

On the shifts of the flood period of the Zarafshan and Piskom rivers under climate change conditions

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Abstract. The article is devoted to assessing shifts in the timing of floods on the Zarafshan and Piskom rivers under climate change conditions. For this purpose, based on the daily water flows recorded during the BCP and TCP periods, flood hydrographs of the studied rivers were constructed. As a result of comparison of hydrographs, shifts of 8-12 days in the beginning and end of the flood on the studied rivers were revealed.

[Rakhmat Ziyayev, Fazliddin Khikmatov. **On the shifts of the flood period of the Zarafshan and Piskom rivers under climate change conditions.** *Nat Sci* 2025,23(6):33-37]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). <http://www.sciencepub.net/nature> 04. doi:[10.7537/marsnsj230625.04](https://doi.org/10.7537/marsnsj230625.04)

Key words: river; flood; flood timing; climate change; shifts; assessment

1. Introduction

Today, as a result of climate change observed on Earth, the issues of effective use of existing water resources are becoming more complex every year. In such circumstances, it is extremely important to study water resources in Central Asia in their inextricable link to security, energy, food, and the environment, and to assess their quantitative changes. It is known that in recent years, quantitative changes have been observed in the flow of mountain rivers under the influence of the above-mentioned process. Studying this issue using the examples of the Zarafshan and Piskom rivers and drawing relevant scientific conclusions in this regard is one of the pressing issues of today.

2. Thematic literature analysis

Many scientists have conducted their scientific research on the issues of assessing quantitative changes in the flow of mountain rivers. In particular, in the last century, this issue was addressed by V.G. Glushkov, E.M. Oldekop, L.K. Davidov, M.I. Lvovich, V.L. Schulz, O.P. Sheglova and others, while currently this issue is being studied by researchers such as V.E. Chub, F. Khikmatov, L.M. Karandaeva, B.D. Salimova, D.Y. Yusupova, S.A. Khaidarov [2, 4]. However, this issue was not considered as a separate object of research in the case of the Zarafshan and Piskom rivers during the flood period. This research differs from the above studies in that the main focus is on determining the elements of the flood period of the Zarafshan and Piskom rivers. The main goal of this research work was to assess the shifts in the timing of river flood flows under climate change based on data from hydrological observations conducted over many years. To achieve the goal of the work, the following tasks were set: Collecting and creating a database of multi-year data on daily water consumption measured

at hydrological stations on the Zarafshan and Piskom rivers; Statistical analysis of the collected hydrological data by dividing it into two periods, namely the base climate period (BCP, 1961-1990) and the current (CCP, 1991-2020) climate periods; Determine the average multi-year daily water consumption based on the daily water consumption data observed in both accounting periods and draw river hydrographs based on this; determine and analyze the shifts of hydrographs in the accounting periods under climatic conditions; To determine quantitative changes in the flow of rivers studied in the BCP and CCP and draw appropriate conclusions.

In the article, the Zarafshan River from the Amu Darya basin and the Piskom River from the Syrdarya basin were selected as the objects of research. The subject of the research is the determination of the shifts in the duration of the flood period in these rivers under changing climatic conditions.

3. Material and Methods

The research initially examined the monthly changes in the flow rates of the Zarafshan and Piskom rivers during the year for the baseline (BCP) and current (CCP) climatic periods. For this purpose, data on average monthly water consumption for the base (1961-1990) and current (1991-2020) climatic periods were collected at the Dupuli hydrological posts of the Zarafshan River and the Mullala hydrological posts of the Piskom River. Based on this hydrological data, average monthly water consumption values were determined for each accounting period. Using average monthly water consumption, annual changes in river flow were studied and analyzed for each accounting period (figure 1).

We will begin the analysis with the Zarafshan River under study. The highest monthly flow value of the Zarafshan River during all accounting periods fell

on July. However, they differ in quantity. For example, the value of the largest flow volume during the base climatic period was $1200 \cdot 10^6 \text{ m}^3$. By the current climatic period, the maximum flow volume in July was significantly smaller than in the baseline period ($1069,9 \cdot 10^6 \text{ m}^3$). Average multi-year flow volumes were determined for these accounting periods. The average multi-year flow volume in the river during the base climatic period (1961-1990) was $4840,4 \cdot 10^6 \text{ m}^3$,

but in the current climatic period it has decreased significantly and amounted to $4630,4 \cdot 10^6 \text{ m}^3$. This means that the amount of water in the river has decreased by $210 \cdot 10^6 \text{ m}^3$ over the past 60 years. This figure is 4.4 percent above the multi-year average flow. In the Zarafshan River, the annual flow distribution in the JID compared to the BID was higher in almost all cases, except for May-June [1, 4].

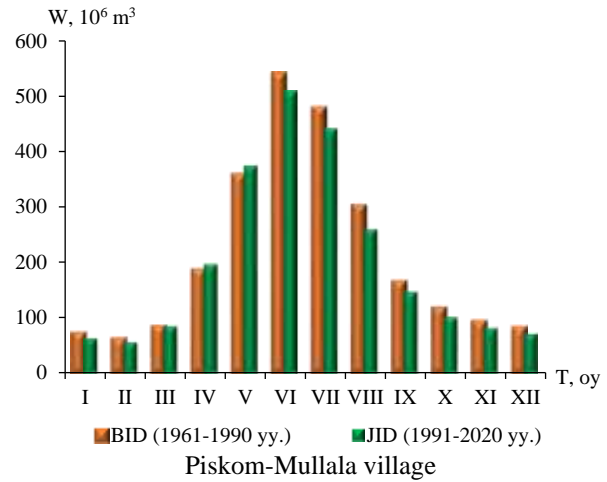
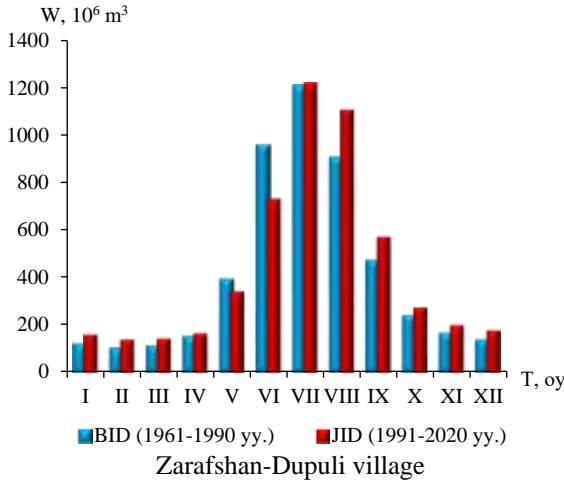


Figure 1. Distribution of river flow rates in the BCP and CCP by month during the year

4. Results

As can be seen from the graph drawn for the Piskom River, the largest monthly value of the river flow during the year in the BID and JID occurred earlier than in the Zarafshan River, namely in June. The flow rates in the Piskom River during the studied accounting periods differ from each other. For example, the value of the largest flow volume during the base climatic period was $538,7 \cdot 10^6 \text{ m}^3$. By the current climatic period, the largest flow volume in June had decreased slightly compared to the base period, amounting to $507,6 \cdot 10^6 \text{ m}^3$. In the baseline natural climatic period (1961-1990), the average multi-year flow volume was $2512 \cdot 10^6 \text{ m}^3$, and in the current climatic period it is $2354 \cdot 10^6 \text{ m}^3$. The water level in the Piskom River decreased by $157 \cdot 10^6 \text{ m}^3$ during the year in the CCP. This value is equal to 7 percent of the annual flow.

calculated water flows (figure 2). From these hydrographs, elements of the flood period were determined (Table 1). Hydrographs drawn together for BCP and CCP were analyzed. The dates of the beginning of the high water period in the Zarafshan River were observed to be almost identical in both calculation periods. However, their deadlines were pushed back by a week in the CCP. As a result of this shift, the total duration of the flood period in the CCP has also been extended by one week (Table 1).

In the next stage of the research, in order to determine the shifts in the flood period of the Zarafshan and Piskom rivers, average daily water flows were calculated for two periods, namely BCP (1961-1990) and CCP (1991-2020).

The hydrographs drawn for the Zarafshan River clearly show shifts in the observation periods of maximum water flows. For example, in the BCP, maximum water consumption was observed on July 14, while in the CCP, the observation period for maximum water consumption falls on July 26. This date indicates that the maximum water consumption observation period in the CCP has shifted by 12 days compared to the BCP. The CCP hydrograph has shifted to the right relative to the previous BCP. This shift averaged 10-12 days during the high tide period and 8-10 days during the low tide period [2, 7].

Flow hydrographs were drawn using the

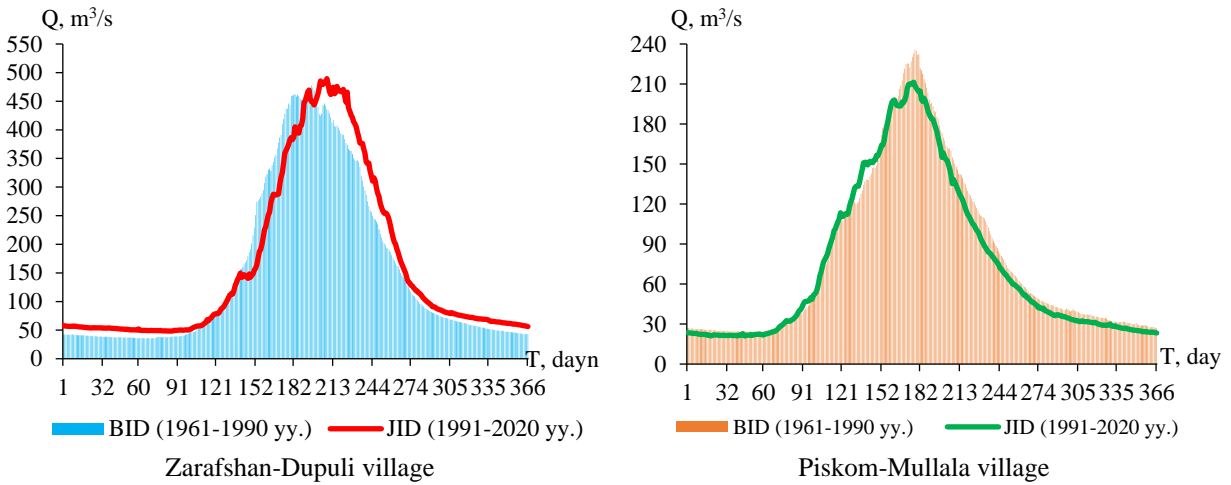


Figure 2. River hydrographs for BCPs and CCPs

Table 1

Elements of the flood period identified for BCPs and CCPs of rivers

Accounting periods	Start date	End date	Continued, day	Water consumption, m ³ /sec			Flow volume, 10 ⁶ m ³
				max	min	o'rt.	
Zarafshan-Dupuli village							
BCP (1961-1990 yy.)	27.IV	04.X	161	$\frac{478}{14.VII}$	73,2	286	3978
CCP (1991-2018 yy.)	27.IV	10.X	167	$\frac{489}{26.VII}$	74,2	282	4069
Piskom-Mullala village							
BCP (1965-1990 yy.)	17.IV	28.VIII	134	$\frac{236}{26.VI}$	73,7	152	1759,8
CCP (1991-2020 yy.)	15.IV	20.VIII	128	$\frac{211}{25.VI}$	73,3	148	1636,8

Piscom River hydrographs, drawn together for BCPs and CCPs, were also analyzed. In the studied accounting periods, the beginning of the high water period was observed on almost the same dates, with a difference of one day. However, the difference between their expiration dates was 8 days. It is noted that the end of the flood period in the CCP was earlier than in the BCP. As a result, the total duration of the flood period in the CCP has also been reduced by one week.

There is also no significant difference in the periods of observation of maximum water consumption from hydrographs. However, there are certain changes in their values. For example, the maximum water consumption value during the flood period in the BCP was 236 m³/s, while in the CCP it was 211 m³/s. The difference between them is equal to 25 m³/s [1, 2].

The river's BCP and CCP hydrographs are

almost identical, with the exception of some minor shifts in the parts from the rise to the peak of the flood period hydrographs. There is a certain degree of fluctuation between its peak and the end of the high water period. The hydrograph shows that this shift is slightly delayed in the CCP compared to the BCP. Changes in flow rates during low water periods were also recorded in the Piskom River, both in the BCP and the CCP.

5. Conclusion/Recommendations.

Based on the results of the study, the following conclusions should be made:

1. In the studied Zarafshan River, the highest monthly value of river flow during the year in BCPs and CCPs occurred in July. However, they differ in quantity. For example, the value of the largest flow volume during the BCP climatic period was 1200·10⁶ m³. In the current climate period, the largest flow

volume in July was slightly larger ($1210 \cdot 10^6 \text{ m}^3$) than in the base period. This can be attributed to the accelerated melting of glaciers in the basin as a result of climate change in recent years;

2. The highest monthly flow value in the Piskom River during different climatic periods during the year was recorded in June. The value of the largest flow volume in the BCP was $538.7 \cdot 10^6 \text{ m}^3$, while in the CCP, the largest flow volume in June decreased slightly compared to the BCP and amounted to $507.6 \cdot 10^6 \text{ m}^3$. It was determined that the water content in the river decreased by $157 \cdot 10^6 \text{ m}^3$ in the 2018-2019 period;

3. The beginning of the high water period in the Zarafshan River in the two calculation periods was at the same time, and the difference between its end dates was 6 days. However, we are convinced that the time when the highest water flow during the flood period in the river was observed has shifted. For example, the highest water level in BCP was observed on July 14, while in CCP this value shifted to July 26;

4. There was no noticeable difference in the timing of the onset of the flood season in the Piskom River between the BCP and the CCP. However, the difference between their expiration dates was 8 days. It has been observed that the end of the flood period in the current climate period is earlier than in the baseline climate period. As a result, the total duration of the flood period in the CCP was shifted and reduced by one week. This indicates that the melting of glaciers in the Zarafshan and Piskom basins is accelerating due to global and regional warming.

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4/4/2025