Transfer of Amudarya flowing part to increase the supportability of the Uzbekistan southern regions

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Abstract. The issues of the availability of irrigation water in the southern regions of Uzbekistan, the existing problems in machine irrigation systems, as well as the disadvantages and advantages of the proposed solutions, are analyzed. In analyzing the current situation, a systematic approach was used to address the issue of the availability of irrigation water in the southern regions of Uzbekistan. When choosing the most optimal options for laying the channel, modern methods of GIS technology were used. A situational analysis showed that water availability in the southern regions of the republic is complicated by the change and violation of the hydrological regime of the river basin by the construction of large reservoirs in its upper reaches. To solve problems with the security of the southern regions of the republic, a new concept is proposed for transferring part of the river flow. The proposed new concept of the transfer option differs from the previous ones by a) There are no additional costs for renting the territory of Turkmenistan; b) Conditions are being created for the development of various infrastructures in the southern regions of the republic; c) The construction of a reservoir on the territory of the Surkhandarya region will allow the danger of overflow of the Tuyamuyun reservoir in the winter and increase water supply to the Surkhandarya, Kashkadarya and Bukhara regions of the republic.

1. Introduction
In the early 2000s, water shortages were felt in 29 countries, with a total population of 436 million. By 2025, about 48 countries will be in a similar situation, and the population suffering from water shortages will exceed 1.4 billion. According to preliminary estimates, in 2035, about 3 billion people will live in countries where there is a shortage of water. In addition, many countries whose water resources are limited will depend on water sources shared by several countries, which increases the risk of disagreement and social tension, which is already happening in countries located in the Euphrates, Jordan and Nile basins, etc.

Water resources of Uzbekistan are part of the total water resources available to the Aral Sea basin. The largest rivers of Central Asia belong to this basin: the Amudarya and Syrdarya, which are the main sources of surface runoff and directly flowing into the Aral Sea, as well as the rivers located within the Aral Basin. These include rivers Zarafshon, Kashkadarya, Tejen, Murghab, Chu, Talas, Assa, and many small rivers [1].

The issues of efficient use of water resources have recently acquired special significance for Uzbekistan since the future development of the republic largely depends on how rationally the available water resources are used. For the efficient use and management of water resources, the
development of a water management system with the availability of reservoirs for the implementation of water resources management has been greatly developed.

Water resources of Uzbekistan, i.e. the amount of water that can be used by the state following the interstate agreement of the countries of the Aral Sea basin is 59.2 km$^3$. Of these, 52.4 km$^3$ are accounted for by the river flow, 4.9 km$^3$ - the drain of collector-drainage systems, and 1.9 km$^3$ - groundwater [1, 2].

A significant part of water resources in the republic (up to 90%) is used in agriculture.

If in the republic the total area of cultivated crops is 4.3 mln. hectare, machine irrigation is provided with irrigation water of 2.3 million hectares, well pumping installations - 0.1 mln. hectare, and by gravity irrigation method - 1.9 million hectares. At the same time, for the provision of agriculture in the republic there are a large number of pumping stations, their total number for 2019 was 1,693, and the total electricity consumption is about 8342.77 million. kW * hour and 28.5 tons of diesel fuel per year. Along with small and medium-sized pumping stations in the water management system, there are large and unique systems of machine lifting with a cascade of pumping stations (Karshi, Amu-Bukhara, and Amuzang).

Pumping stations account for a significant part of the energy consumed for agricultural needs. On average, 59 billion m$^3$ of water is pumped over by pumping stations per year, of which 27 billion m$^3$ are supplied by the head pumping stations and 32 billion m$^3$ fall on the second and subsequent stages of ascent. At the same time, the total energy consumption of pumping stations amounted to 8.3 billion kWh or about 15% of the annual electricity generation of all energy in Uzbekistan. If we additionally take into account pumping stations, which are on the balance of farms and collective farms, then the figures for energy consumption become even more significant.

Given this combination of circumstances and the importance of the problem under consideration, at present, there is an urgent need to find new schemes and optimal solutions for the rational use and redistribution of water resources throughout the republic, as well as to reduce the share of machine water rise in providing irrigation water to irrigation water.

2. Methods
In analyzing the current situation, a systematic approach was used to address the issue of the availability of irrigation water in the southern regions of Uzbekistan. The existing problems in machine irrigation systems were analyzed, as well as the disadvantages and advantages of the proposed solutions to them, taking into account the principles of a systematic approach. When choosing the most optimal options for laying the channel, modern methods of GIS technology were used.

3. Results and discussions
The results of studies on the analysis of the operation of pumping stations in the republic showed [3,4] that in recent years, the effective operation of pumping stations has been complicated by the following two factors and reasons:

1. External adverse factors (changes in the hydrological regime of water sources [5, 6, 7, 8], commissioning of large reservoirs in the upper reaches of the rivers) [9, 10, 11, 12];
2. Factors associated with operational disruptions [13].

Currently, water supply in the southern regions of the republic is complicated on the one hand by a change in the hydrological river basin and a violation of the natural regime of the river, caused by the commissioning of large reservoirs in the upper reaches of the rivers (Rogun and other reservoirs). This circumstance complicates the operation of large systems of machine lifting and the required (guaranteed) water intake from the Amu Darya for irrigation on irrigated areas. On the other hand, the general technical condition of pumping stations and their main equipment in the republic is in most cases in unsatisfactory condition.

This combination of circumstances is caused by aging and increased wear of the main equipment, a decrease in their energy performance and energy efficiency [14]. The equipment of many pumping stations is morally obsolete and the issue of modernization and re-equipment of pumping stations is
urgently ripe due to the replacement of existing obsolete and worn-out energy and power equipment at pumping stations with more modern models of foreign and local production using high-tech energy-saving innovative technologies.

Modernization of pumping equipment using the abovementioned innovative technologies will be carried out through phased modernization of pumping station equipment through the installation of capacitor devices to compensate for the power consumed by pumping stations from the power system, as well as through the use of high-tech energy-saving innovative technologies, in particular, through the use of a frequency converter, which a number of authors propose [15, 16].

To solve the problems with the security of the southern regions of the republic, they offer various options for transferring the Amu Darya water to Kashkadarya, Bukhara, and Navoi regions. According to one of these options proposed by the staff of the Scientific Research Institute of Irrigation and Water Problems of the Ministry of Water Resources of the Republic of Uzbekistan (SRI IVP), construction will be provided for three pumping stations and one reservoir in the Boysun gorges. Fig. 1 shows a 1-st variant: Transfer channel with a cascade of pumping stations (to the choice of the route of the new channel for the transfer of Amudarya water).

![Figure 1. 1-st variant: Transfer channel with a cascade of pumping stations.](image)

Employees of the Scientific Research Institute of Irrigation and water problems also offer a 2-nd variant: Gravity flow option of passing the route of the Amudarya water transfer channel (to the choice of the route of the new channel of Amudarya water transfer).

We propose a 3-variant: Scheme of a new variant of laying the route of the channel for the transfer of Amudarya water (Fig. 2) [17].

Ways to solve the problem:

1. Design and construction of a reservoir with a volume of 2.0 km³ in the territory of the Surkhandarya region (in the region of Sherabad, Boysun) to accumulate the discharge costs of Rogun, Nurek, the first and second Saguda hydropower plants operating in the energy mode (accumulation of water resources and their use for irrigation in Uzbekistan, as well as protection against threats of catastrophic flooding during accidents at reservoirs);
2. Construction of a new main canal, originating from the aforementioned new reservoir and transporting the Amudarya water to the Pachkamar reservoir, and further to the irrigation networks of the southern regions of the Republic.

This concept, developed on the basis of retro perspective approaches, differs significantly from other options for the transfer of the following indicators:

- a reservoir is provided for in the supply area;
- the main canal, in an exceptional way, will pass through the territory of Uzbekistan;
- the main part of the main canal will be designed by gravity, which contributes to a sharp decrease in operating costs during transportation of water;
- water withdrawal is independent of the influence of Turkmenistan;
- the water management complex of Uzbekistan, in accordance with the limit allocated to it, will achieve an increase in the volume of used water resources by at least 35%, by increasing efficiency to 85%);
- claims against Tajikistan will be removed since the regulation of the hydrological regime of the upper reaches of the Amu Darya will affect the water consumption schedules of Uzbekistan in a more balanced way.

Figure 2. 3-rd variant: Diagram of a new variant of laying the route of the channel for the transfer of Amudarya water.

Advantages of the concept from existing similar projects

1. Significantly increases the efficiency of the canal, which saves the volume of water resources of Uzbekistan for the Kashkadarya and Bukhara regions by 25-40%, while maintaining the existing irrigation standards for agricultural crops;
2. There are no additional costs for renting the territory of Turkmenistan;
3. By geographical location, the complex will be located near the road and railways Termez - Karshi - Samarkand - Tashkent. This arrangement contributes to the closer development of various infrastructures that will improve the environmental situation along the above roads;
4. The construction of a reservoir on the territory of the Surkhandarya region can serve to achieve two goals:
   • the risk of an overflow of the Tuyamuyun reservoir created by discharges of water in the winter from higher reservoirs in the upper reaches of the Amu Darya will be prevented [18];
   • water supply will be increased through the construction of a new canal of the Surkhandarya, Kashkadarya and Bukhara regions [19];
   • the choice of the dam water intake option can contribute to improving the quality of water taken and the quantitative control of runoff [20].

4. Conclusion
To summarize it is necessary to note the following:
1. Water supply in the southern regions of the republic is complicated by a change in the hydrological river basin and violation of the natural regime of the river by the construction of large reservoirs in the upper reaches;
   2. The general technical condition of pumping stations and their main equipment in the republic is in most cases in unsatisfactory condition. This combination of circumstances is caused by aging and increased wear of the main equipment, a decrease in their energy performance and energy efficiency.
3. To solve the problems with the security of the southern regions of the republic, various options are proposed for transferring Amu Darya water to Kashkadarya, Bukhara, and Navoi regions.
   4. The proposed new concept of the transfer option differs from the previous ones in that it:
      a. There are no additional costs for renting the territory of Turkmenistan;
      b. Conditions are being created for the development of various infrastructures in the southern regions of the republic;
      c. The construction of a reservoir on the territory of the Surkhandarya region will allow the danger of overflow of the Tuyamuyun reservoir in the winter and increase water supply to the Surkhandarya, Kashkadarya and Bukhara regions of the republic.

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