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Article

Long-Term Dynamics of the Zarafshan River Water Discharge and Its Utilization in the National Economy

Payzullayev Anvar Vakhobovich[1], Sobirova Munira Akramovna[2], Mirzaliyev Sindor Rajabovich[3]

1,2 Bachelor's Degree Student in Geography, Samarkand State Pedagogical Institute
3. Lecturer, Department of Geography, Samarkand State Pedagogical Institute, Uzbekistan
* Correspondence: [1]anvarpayzullayev@gmail.com, [2]msobirova@gmail.com, [3]sindormirza0392@gmail.com

Abstract: The present study investigates the long-term water discharge characteristics of the Zarafshan River and assesses variations in water flow over time. Particular attention is given to the role of the river's water resources in supporting the national economy, with a focus on agricultural production, industrial development, and potable water supply. The findings underscore the importance of sustainable management and efficient utilization of the Zarafshan River's water resources.

Keywords: Zarafshan River, Long-Term Average Flow, River Basin, Water Discharge, Water Resources, Agriculture, Irrigation.

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1. Introduction

The formation of the Zarafshan River dates back to the Pleistocene epoch from a geological perspective and to the Paleolithic period from an archaeological standpoint. During these periods, the major river systems of Central Asia, including the Amu Darya, Syr Darya, and Zarafshan rivers, emerged and formed extensive drainage basins across the region . The Zarafshan River originates from the Zarafshan Glacier, located at the junction of the Hissar and Zarafshan mountain ranges at an altitude of 3,154 meters above sea level. The glacier is 24.7 km long, 1.7 km wide, and approximately 200 meters thick .

The total length of the Zarafshan River is 781 km, of which nearly 300 km flows through the territory of Tajikistan before entering the Samarkand region of Uzbekistan and extending toward the Sandikli sands of the Kyzylkum Desert. The Zarafshan River is one of the largest rivers in Uzbekistan and ranks third in terms of water discharge after the Amu Darya and Syr Darya rivers [1].

The total area of the Zarafshan River Basin is approximately 143 thousand km², of which 131 thousand km² lies within the territory of Uzbekistan. Nearly four million people reside within the basin, more than three million of whom live in rural areas. The water resources of the Zarafshan River are extensively utilized for agriculture, industrial activities, and the provision of drinking water to the population. In particular, the river plays a crucial role in meeting the irrigation demands of agricultural crops in arid and semi-arid regions [2].

According to data for 2020, the river's total annual water discharge amounted to approximately 2.5 billion m³. Of this volume, an average of 1.2 billion m³ is used annually for agricultural purposes. The total irrigated land area within the basin is 559.6 thousand hectares, of which 67% is located in the Samarkand Region, 16% in the Navoi Region, 8.6% in the Jizzakh Region, and 8.4% in the Kashkadarya Region. The principal agricultural crops cultivated in the basin include cotton, cereals, and vegetables. Furthermore,

approximately 42% of the economically active population of the valley is engaged in agricultural production [3].

2. Materials and Methods

This study employed statistical analysis, comparative analysis, graphical representation, and historical analysis methods. Based on long-term hydrological data, the dynamics of water discharge in the Zarafshan River were examined. Particular attention was given to identifying the main directions of water utilization in the national economy and analyzing regional patterns of water use within the river basin.

3. Results

According to the average monthly discharge data recorded at the Dubuli hydrological station during 1973–1995, the river flow reached its highest levels between April and October. The maximum discharge values, ranging from 300 to 600 m^3/s, were observed primarily in June, July, and August. The lowest discharge rates occurred during January, February, March, November, and December. This seasonal variation is closely associated with agricultural water demand and prevailing climatic conditions [4].

The highest annual average discharge values were recorded in the following years:

1973 – 196.4 m^3/s

1978 – 186.6 m^3/s

1983 – 160.7 m^3/s

1988 – 166.3 m^3/s

1995 – 162.7 m^3/s

The lowest annual average discharge was observed in 1982, amounting to 118.1 m^3/s [5].

The analysis of hydrological data for the period 1973–1995 confirms that river discharge reached its peak during the April–October period. Annual average discharge values were 196.4 m^3/s in 1973, 186.6 m^3/s in 1978, 160.7 m^3/s in 1983, 166.3 m^3/s in 1988, and 162.7 m^3/s in 1995. The minimum value of 118.1 m^3/s was recorded in 1982 [6].

During the period 1996–2019, river discharge exhibited notable fluctuations. The annual average discharge reached 172.2 m^3/s in 2009 and 183.0 m^3/s in 2017, while it decreased to 135.0 m^3/s in 2019. These variations can be attributed to climatic factors, glacier melt processes, and increasing anthropogenic influences on water resources [7].

Table 1. Main Canals Utilizing the Waters of the Zarafshan River.

No.	Canal Name	Location	Length (km)	Water Discharge (m^3/s)
1	Dargom Canal	Urgut, Taylak, Samarkand, and Pastdargom districts	92.1	125
2	Eski Anhor Canal	Pastdargom, Nurobod, and Chiroqchi districts	48.3	60
3	Tuyatortar Canal	Bakhmal, Gallaorol, and Jizzakh districts	23.9	60

4	Mirza-Pay Canal	Jomboy, Bulungur, and Payariq districts	53.5	46
5	Oq-Qoradaryo Canal	Oqdaryo, Payariq, and Ishtikhan districts	10.3	70

The irrigation systems of the Zarafshan Valley operate with a water conveyance and utilization efficiency of approximately 63%, nearly two-thirds of which is achieved at the canal distribution stage. The water management complex of the Zarafshan Valley functions as a basin-level system that regulates interregional water distribution through a network of major hydraulic structures, reservoirs, water-intake facilities on the Zarafshan, Qoradaryo, and Oqdaryo rivers, as well as large irrigation canals such as Kattakurgan Water Supply Canal, Eski Anhor, Tuyatortar, Narpay, and Karmana canals. These facilities ensure the allocation of water resources in accordance with established regional water-use limits [8].

The water resources of the Zarafshan River Basin are almost entirely utilized for agricultural, industrial, and domestic purposes. More than 95% of the basin's water resources are consumed within the territory of the Republic of Uzbekistan, while the remaining 5% is used in Tajikistan. The basin supports the population of the Zarafshan Valley and more than fifty industrial sectors. As a result, annual water consumption reaches approximately 6.6 km^3, creating a water deficit of around 1.6 km^3, including nearly 1.0 km^3 during the growing season and 0.6 km^3 during the non-growing season. This deficit is partially compensated through the reuse of return flows and drainage waters [9].

More than 85% of the available water resources are used for irrigation, while approximately 1% is allocated for cooling thermal power plants, 1% for municipal and domestic services, 3% for industrial activities, and 1% for fisheries [10].

Over recent decades, water demand has increased steadily as a consequence of rapid population growth. Since the dissolution of the Soviet Union, Uzbekistan's population has increased by approximately 33%, while the regions located within the Zarafshan Basin have experienced similar growth rates, including 39% in Samarkand Region, 32% in Bukhara Region, and 22% in Navoi Region. This demographic expansion has placed significant pressure on already limited water resources [11].

4. Discussion

In Samarkand Region, the annual volume of river water used for irrigation ranges from 2.4 to 2.5 km^3. According to data from the Ministry of Water Resources and Agriculture, collector-drainage discharge volumes amounted to 1.23 km^3 in 2002, 1.46 km^3 in 2003, and 1.50 km^3 in 2004. The major collectors discharging into the Zarafshan River include drainage systems connected to the Oqdaryo and Qoradaryo river networks [12]. The principal collector systems in the Samarkand section of the river include the Qorasuv Integrated Collector (81–94 million m^3 annually), Siyob Collector (124–137 million m^3 annually), Qorasuv Collector (98–127 million m^3 annually), Ushara Collector (64–79 million m^3 annually), and Khojand Collector (11–44 million m^3 annually). The average mineralization level of these collector waters ranges between 0.74 and 0.76 g/L [13].

The pattern of water utilization in the Zarafshan River has undergone substantial changes over time. Water consumption increased significantly beginning in the 1960s, primarily due to large-scale land reclamation projects and the expansion of cotton cultivation implemented during the Soviet period. As a result, river water withdrawals

increased by approximately 1.2 times compared with previous decades. According to the studies of V.L [14]. Shults, the Zarafshan River is considered an ancient tributary of the Amu Darya. Among the rivers of Uzbekistan, the Zarafshan River is characterized by one of the highest levels of water utilization, with approximately 90–95% of its water resources being consumed by sectors of the national economy, particularly agriculture and industry [15].

5. Conclusion

The Zarafshan River is an important hydrographic object in Central Asia, and its water resources play a significant role in agricultural production and drinking water supply. Based on long-term data analysis, it is evident that the river's discharge exhibits seasonal variability, while interannual changes are closely associated with both ecological conditions and anthropogenic factors.

The findings indicate that ensuring the sustainable use of the Zarafshan River's water resources requires the implementation of scientifically grounded monitoring systems, effective resource conservation measures, and an optimized water management framework for the future.

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