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Features of the Formation and Utilization of River Water Resources in the Amudarya Basin Under Conditions of Water Scarcity

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Abstract: The article is based on the results of research work carried out by the authors of the article under the grant "Agromeliorative state of the territories of the Amudarya River basin in the context of climate change in Central Asia". Based on the analysis, an assessment is given of the formation of river runoff in the Amudarya River basin in the territory of Uzbekistan with the volumes of the formed river runoff equal to 50% (average long-term) and 90% (low-water year) of provision. The parameters of the formed annual river runoff and for the vegetation period of agricultural crops are given. The climate changes observed in Uzbekistan, associated primarily with an increase in air temperature, have led to a decrease in the volume of snow reserves in mountain basins and, ultimately, to a decrease in runoff and an increase in the frequency of low water periods and droughts. The most vulnerable to climate change are the small rivers of the Amudarya basin, especially the Zarafshan-Surkhandarya, Sherabaddarya and Kashkadarya rivers, which have seen a significant reduction in runoff and an increase in the frequency of low water levels and droughts, especially in the last decade.

Key words: Amudarya, river, canal, water resources, mountain basin.

INTRODUCTION

An essential waterway in Central Asia, the Amudarya River is significant to the region's ecology and economy. The river, which rises in the Pamir and Tien Shan mountains, is vital to agriculture because it supplies water for a vast irrigation system that sustains the livelihoods of a large number of people in the basin. The management of this vital resource is made more difficult by Central Asia's dry environment and the continuous problems with water scarcity. The river's flow is significantly impacted by natural factors such as reduced snowmelt and shifting climatic conditions, as well as by human activities including intensive irrigation and extensive water use. These factors contribute to a marked reduction in river flow, leading to serious environmental and socio-economic consequences. The shrinking of the Aral Sea, altered ecosystems, and the impact on agricultural and economic activities highlight the gravity of these issues [1, 2].

The need and relevance of the analysis and assessment of water resources of the rivers of the Amudarya basin on the territory of the Republic of Uzbekistan are due to the expected reductions in river water to ensure the reliable functioning of the country's strategically important water management facilities: Amu-Zang, Zhailun, KMC and Amu-Bukhara machine canals, as well as industrial and energy facilities of the country: Talimarjan State District Power Plant, Navoi State District Power Plant and Takhiatash State District Power Plant in which up to 9m³ of water are needed to generate 1 kW hour of energy (for the operation of steam condensate turbines converting waste steam back into water), as well as water supply to economic sectors [3]. The use and management of water resources in the Amudarya Basin become critical issues in this environment, especially when there is a water shortage. In order to solve water shortage and ensure sustainable management, this article examines the features of water resource development and usage in the Amudarya Basin. It also looks at various options and obstacles that may arise. The

main emphasis of this conversation is the complex relationship between water supply and government, as well as the socioeconomic and ecological issues facing the area [4-5].

MATERIALS AND METHODS

The Amudarya River Basin, which crosses multiple Central Asian nations including Tajikistan, Afghanistan, Turkmenistan, and Uzbekistan, is the subject of the research. The basin is distinguished by its vast irrigation networks, sporadic snowpack, and dry environment. The research provides a thorough knowledge of the dynamics of the water resources by examining many sub-regions within the basin.

This work offers a thorough investigation of the ways in which anthropogenic causes and natural variability affect river flow in the Amudarya Basin by combining sophisticated climate models with specific hydrological data. Through the integration of data on temperature variations, precipitation variability, and snowmelt patterns, this research offers a comprehensive knowledge of the ways in which climate change affects river flow and water availability. By using this method, future water availability scenarios under different climate circumstances may be predicted with more precision.

The Surkhandarya basin includes: directly the river basin Surkhandarya and the river basin Sherabad. The tributaries of the Surkhandarya rivers Karatag, Sherkent and the left bank of the Obizarang river belong to Tajikistan. In the Surkhandarya basin itself on the territory of Uzbekistan, there are 4355 watercourses, of which 105 are 10 km or more long, and only 33 watercourses are more than 20 km long, not counting the extensive network of irrigation canals and collectors.

In table Table 1 provides data on flow volumes of **50% (long-term average)** and **90% (expected 2024 low-water)** supply for the rivers of the Surkhandarya basin [2].

TABLE 1. Flow volume 50% (mid-year) and 90% (low-water period) of rivers availability in the Surkhandarya basin (km³)

River - point	Annual flow (formation)		Vegetation runoff (use)	
	50%	90% low-water	50%	90% low-water
Surkhandarya - Shurchi village (1970-2019)	2.21	1.14	1.61	0.65
Surkhandarya - below South Surkh. reservoir (1978-2019)	1.04	0.23	0.82	0.08
Tupalang – Zarchob village (1930-2019)	1.75	1.27	1.49	1.06
Tupalang - river mouth Obizarang (1945-2019)	0.88	0.39	0.69	0.30
Akkapchigay river mouth (1991-2019)	0.026	0.013	0.013	0.010
Sangardak – river mouth King-Guzar (1929-2019)	0.49	0.32	0.39	0.26
Sangardak – 7.5 km from the river mouth (1981-2019)	0.40	0.30	0.23	0.10
Khalkajar - Bazar-Joy village (1953-2019)	0.18	0.12	0.14	0.08
Khalkajar – river mouth (1973-2019)	0.23	0.16	0.08	0.04
Khangaronsai - Baisun village (1970-2019)	0.02	0.01	0.01	0.01
Sherabad - Derbent village (1958-2019)	0.14	0.09	0.11	0.05
Sherabad – river mouth Maidan (1970-2019)	0.13	0.09	0.10	0.05
Karatag – river mouth (1983-2019)	0.75	0.35	0.53	0.20

Water resources of the Kashkadarya basin (Table 2). Intensive irrigated agriculture is developed in the basin, and therefore both the Kashkadarya itself and its tributaries are almost completely used for irrigation. The basin lacks its own water resources for this purpose and irrigation systems are fed by a canal from the Zarafshan River basin. The entire western part of the basin is fed by the waters of the Amudarya, supplied through the Karshi main canal.

This research intends to give a comprehensive understanding of the potential and problems related to water resource management in the Amudarya Basin during situations of water shortage by integrating hydrological, meteorological, agricultural, and environmental data.

RESULTS AND DISCUSSIONS

There are 3,122 rivers in the Kashkadarya basin, of which only 149 rivers are more than 10 km long, 33 are 20 or more km long. At various times, observations of water flow were carried out or are being carried out on 18 rivers in

51 sections, and the lower Karasuv River, Garauchashma and Shurabsay are not rivers as such, but so-called “Karasu” in Central Asia, that is, water bodies formed due to the seepage of irrigation water into soils and their release to the surface of the earth naturally below irrigation zones and having all the signs of natural rivers. Of the 51 posts, 25 are located on sections of rivers with a flow regime undisturbed by economic activity, taking into account the Akdarya post - Khazarnau village, which, before the creation of the reservoir above the post in 1984, was also located on a river with undistorted flow. Therefore, only data from these 25 stations are used to assess the natural water resources of the basin [3, 4].

TABLE 2. Flow volumes 50% (long-term average) and 90% (low-water period) of the supply of rivers in the Kashkadarya basin (km³).

River - point	Annual flow (formation)		Vegetation runoff (use)	
	50%	90%	50%	90%
Kashkadarya – Varganza village (1927-2019)	0.15	0.09	0.09	0.05
Varganza - head from the river Kashkadarya (1991-2019)	0.026	0.014	0.013	0.010
Kashkadarya - village Chirakchi (1947-2019)	18.5	10.36	19.85	6.7
Kashkadarya - Chimkurgan reservoir (1970-2019)	0.30	0.10	0.26	0.06
Right Bank Chimkurgan reservoir – head (1976-2019)	0.07	0.04	0.06	0.04
Left Bank Chimkurgan reservoir – head (1976-2019)	0.07	0.04	0.06	0.06
Dzhindydyarya – Jauz village (1947-2019)	1.33	0.84	1.56	0.91
Akdarya, Khazarnava (1928-2019)	11.8	8.1	20.14	12.75
Tankhaz, Kattaghan (1952-2013)	3.86	2.06	6.59	3.74
Yakkabagdarya – Tatar village (1931-2019)	5.83	3.69	10.08	6.15
Guzardarya - Pachkamar village (1971-2019)	4.52	2.73	8.46	4.27
Kichikuryadarya – Gumbulak village (1969-2019)	0.98	0.3	1.27	0.27
Uradarya – Bazartepa village (1966-2019)	3.66	2.13	5.46	2.39

In the Kashkadarya basin, as in many river basins of Central Asia, two areas are clearly distinguished: the region of runoff formation and the region of its dispersion. The boundary between them can be roughly drawn along an isohypse of 600-700 m [5-7].

TABLE 3. Flow volume 50% (medium period) and 90% (low water period) of the rivers' availability in the Zarafshan river basin (million m³).

River - point	Annual flow (formation)		Vegetation runoff (use)	
	50%	90% low-water	50%	90% low-water
Zarafshan (Karadarya) – Khatyrchi (1950-2019)	1082	557	730	382
Zarafshan - Navai city (1967-2019)	1033	518	436	122
Zarafshan - Ziatdin (1939-2019)	2126	1149	1225	569
Akdarya channel. Zarafshan-Khatyrchi river (1950-2019)	536	329	164	42.6
Katta-Kurgan Reservoir – river mouth (1976-2019)	1003	815	406	154
Katta-Kurgan Reservoir – river head (1976-2019)	848	236	688	109
Chegonak head (1991-2019)	26.8	16.2	17.4	11.7
Akdarya - Agalyk (1991-2019)	30.8	13.5	12.0	4.37
Tusun – river mouth (1991-2019)	38.9	5.05	25.2	3.52
Urgut - Urgut city (1946-2019)	13.1	6.62	7.84	3.82
Zarafshan-Ak-Karadar. water conduit (Chupanati) (1946-2019)	1325	687	1143	534
Amankutan – (1970-2019)	33.4	17.7	19.1	8.85
Karagach – Mavlyan village (1979-2019)	9.15	3.15	4.43	1.74
Biglyar – Yangi-Akchab village (1965-019)	15.14	4.42	9.33	1.90

Water resources of the Zarafshan basin (Table 3). The western part of the river basin is located within the Republic of Uzbekistan. Zarafshan, consisting of two parts:

1. Eastern, contoured by low mountains from which small rivers flow, either used for irrigation or drying up, and western plain, practically devoid of permanent watercourses.

2. The eastern Uzbek part of the basin is limited from the east by the state border with Tajikistan in the area of the Rawat-Khodzhin dam [8, 9].

On the territory of Uzbekistan, to the west of the said dam, only a small part of the river flow is formed in small watercourses flowing from the northern slopes of the western spurs of the Zarafshan ridge and the southern slopes of the Nuratau, Karatau and Aktau ridges.[4,5]

The main flow of these rivers comes from the melting of seasonal snow and rains.

In total, there are 2,353 natural watercourses in the basin on Uzbek territory, of which only 137 are more than 10 km longer most small rivers dry up in the summer.

In the river basin Zarafshan's main flow is formed on the territory of Tajikistan and almost completely flows into Uzbekistan in the area of the Rawat-Khodzhin dam.

Observations of water flow on the territory of Uzbekistan were carried out on a total of 13 rivers (including Zarafshan) at 38 points.

In total, on the territory of Uzbekistan in the river basin. Zeravshan is formed by 7,96 m³/s or 254 million m³/year of water resources, while 163 m³/s or 5,139 km³/year or 21 times more than its own flow comes from the territory of Tajikistan.

Lower Amudarya. The beginning of the Amudarya delta is located in the width of the city of Nukus or Tuyamuyun gorge. The hydrological network in the lower reaches of the Amudarya includes posts - Darganata (Turkmenhydrometrology), Tuyamuyun Gorge, Kipchak, Samanbay and Kyzyljar (Uzhydrometrology). Two time periods can be distinguished - before the construction of the Tyuyamuyun reservoir on the Amudarya River in 1980 and after its construction. This reservoir has noticeably changed the hydrological regime of the river, as evidenced by the fact that the average long-term runoff values during the growing season for the indicated periods (1954–1979 and 1980–2013) differ from each other by almost two times (2414 m³/s and 1248 m³/s respectively, Table 4). [7,10]

TABLE 4. Low volume 50% (mid-year) and 90% (low-water period) of the lower amudarya resource (km³).

River - point	Annual flow (formation)		Vegetation runoff (use)	
	50%	90% low-water	50%	
Amudarya - Darganata (1976-2014)	34.8	19.0	48.9	44.7
Amudarya – Tyuyamuyun (1980-2013)	27.5	11.6	19.5	6.8
Amudarya - Kipchak (1980-2013)	16.6	7.4	11.9	3.83
Amudarya - Samanbay (1974-2013)	6.87	0.48	3.95	0.20
Amudarya - Kyzyljar (1974-2013)	6.09	0.48	3.78	0.15

In addition, the noted trend of flow reduction has noticeably decreased compared to the previous period until 1980 due to the regulating capacity of the reservoir. In general, characterizing the hydrological situation of the lower reaches of the Amudarya, it is necessary to highlight a significant portion of the anthropogenic impact on the hydrological regime of the lower reaches, associated with the regulation of flow by the Tuyamuyun hydroelectric complex and significant volumes of water intakes for various needs, primarily for irrigation of agricultural crops, as well as an increase in evaporation losses, especially in dry years.[9,8]

A diversified strategy is needed to solve the issues found. Purchasing contemporary irrigation equipment and enhancing water management techniques are essential first measures. Sustainable management of water resources in the Amudarya Basin will also depend on fostering regional collaboration and creating climate change adaptation plans.

CONCLUSIONS

The climate changes observed in Uzbekistan, associated primarily with rising air temperatures, have led to a reduction in the volume of snow reserves in mountain basins and, ultimately, to a reduction in runoff and an increase in the frequency of low water and drought. The small rivers of the Amudarya basin, especially the Zarafshan River, are the most vulnerable to climate change, Surkhandarya, Sherabaddarya and Kashkadarya, in which there has been a significant reduction in flow and an increase in the frequency of low water and drought, especially in the last decade.

The findings highlight the intricate interactions between irrigation techniques, hydrological changes, environmental effects, and socioeconomic issues, to sum up. A comprehensive strategy that incorporates scientific research, technological innovation, and international collaboration is needed to address these difficulties.

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