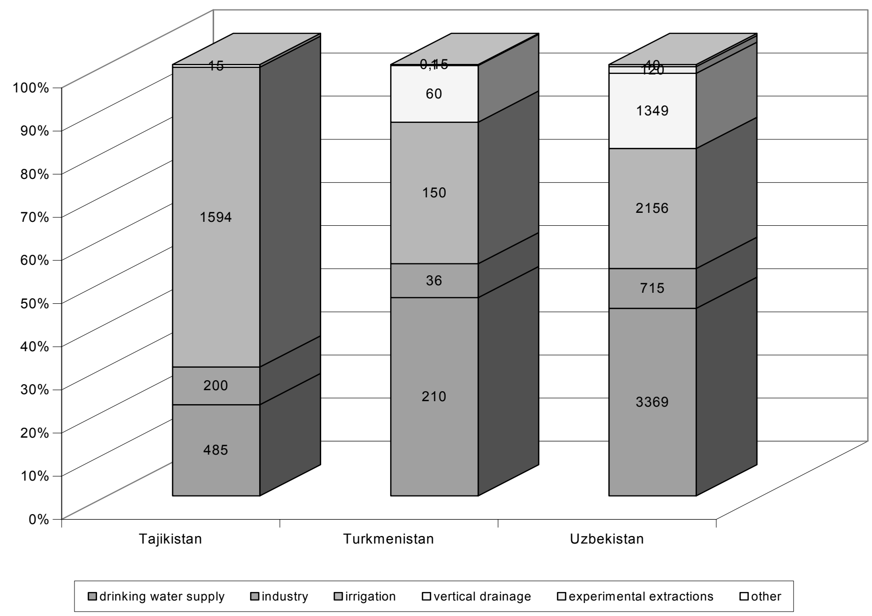
Economic aspects are discussed in broader sense and results are taken from farmers' interviews, personal communication with national hydrogeologists. In general, may farmers claim that it is worth to invest in finding groundwater for producing agricultural products and rearing livestock.

Groundwater resources becoming alternative source of supply for irrigated agriculture, livestock ranching worldwide. Amudarya River basin (Tajikistan, Afghanistan, Uzbekistan, and Turkmenistan) countries due to its climatic characteristics, economic development strategies and geopolitical situation have been experiencing everlasting competition over water resources. Mostly arid, agrarian countries pursue their own development and integration into global community through expanding irrigated lands, growing cash crops such as cotton, rice and wheat for meeting their domestic food security.

BACKGROUND

Groundwater resources have become a reliable and guaranteed water supply for practicing agriculture. For example, drought hit all basin countries and farmers turned for extensively using groundwater resources. Groundwater is site-specific, easy to locate and use for water supply. For example Government of Uzbekistan has issued a special program for providing boreholes and drilling wells in Khorezm province and Karakalpakistan Autonomous Republic for having access to safe and reliable groundwater resources supply for population domestic needs after those regions were hit by severe droughts. There are few farmers that have powerful pumps who efficiently practice agriculture.Groundwater resources were not widely used for irrigated agriculture in post Soviet Central Asian Republics (Tajikistan, Uzbekistan, and Turkmenistan). But the groundwater resources were used primarily for livestock sector and very site-specific purposes for example drinking water supply. There are numerous research and assessment studies on “regional operational groundwater reserves” that deal with assessment of those resources. The foremost purpose of those studies was to use groundwater for meeting drinking water supply needs of local population, in particular domestic water supply and livestock sectors. During the Soviet period, groundwater was not widely used in irrigated agriculture due to sufficient surface water with reliable water supply delivered to the farmers. Water allocation and irrigation system infrastructure were well maintained and operated with massive funding from central government.On the other hand, traditionally, Afghanistan has relied on surface water and groundwater springs and karezes for agricultural irrigation. During recent drought years, the use of deeper groundwater, abstracted via pumped dug wells and boreholes has increased rapidly. Private farmers have drilled many of these new wells and boreholes, there is concern that, in some areas, groundwater abstraction rates are already exceeding, or will soon exceed, sustainable groundwater resources (David Banks, 2002).

Figure 1. Groundwater Use for Different Purposes



Groundwater as a main source for irrigation

Groundwater overdraws is not the case in Amudarya river basin but the water drought experienced in 2000-2001 in downstream part of the River have brought to people the idea of "why not to use groundwater for irrigation". Many farmers (who could afford) started the pumping of groundwater from the irrigation fields to sustain the production during low flow periods and maintain the salinity issues. The main goal of the project is to document and understand the new realities of the groundwater use in agriculture by small holders and private farms and draw the policy makers' attention to this very important resource as potential in reducing the poverty. Groundwater is a reliable source of water and farmers and locals who distant from source of surface water can obtain it. One can just rent a land of several hectares and plant quick cash crops. Then finds a driller and drills well with engine and pumps. The next step is to hook up to electric lines and start to extract groundwater for watering their crops. There are just initial capital investments and electric bills for whole system to work. There is no social structure to monitor the groundwater resources. For example, Ministry of Agriculture and Water Resources of Central Asian (MAWR) invests and monitors the objects of water management till the interfarm level, e.g. main canals and main drainage systems. So, they do not quit deal with water of private farms or shirkats (cooperative farms). Within MAWR there are few data about groundwater level and mineralization on provincial and district level but much generalized. This is to control salinity problems. Therefore, this project is dedicated to document the socio-economic basis of today's groundwater use at farm level.

Groundwater Use in Central Asia

The groundwater use extent in various basin countries varies from country to country and upstream to downstream. For example, groundwater is used for irrigation in upstream and downstream countries and less in downstream. For example, in Turkmenistan the groundwater table has increased and there is no need to use groundwater for irrigation. Waterlogging has created salinity problems and there is no need for using groundwater.In recent years, Uzbek rural agriculture production system dependent on groundwater pumped from private tube wells has grown increasingly. Nevertheless, few studies have revealed how water markets should be operated and what the social and environmental consequences of privatization will be. Private sector of tube well water extraction and operations are not monitored or regulated (Fuchinoue et al., 2002).

From the graph the Tajikistan's groundwater share in irrigation constitutes up to 70%, Turkmenistan's share is about 38% and Uzbekistan's is approximately 37%. Groundwater for drinking water supply is about 40% in Turkmenistan and Uzbekistan and 17% in Tajikistan. Thus we can speculate that the maintenance and operation of infrastructure is better managed in Turkmenistan and Uzbekistan. The situation in Tajikistan is not quite satisfactory due to civil war. Many reports state that the great part of networks water supply are deteoriated and worn-out without any considerable funding from state and relevant agencies. The vertical drainage is developed in Turkmenistan and Uzbekistan downstream countries. This indicates that groundwater levels are high and close to the surface in downstream part of the Amudarya basin. The vertical drainage systems have been installed in order to decrease groundwater level. Many farmers or dekhans tend to rent plots of lands ranging in size from 1-10 hectares and drill boreholes and wells and just start to pump groundwater for irrigating crops. The only costs are drilling, instalments of pump, engines. The electric costs are not paid regularly or at all. The locations of wells are tend to be placed near electric lines and they tend to just hook up the wires and operate pumps.The groundwater is extensively used in Uzbekistan about 99%, in Tajikistan and Turkmenistan about 30-40% for various uses. This can be explained by the fact that groundwater management infrastructure is well maintained in Uzbekistan with central funding from the government. Another explanation can be uncontrolled water extraction by local farmers and population for various uses.

Figure 2. Intensity of Groundwater Use

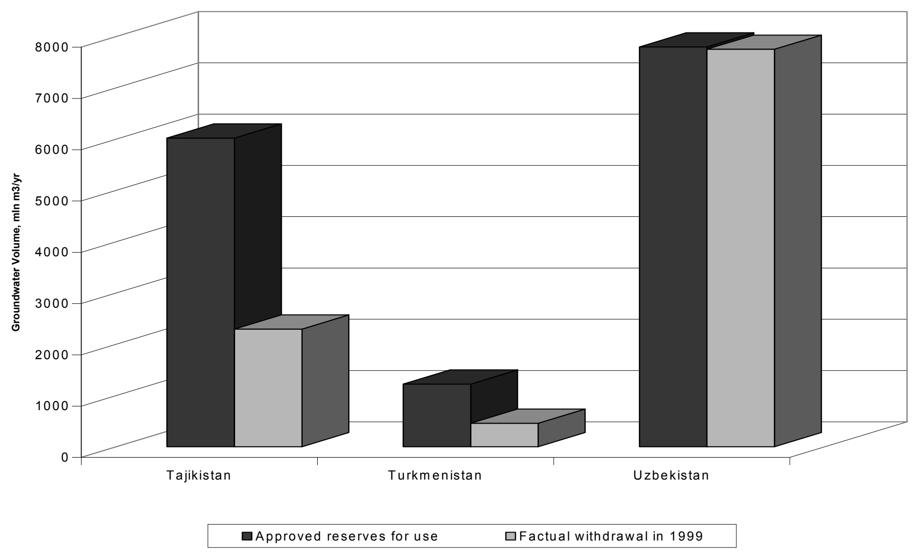


Figure 3. Relationship between Actual Groundwater Use and its Use per Capita, 1994

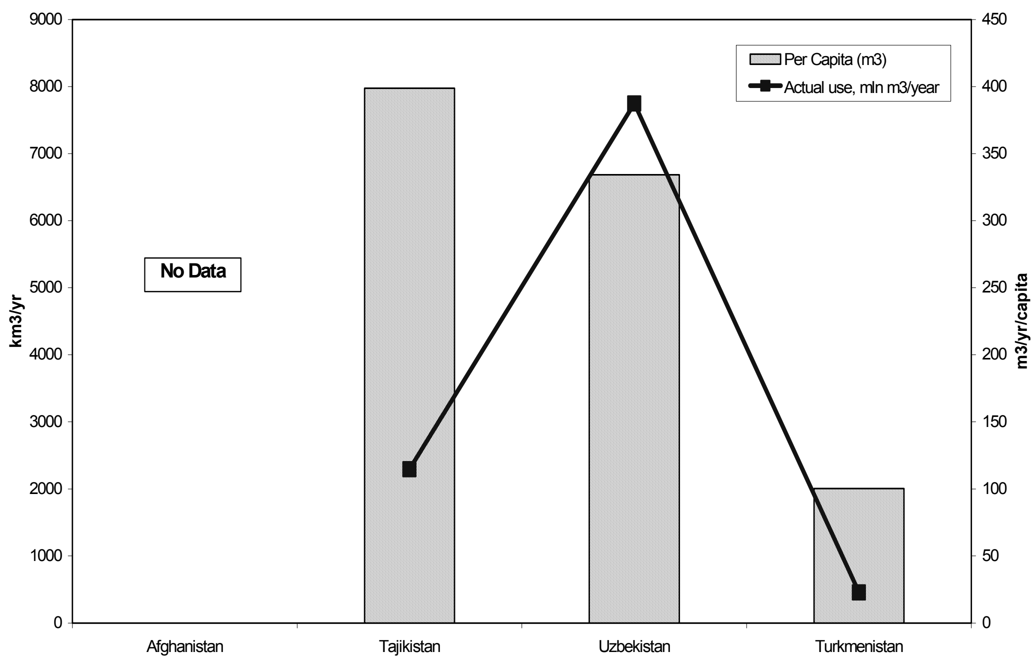


Figure 3 depicts per capita use and actual groundwater withdrawal in Amudarya River Basin. Per capita groundwater use is the highest in upstream-Tajikistan and decreases downstream in Turkmenistan. This can be explained by the groundwater table increase in downstream countries with waterlogging problems from irrigated croplands. The highest groundwater use is observed in Uzbekistan, the least in Turkmenistan. The irrigated areas of high groundwater table levels have increased in Amudarya River Basin was 1,290,000 million hectares in 1990 and 1,566,000 hectares in 1999, the total change was 21% (GEF Project, 2001). For example in Tajikistan the increase was about 21%, in Uzbekistan-20%, and in Turkmenistan-24%. However, one should take into account the fact that three drought years of 1999-2002 have probably resulted in decreasing substantially groundwater table levels.

Table 4. Irrigated lands with high groundwater table level in Amudarya River Basin from 1990-1999.

Amudarya River Basin	Areas with water table <2 m (thousand hectares)		% increase from 1990-1999
	1990	1999	
Tajikistan	**92**	**111**	**21**
Bukhara	62	62	0
Kashkadarya	5	4	-20
Karshi	5	3	-40
Navoi	28	40	43
Samarkand	37	48	24
Surkhandaya	16	19	19
Khorezm	192	234	22
Karakaplakistan (south)	107	128	20
Karakalpakistan (north)	218	263	21
Uzbekistan	**670**	**801**	**20**
Dashoguz	182	238	31
Akhal	43	107	149
Mari	136	116	-15
Lebap	162	187	15
Balkan	5	6	20
Turkmenistan	**528**	**654**	**24**
Total in Amudarya River Basin	***1,290***	***1,566***	***21***
Source: GEF Project Water Resources Management and Environment, 2001. Uzbekistan			

The total withdrawal of groundwater from Amudarya river basin within lower Amudarya reaches (Uzbekistan part) on 01.01.03 is about 2 km^3/year (Annual Information Bulletin of Ministry of Agriculture and Water Resources, 2003). In 1995 in Uzbekistan for industrial needs - 17.6 m^3/sec (0.56 km^3) was used.

Groundwater resources should be the main source for drinking and domestic water supply of local populations. In drought years (2000-2001) there were 5000 wells of manual pumping (depth of 10-15 meters) that were bored in Karakalpakistan, and Khorezm region for drinking and domestic needs. The mineralization of groundwater of bored wells is about 3,0 g/L (Annual Report of

HYDROINGEO, 2001). Farms are not charged for irrigation water, but in 1995 a land tax was introduced. The amount payable depends on irrigation and land quality, which is calculated by province on the basis of a soil fertility parameter. For example, in Karakalpakstan, the tax varies from $US 0.64/ha for the lowest fertility class to $US 6.5/ha for the best fertility class. In the south of the country, the tax varies between $US 1.1 and 11.2/ha.The total groundwater used (pumped) in 1995 in Uzbekistan was 206.2 m^3/sec (6.5 km^3), including for drinking water supply - 60.81 m^3/sec (1.92 km^3). Rural water supply and pastures - 22.17 m^3/sec (0.69 km^3), and for irrigation - 105.59 m^3/sec (3.32 km^3) (Vodproekt, 2001). Groundwater used for irrigation is almost 50% of the total groundwater use in Uzbekistan. In Karakalpakstan the groundwater use in 1995 was 0.71 m^3/sec (0.022 km^3) and groundwater use data for irrigation is not available.

Institutional Incentives for Groundwater Use in the Region

In north, central Tajikistan and Pamir, local communities, mining industry, and cattle-feeding farms satisfy their water needs from springs and mountainous streams. The water quality of those sources is of good quality. There are some areas of limited fresh groundwater such as loamy layers of paleozoic formations, gypsum sediments and distant from streams. District centers of mountain provinces and resorts (Obigarm and Hodjaobigarm) have water pipe systems. Springs that are used as sources of water supply are located 2-3 km from water users. The total water resources withdrawal through pipe systems amounts to 0,25-0,3 m^3/sec; of which 90-95% are from groundwater source. The existing water withdrawal comprises few percentages of natural reserves of groundwater resources (Water Resources of USSR, 1971).In south Tajikistan, water supply of local communities and industries had been supplied primarily from streams and in rare occasions from springs. However, during the last years, major water users were switched to groundwater supply systems. Water supply of district centers and many farms is carried out by captation of unconfined groundwater of alluvial deposits through single and group of boreholes. Latter sources are located in the distance of 5-6 km from water users and often in the centers of big collective farms. Small farmes and settlements use wells and irrigation water for water supply. The total groundwater extraction was 6450,5 thousand m^3/day in 1994. 2460,7 thousand m^3/day was used for irrigation and it constitutes about 38% from the total withdrawal (Salimov, 2001).

According to specialists of GIDROINGEO institute, use of groundwater in little volume for irrigation is partially due to economical inefficiency (Mirzaev, 1996., Borisov, 1990). Production cost per 1m^3 of groundwater should be composed of the following:

a) Production cost per 1m^3 by inputs on hydrogeological design-exploration works. Cost of exploration per 1m^3/day of water makes 1-5 US dollars, in an average 2-3 dollars. Cost per 1m^3 for amortization period (10000 days) by inputs on exploration works is 0.01-0.05 dollars.

b) Amortized deduction per 1m^3 is estimated at 0.1 dollars (with borehole discharge of 2500 m^3/day or 29 L/sec).

c) Operational inputs per 1m^3 of groundwater for average discharge boreholes make 0.3-0.4 dollars per 1m^3 of groundwater. Thus, production cost per 1m^3 of groundwater makes about 0.5-1.0 dollars.

Input per 1m^3 of self-flowing surface water supply to farms is 0.13-0.15 dollars, and in the areas of mechanical (pumped) irrigation is about 0.3 dollars. Thus, production cost of groundwater resources is higher than of surface water. However, use of groundwater resources for irrigation purposes will be justified in water scarce conditions.

Production cost of groundwater resources during their operation for irrigation in unfavorable in meliorative degraded lands will be equal to production cost of surface water due to the following reasons: achievement of meliorative effect, increase coefficient of land use, prevention of deterioration of surface river-water quality as a result of drainage water discharge, economy of water due to reduction of evaporation from unconfined groundwater level, etc. According to S.Sh. Mirzaev, uncertainty in economical appropriateness of groundwater use for irrigation is not validated. According to HYDROINGEO Institute, in the Amudarya river basin by 01.01.03 there were drilled approximately 27000 boreholes with different depth, 50-500m, cost of drilling one borehole ranges within 500-2000 US dollars. The boreholes are equipped with pumps of different type with diameter of 6”, 8”, 12” inches, capacity of pumps is 10-70 L/sec, cost of pumping equipment ranges from 610 to 2000 US dollars depending on pump diameter. For operation there is often used electric power of state electric transmission lines, in desert and under-populated areas there are used movable electric power stations, cost per one unit is 6500 US dollars (Personal communication with farmers).

Two types represent existing water conveyance systems: water-pipeline, waterway and rarely transportation in cisterns. Cost of input per m^3/sec for different types of users only depends on technical-economic parameters of water intake and is given above, amounting to 0.06-0.07 USD/m^3/year. Decentralized water supply of rural population, especially downstream Amudarya River, is realized by operation of unconfined groundwater resources by construction and equipment of shallow wells of 15-20m, with setting interval between filters of about 7-15m. Extraction of groundwater resources is made by manually operated pumps, cost of one pump is 100 USD, drilling with equipping steel pipes is 100-150 USD (sands), capacity of pump is 1-2 L/sec. According to David Banks, in Afghanistan, dug wells are typically 3-4 times cheaper than boreholes. Typical drilling prices in Afghanistan are 350-400 Rp/m in soft strata, 900 Rp/m in hard/strata. In some parts of Afghanistan, where demand is high, prices can reach 18-20 USD/m (David Banks, 2001).

CONCLUSION

There is no available data or extensive research reports on groundwater use for agriculture and crop production in Uzbekistan. The existing reports and studies are limited to resource estimation, water balance calculations, water quality for very specific locations and advanced scientific studies or for large scale development assessments where the information about groundwater tend to have very technical purpose. The authors argue groundwater resources are used for agricutlure, livestock and private plots throughout Amudarya River Basin both in Central Asian countries and Afghanistan. Recent drought has facilitated groundwater use by peasents and private farmers in Lower Amudarya. Private farmers than cooperative farms (state owned) use groundwater more excessively due to quick access to cash and fewer bureacratic obstacles. Cooperative famrs need longer procedure in order to obtain and implement drilling and equipment from government bodies. The main methods of groundwater use are traditional and more sophisticated in forms of karezes in Afghanistan and pumping centrifugal mechanisms in Central Asian states. The cost of pumping groundwater varies by countries and the local geology, the deapth of groundwater aquifers. For example, in Uzbekistan the total cost of drilling, installation and hooking up to electrical lines approximately $2,500-5000. On the other hand, in Afghanistan the cost is about $100-1000.

REFERENCES

Borisov V. A., Vavlenko L. I., Musaev T. P., Sultanova D. G. "*Index Assessment of Quality of Drinking Groundwater of Uzbekistan*", Conference Problems of Drinking Water Supply and Ecology, Tashkent, 2002.

David Banks. Norwegian Church Aid - Afghanistan Program (NCAAP), Policy Document: *Guidelines for Sustainable Use of Groundwater in Afghanistan*, 2002.

Fuchinoue, H., Tsukatani, T., Toderich, K.N., Discussion Paper No. 554 *Afghanistan Revival: Irrigation on the right and left banks of Amu Darya* October 2002.

S.Sh. Mirzaev. *Groundwater reserves of Uzbekistan*. Tashkent, "Fan", 1974, p.224.

T. Salimov. *Management of Water Quality*, Dushanbe, 2001.

Water resources of USSR. Volume 14. Central Asia, issue 3, Amudarya river basin. Saint-Petersburg, Gidrometeoizdat. 1971, p. 471.

Aral Sea Basin Program (Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan). Water and Environmental Management Project, Project Document. Volume II – Supplementary Report, May 1998.

Gidroingeo offers (information for customers of Scientific Research Works), Tashkent, 1990.