ENGINEERING SCIENCES

IMPROVEMENT OF WATER ALLOCATION EFFICIENCY IN THE AMU-SURKHAN RIVERS BASIN

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ABSTRACT

In the article efficiency of water distribution in the territory of Amu-Surkon basin is analysed and based on the results, provided the recommendations. The study is conducted within the project QH-A-QH-2018-409 "Increase efficiency of water resources management in Surkhandarya region: improve interbasin re-distribution of the water resources of Surkhandarya and Sherabaddarya Rivers" funded by Uzbekistan government. The main problems of water management in the Surkhandarya region are: outdated irrigation systems requiring an urgent modernization; large dependence on pump irrigation; low energy efficiency of pumping stations due to use of the old high energy-consuming equipment; irrational distribution and large unproductive technical and operational water losses. Increase of sensitivity to climate change with forecasting of 50% water deficit by 2050 leads to drought and further desertification, including impact on food security. In the article some results are introduced related to improve water allocation by redistribution of water resources between the river basins in the region aimed to reduce of pumped water use for irrigation.

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Introduction. The main issue in use of the land and water resources in Uzbekistan is lack of surface water resources. The imbalance between the limited water resources in Surkhandarya region and its irrational distribution hinders the growth of food production in the context of increase in population, which will lead to social problems in near future [2].

Surkhandarya region is located in the south of the Republic of Uzbekistan in Surkhan-Sherobad valley, bordered on the east by Tajikistan, south by the Amudarya River and north-west by Kashkadarya region (ex. Karshi deserts). The Amu-Surkhan Basin includes: Amu-Zang, Surkhan-Sherabad, Tupalang - Karatag irrigation systems and set of pump stations which provide water to agricultural fields in the region. Surkhandarya is a main river in the region formed from the confluence of the Tupalang and Karatag rivers. The total length of the river is 175 kilometers, the basin area is 13,500 square kilometers. There are also such small rivers as Sherabaddarya, Dashnabad, Obizarang, Sangardak, Khojaipak and etc. In the region operates a system of reservoirs as South-Surkhan, Aktepe, Uchkizil, Degrez. Numerous canals including Sherabad, Amu-Zang, Djarkurgan, Zang, Khazarbag-Akkapchgay, Kumkurgan and etc., and over 815 state and private pump stations operate in the region (Fig.1).

Construction of large reservoirs and dense branching of the irrigation network with hydraulic structures dramatically changed water balance in the region, with positive consequences in some parts and negative ones in others. Water supply sharply decreased in southern zone due to significant runoff to irrigating the lands in northern zone, and to compensate water shortage in southern areas, there is need to lift large volume of water from Amudarya River.

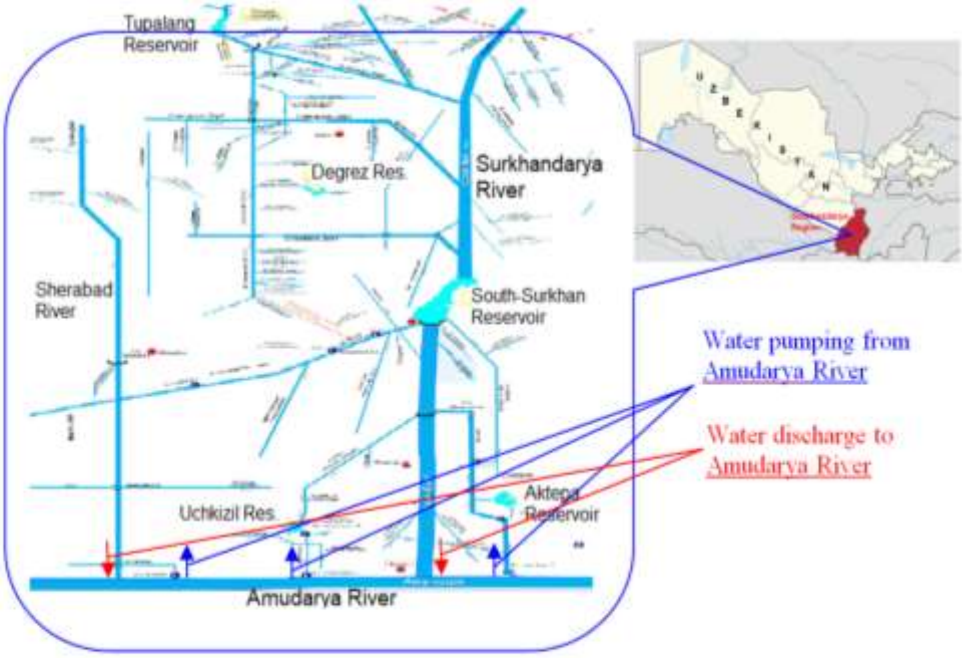

Fig.1 The study area and water infrastructure location

Unsatisfactory water supply is based on the followings: the irrigation infrastructure built in 1960-1980 is outdated, there is a great dependence on pump irrigation, which covers 65% of the total area and consumes 70% of annual budget for operation and maintenance, irrational distribution and large unproductive water losses in the system and irrigating lands [4, 9]. Study of operating experience of the irrigation infrastructures has shown that there are options to improve the situation by redistributing of water resources among Surkhandarya and Sherabaddarya river basins, at the same time reducing of irrigation by water pumping. Drawing up a new scheme of the river flow distribution between the basins can be achieved by GIS modelling of the irrigation systems network. Water allocation calculating and planning, water availability assessing and its effectiveness for short and long term is an urgent and practically significant issue for the region at present.

Methodology and results. Generally accepted mathematical methods and GIS modelling were used in the research [8]. The research has been conducted, including the study of the water facilities state in river basins, their operation modes, water demand and availability, water distribution scheme and its efficiency, including water lifting and energy consumption. A water balance scheme of the Amu-Surkhan basin infrastructure is developed based on MS EXCEL, and calculated considering irrigated territories and water needs of sectors of economy. GIS modeling is conducted with a database of water management facilities of the basin: watercourses, water management facilities (canals, hydraulic structures, reservoirs, pumping stations, hydro posts, etc.) based on ARCGIS, including 3-D

Format [1,7]. Developed an inter-basin redistribution scheme with transfer of Tupalang and Surkhandarya rivers runoff to the Sherabaddarya river basin, and assessed social, environmental and economic efficiency.

Water resources formation and water consumption data analyses show that about 57% of the region's water demand is satisfied (Table 1). The table shows, that 4,157 km^3 of water is formed in the region, but their useful use is 2,195 km^3. The rest part of water is lost in the irrigation network and in the fields. In addition, due to lake of reservoir capacities the excess water of the rivers outflows to Amudarya River.

Table1. Analyses of water availability in the region

Sectors of economy and water demand, Mio m^3		Water sources and resources formation, Mio m^3		Irrigation capacity of the water bodies, Mio m^3	
Agriculture	3660	Surkhandarya River basin	3590	1900	
Communal service	20	Springs and says	219	113,88	
Industry	18	Varsob River	130	67,6	
Others	24	Sherabad River	218	113,36	
		Return water			230
		Tupalang Reservoir			80
		South-Surkhan Reservoir			610
		Degrez Reservoir			10
		Uchkizil Reservoir			80
Total	**3722**		**4157**	**2194,84**	**930**
Total irrigation capacity, Mio m3					**3124,84**
%				**57**	**84**

At the same time, in order to compensate of water demand for Dzharkurgan, Kumkurgan, Muzrabat and Termez districts, water withdraw is conducted from Amudarya River by pumping to Amu-Zang, Kattakum and Jayhun canals (Fig.1.). Long period monthly water outflow and pumping volumes introduced in Fig. 2.

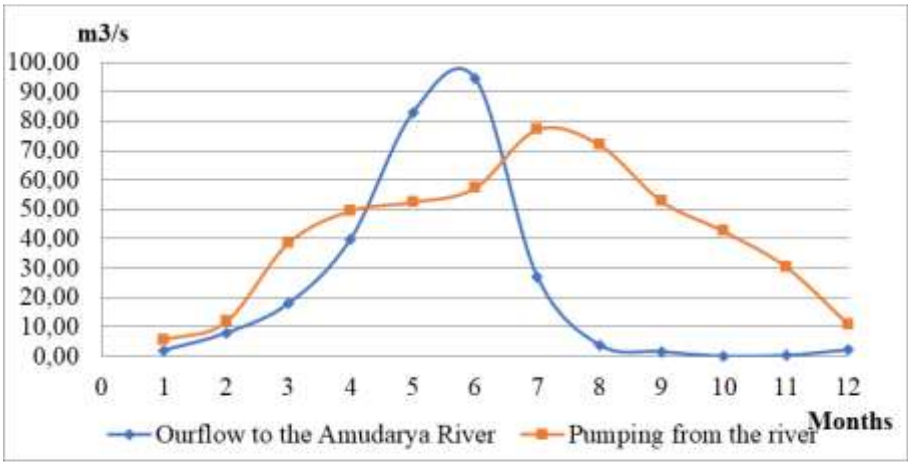

Fig.2. Long term (2004-2019) average monthly discharge data of outflowed to and pumped water from the Amudarya River

The pumping capacity of the region is 330 m^3/s and accordingly, annual volume of pumped water equal to 2097 Mio m^3. Energy consumption is over 930 Mio kilowatt-hour which amounts over $20 Mio US a year.

Study of the irrigation structures operation in the region and water resources management show that there is potential for reduction of water pumping volume, including from Amudarya River, by rational regulation of water resources and redistribution of water among Surkhandarya and Sherabaddarya basins.

Model development. By the GIS facilities vector map of the rivers and interbasin spaces of Surkhandarya region is developed. The operating basin geo-systems characterize a nature-resource potential of the area. The model reflects watersheds, water distributing net (rivers, canals, reservoirs) and drainage system, water pumping points. As standard device the hydrology module is used containing *SpatialAnalyst*, as specialized - *ArcHydro* module, which produces such output products as: hydro graphic map with data and description, river basins and watershed devices, 3D introduction of specified water bodies. Using the data produced by ArcHydro facilities and statistic info the forecasting of flooding and high water can be improved. The water bodies are identified by passport data containing a name, technical specification, operating start date and etc. The pumping stations' data contains pump equipment quantity, motor type, capacity, volume of lifted water, operation start year and etc. To develop the maps the shp format of vector layers and their converting methods are used. As source for vectoring several Surkhandarya maps were integrated to uniform water consumption of the region. For vectoring of line structures EasyTrace and to digitalize the point objects R2V for Windows is used, which matches with many raster objects. To improve the plan map 3D map has been developed with relief characteristics, slope and elevation of the place by using of GoogleEarth package [3,5,6]. The map shows the characteristics at inter active regime and allow monitoring all parameters operatively. The developed device supports the officials to take a right decision at water shortage or flooding periods assess the situation related to hard-to-rich areas along the river banks and reservoirs.

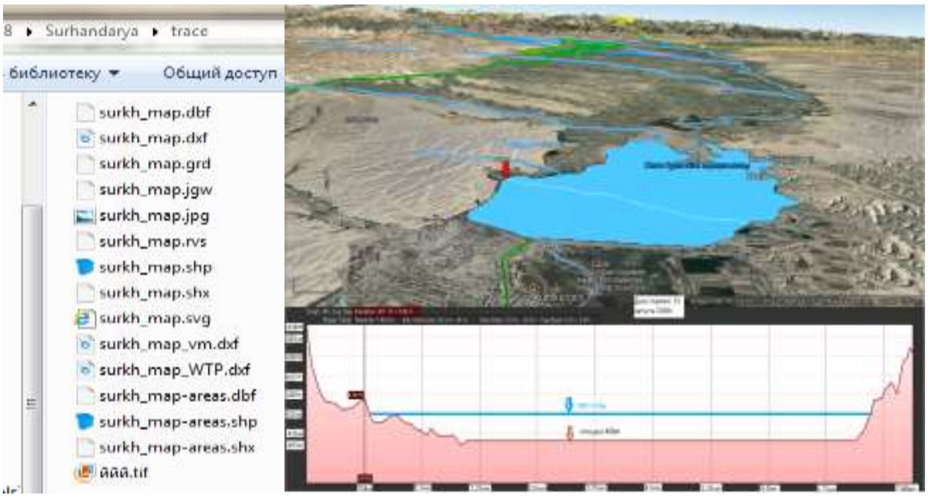

Fig.3. GIS files and South-Surkhan 3D model.

The developed tool allow to find out the places for increase a water reserving capacity of the region: at Sherabaddarya basin - 100 Mio m^3, Aksusay - 90 Mio m^3, Obizarang - 14 Mio m^3 and options to transfer of water dischage by interconnection of the canals (Chilmirob, Akkapchigay and etc.).

Conclusions.

1. Proposed to improve the irrigation systems net leading to reduction of water losses and increase the efficiency of water resources use in the region.
2. Developed soft for calculating the water balance within the Amu-Surkhan Irrigation Basin considering the all irrigated lands, and GIS modelling method of the water structures will improve operative decision making by water management companies in water redistribution among Surkhandarya and Sherabaddarya basins.
3. At rational management of water resources instead of pumping 1320,53 Mio m^3 water from Amudarya River, it would be enough to pump only 585,16 Mio m^3 water, and at the same time $53,5 Mio US would be saved per year due to energy saving.

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