Assessment and forecast of water resources use in Uzbekistan

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Abstract. The article examines the assessment of the state and problems of irrigation water use in the republic in the past and in the near future. A comparative analysis of the state of water resources use for the period of the last 30 years from 1989 to 2019 was carried out. According to the estimates, own water withdrawal for 5 years (2014 / 15-2018/19) shows that an average of 53.2 billion m³ were used for irrigation, including 50.5 billion m³ from rivers. At present (2018-2019), an average of 57.06 billion m³ of water is taken for irrigation of 4.289 million hectares of land, against 63.02 billion m³ approved in 1989. At the same time, the actual water consumption amounted to 48.9 billion m³. Specific water consumption (in the years of average water content) in the Amudarya river basin is 12.5 thousand m³/ha, in the Syrdarya basin - 10.4 thousand m³/ha. Forecast calculations show that there is a tendency to reduce water from rivers to agriculture by an average of 0.104 billion m³/year, with an increase in other sectors from 11.53% (communal and household sector) to 100% (fisheries). The volume of discharges into CDS is decreasing due to the use of collector-drainage waters throughout the region, while specific water consumption has increased to 11.50 thousand m³/year, with an increase in other sectors from 11.53% (communal and household sector) to 100% (fisheries). The reasons for the lack of water for irrigating agricultural crops during the period of vegetative irrigation are stated. The issues of water saving and ways of transition to modern technologies for the use of surface and ground waters, redistribution of water and solutions for the interstate use of river resources are touched upon.

1 Introduction

At the end of the twentieth century, negative changes occurred on the irrigated lands of Central Asia, the drying of the Aral Sea continued, soil degradation, the natural regime of groundwater was disturbed, secondary salinization, shale formation, deterioration of the physical properties of soils, etc. [1]. The main cause of the Aral Sea crisis is a sharp decrease in the inflow of river waters, which is associated with climatic phenomena and anthropogenic human activity and the flow regime of transboundary rivers in the upper reaches of the Amu Darya and Syr Darya (Kirgizstan, Tajikistan). Indeed, if before the 60 s of the last century the

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use of water resources of interstate rivers did not exceed 50%, then in the 90s it reached 90%. The same thing happened in many countries of the world, in the process of human economic activity, serious environmental changes continued (reduction of resources and changes in the mineralogical composition, river and underground waters, decrease in soil fertility, flooding, etc.) [2].

Many countries and regions of the world experience water stress, when the annual water resources per capita are 1000-2000 m$^3$. With resources of less than 1000 m$^3$, many countries are experiencing "water scarcity", more than one billion people, including China and India, live in arid areas [3].

The growing need to provide the population with food and agricultural products in the regions has led to an almost complete selection of river water resources, and a simultaneous increase in the volume of polluted water with the formation of zones of ecological imbalance. The situation in Central Asia regarding the use of water and energy resources is particularly acute due to uncoordinated decisions on the construction of energy giants on the Amu Darya and Syr Darya rivers. These issues were repeatedly discussed at joint conferences and, in particular, at the international conference held in Tashkent on May 12, 2011 in preparation for the 6th World Water Forum.

At the Tashkent Water Forum held in 2012, foreign experts emphasized that even with large-scale efforts of Uzbekistan, the problem of conservation and rational use of limited water resources in Central Asia cannot be solved, an integrated approach is needed, taking into account the interests of all countries and peoples living in the region [4].

In recent years, mechanisms have been created for the effective use of the flow of transboundary rivers on the basis of generally accepted international norms and rules to ensure equal, mutually beneficial cooperation. Studies have established that the main factor of water allocation should be ensuring food security in Uzbekistan, improving the quality of water resources and protecting the natural environment. On the irrigated lands of the Republic, as a result of changes and rising ground water levels, regional salinization of land and local development of the process of flooding within cities and localities are observed. The priority scientific areas of research in the Republic are also the protection of the population and their places of residence from the impact of external stresses and ensuring environmental safety.

According to published reports researchers VCM of the Republic of Uzbekistan and teenish noted that the policy of the government of the Republic of Uzbekistan for the rational use of water resources, reduced water intake to an average of 51 billion m$^3$ magainst 64 billion m$^3$ in 80-ies [6, 7]. Global climate change in the modern world is one of the primary tasks of rational use of scarce water resources.

Physical deterioration of hydro-reclamation systems (HMS), salinity of land, irrational use of water and its low efficiency are the main limiting factor limiting the development of irrigated agriculture. Maximum water conservation and productive use of water is the basis for effective management of irrigated agriculture. The use of advanced irrigation techniques leads to water savings of 2-2.5 times and an increase in yields of 1.5-1.7 times.

From the point of view of approaches to the creation of hydro-reclamation systems of a new generation, it is necessary to find the right ways to create agro-reclamation landscapes that meet the requirements of environmental sustainability, economic feasibility and social requirements.

**2 Methods**

Based on the purpose of the assessment and forecast of water use in the future, it is necessary to conduct in-depth studies, taking into account the need to create a holistic picture both for the entire region of Uzbekistan and for the hydro-reclamation system of each individual
region. Under the current conditions, the main task is to achieve further growth of productive forces in Uzbekistan, which is possible mainly due to increased efficiency of use, accumulated potential in the water sector in order to increase the productivity of each irrigated hectare and cubic meter of irrigation water. To make a practical implementation: - coordinated regulation of river flow on the basis of the commitments and the global and regional partnerships; - joint implementation of new, advanced technologies and irrigation techniques; - on the basis of a comprehensive reconstruction of the HMS, to ensure an optimal reclamation regime on irrigated land in order to protect against secondary salinization; The methods of solving the problems are-analysis of the state of water use in Uzbekistan, comparison of actual data on water use for the period of 30 years from 1989 to 2019 and the presentation of forecast calculations for the period from 2025 to 2050. The method of applying the comparative analysis of annual water resources indicators for Uzbekistan over a period of 30 years allows us to select digital data, assess the state of water use and predict the appearance of deficient years of runoff.

The object of research is the river basin of the Aral Sea and irrigated land. The object of the study in a narrow plan is the WUA in the HMS. which provides agricultural crops with water and drainage through drainage. The main indicators of the analysis and evaluation are: water availability and drainage, which are considered as an indicator of the functioning of the hydro-reclamation system [11, 12].

3 Results and discussion

It is known that the annual volume of water used within the republic is about 18%, and the inflow from neighboring countries is 82%. The approved volumes of water resources for Uzbekistan are 63.02 km³, of which the collector-drainage runoff is 6.84 km³, underground water is 2.59 km³, and tributaries to the Amu Darya and Syr Darya rivers are 53.59 km³ [13, 012009]. In the average annual context for the republic over the past 5 years (2014/15-2018/19), 53.1 billion m³ of water was used, including 50.5 billion m³ from rivers, 0.63 billion m³ from underground sources, m3; return water -1.95 billion m3. Of the total resources of the Amu Darya and Syr Darya rivers, part of it falls on neighboring republics, and Uzbekistan's own fence in 2018-2019 amounted to 57.06 billion m³, against 63.02 km³. The volume of reduction of water intake from rivers over a thirty-year period was 5.96 km³.

In the recent year (2018-2019), an average of 57.06 billion m³ of water was taken for irrigation of 4.289 million hectares of land, i.e. the largest consumer of water resources is irrigated agriculture, which takes 84% of the volume of water resources [6]. The specific water consumption (in the years of average water content) in the Amu Darya River basin is 12.5 thousand m³/ha, in the Syr Darya basin 10.4 thousand m³/ha. The volume of discharges in the CDU is reduced, due to the use of collector and drainage waters throughout the region. The amount of discharge decreased by 21.3 km³ in 2019 compared to 1989, which is 15.2%. However, the intake of waste water for irrigation of repeated crops in relation to the total intake of river water increases annually. In particular, according to the Ministry of Water Resources of the Republic of Uzbekistan, the specific water intake increased from 10.4 thousand m³/ha to 11.50 thousand m³/ha due to a decrease in the area of irrigated land. The analysis of the state of water intake and water use is presented in Table 1.

Table 1. The condition of the water intake and the estimated forecast for the economy of Uzbekistan (according VCM Times and NIIIT)

<table>
<thead>
<tr>
<th>Consumers</th>
<th>Actual water consumption, bln. m³</th>
<th>Forecast of decrease (-) or increase (+) in water consumption, bln. m³</th>
</tr>
</thead>
</table>
Table 1 shows that over 30 years there is a tendency to reduce water intake in agriculture by 8.8%, with an increase in other industries: 11.53% - the municipal and household sector, 11.59% - industry, up to 100% in fisheries. The specific discharge relative to the total intake decreased from 35.38% in 1989 to 23.75% in 2019, or by 11.64 %. The total flow in the republic ranges from 22-24 km³, of which 70% returns to irrigation sources (15.4-16.8 km³).

Currently, additional water reserves are required to obtain the project yield of both primary and secondary crops. In the future, it is necessary to use the waters of technogenic origin, i.e., the flooded territories, the volume of which is from 8 to 10 km³ [14, 15, 17].

Assessing the overall ratio of collected, discharged and used water, the trend of reducing the total water intake in the republic, as well as in individual regions, will continue.

Irretrievable water consumption in agriculture in the near future will be reflected in a decrease in the share of used water from the total volume by 2025 (a decrease in the share over 6 years by 0.86 mld. m³) will amount to 48.04 mld. m³, by 2030 (a decrease in the share over 5 years by 0.71 billion. m³) will amount to 47.33 billion m³.

An analysis of the estimated water intake forecast and the estimated water use is presented in Table 2.

**Table 2.** Estimated forecast for the sectors of the national economy of Uzbekistan in the near future

<table>
<thead>
<tr>
<th>№</th>
<th>Consumers</th>
<th>Forecast of decrease ( - ) or increase ( + ) in water consumption, млрд. м³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>For 10 years (2030-2040)</td>
</tr>
<tr>
<td>1</td>
<td>Agricultural industry</td>
<td>-1.42</td>
</tr>
<tr>
<td>2</td>
<td>Municipal and household</td>
<td>+0.10</td>
</tr>
<tr>
<td>3</td>
<td>Industry</td>
<td>+0.02</td>
</tr>
<tr>
<td>4</td>
<td>Energy industry</td>
<td>+0.98</td>
</tr>
<tr>
<td>5</td>
<td>Fisheries</td>
<td>+0.06</td>
</tr>
<tr>
<td></td>
<td>IN TOTAL</td>
<td>-0.26</td>
</tr>
</tbody>
</table>
Table 2 shows that the trend continues to decrease water intake in agriculture, which will decrease, with an increase in other industries, if overall water consumption in 1989 was 60.19 billion m³, and by 2050 it will be 55.44 billion m³. For the period of 10 years (2030-2040), the decrease in water resources for irrigation will amount to 1.42 billion m³, and for 20 years - 2.84 billion m³ and by 2050 will amount to 43.07 billion m³. This means that the irrevocable water consumption for irrigation will decrease by 4.26 billion m³ on average over the last 30 years (from Table. 2: 1.42 +2.84) and by 2050 will amount to 43.07 billion m³. The largest consumer remains irrigated agriculture, taking 84.04% (2030) and 77.68% (2050), i.e. there will be a decrease of 6.36%. Decrease ( - ) or increase ( + ) in water consumption over the last 20 years: agriculture -4.26 billion m³, with an increase in other sectors: +0.3 billion m³ - municipal and household industry, +0.06 billion m³ – industry, +2.94 billion m³ - energy and +0.18 billion m³ – fisheries [20].

The irrational use of water, land and biological resources of the territory has led most of the regions of the region, especially in the Aral Sea region, the Kyzylorda region (Kazakhstan) to an extreme socio-economic situation [14- 17].

4 Discussion of research

It is known that at the disposal of Uzbekistan there are 11.5 km³ of surface runoff of internal rivers and 42.0 km³ of transboundary rivers, as well as 9.43 km³ of return and underground waters.

A promising area of research is the numerical and information support for the management of runoff and operational regulation of water both at the interstate level and local runoff.

Another area of research is the development of mathematical models that take into account all the details of climate change: drought and water scarcity, etc..

Based on the soil and climatic conditions and the productivity of agricultural land, a set of reclamation measures, irrigation equipment and technologies necessary to increase the productivity of irrigated land is assigned.

Along with the implementation of complex land reclamation (soil moisture, drainage, control with salinization, etc.), the choice of equipment and irrigation technology is important. Systematization of the problems associated with complete depletion of water resources is presented below:

- the water shortage was felt in dry years (1982, 1986, 1997, 2000, 2009, 2013, 2018), what led to the nedopoliva and drying crops during this period, the access to water resources and, first of all transboundary rivers have increased the competition among countries in the region. For example, the waters of the Syr Darya in recent years barely reach the middle of the territory of Uzbekistan, the western regions are almost dehydrated. [21]

- existing and under construction reservoirs in the upper reaches of transboundary rivers do not remove this problem from the agenda [1, 2, 5];

- there was a deterioration of the ecological state in the lower reaches of most large and small rivers and a strong pollution of river waters. The current ecological state of the natural ecosystems of the Aral Basin characterizes the most difficult problem resulting from water consumption and agriculture. The water consumers of the lower reaches receive water for agricultural and domestic needs with a high salinity of 1.5-1.8 g/l, with a concentration of salts exceeding the norms for (k post Kyzylzhar, Amu Darya River) 240% calcium, magnesium -420%, hydrocarbonates -120% and sulfates -620% [6, 16];

- there was flooding of land and settlements, national economic objects. The main cause of flooding is the loss of water from water management facilities. As a result, more than 132
cities and settlements, 7322 cultural and historical objects, of which 2,050 within our Republic are under the negative impact of flooding [17];

5 Conclusion

1. The Republic of Uzbekistan, like other states of the middle and lower reaches of the Amu Darya and Syr Darya rivers, is experiencing a shortage of water resources, especially in low-water years;
2. The demand for irrigation water in the republic increases annually, including up to 59 km$^3$ used for irrigation, which is fully covered by the resources of the trans-boundary rivers Amu Darya and Syr Darya. Calculations have shown that the irrevocable water consumption for irrigation will decrease by 1.57 billion m$^3$ on average over the last 10 years (from Table 1: 0.86 +0.71) by 2030 may be equal to 47.33 billion m$^3$.
3. In the republic over the past 5 years (2014/15-2018/19), an average of 53.1 billion m$^3$ of water was used per year, including from the Amu Darya and Syr Darya rivers -33.04 billion m$^3$, from underground sources – 0.63 billion m$^3$, return water -1.95 billion m$^3$. Of the total resources of the Amu Darya and Syr Darya rivers, part of it falls on neighboring republics, and Uzbekistan's own fence in 2018-2019 amounted to 57.06 billion m$^3$, compared to 63.02 km$^3$ approved in 1989.
4. The volume of water consumption reduction over the thirty-year period (1988/89-2018/19) amounted to 5.96 km$^3$. Non-returnable water consumption in agriculture in the near future will be reflected in a decrease in the share of used water from the total volume by 2025, taking into account the needs of the population (40 million people), to 48.04 billion m$^3$ (against 57.06 billion m$^3$ in 2018/19).
5. Assessing the overall forecast of the ratio of abstracted, discharged and used water, the trend of reducing the total water intake from transboundary rivers in the republic will continue and by 2040 will amount to 45.91 billion m$^3$, and by 2050 it may decrease to 43.07 billion m$^3$. The average long-term decrease in water intake in agriculture will be 19.38 %, with an increase in the social sphere of 27.7% (utilities), industry 26.08%, energy 40% and 24% in fisheries.

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