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ABOUT THE REACTION OF THE DRAIN OF RIVERS WITH GLACIER FOOD TO CLIMATE HEATING

Abstract: *The article discusses the change in river flow with glacial nutrition during global warming. It was established that on the Sokh river with a large share of glacial nutrition, a low-water period had been observed until the mid-seventies, after - during a period of global warming - a high-water period. Accordingly, in the cool period there was an increase in the area of glaciers, during the period of warming - a decrease. The latter can lead to a significant negative trend in runoff and an increase in its variation, which has been observed in recent decades in the river basin Isfayram.*

Key words: *global warming, rivers with glacial nutrition, rivers of glacial-snow nutrition, runoff distribution, water content, runoff modulus, annual runoff, glaciation, gauging station, hydrological year, mean long-term runoff, precipitation.*

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Introduction

As you know, the economies of the Central Asian republics, especially Uzbekistan, are largely based on irrigated agriculture. Moreover, there is a significant increase in population. Therefore, the problem of water scarcity in Central Asia is becoming more acute. Modern climate warming can exacerbate this problem.

As you know, global warming of the twentieth century is recognized as unparalleled in the last millennium. The average annual global air temperature for 100 years rose by 0.60 ± 0.20 ° C. The warming was uneven and the 20th century can be divided into 3 parts - warming in 1910-1945, slight cooling in 1946-1975 and sharper warming after 1976. [1]. Forecasts due to global warming for Central Asia, as well as around the world, range from apocalyptic to a decrease in the desert area [2 - 4]. According to the most unfavorable scenarios, the flow of the Syrdarya in the future may decrease by 30%, and the Amu Darya - by 40%. Other scenarios show that in the future the annual runoff of the Central Asian rivers will not change significantly [4].

On the basis of such conflicting forecasts, it is extremely difficult to draw any conclusions for planning the sustainable development of the Central Asian republics, especially Uzbekistan, and to develop adaptation measures to mitigate the possible negative effects of climate warming.

More or less confidently, one can say about the change in the annual distribution of runoff, since with the warming of the climate the proportion of liquid precipitation increases, snow accumulation decreases, the areas and volumes of glaciers decrease, which is noted by many authors [5].

However, there is no unanimity in this. For example, in [6] an almost ubiquitous increase in precipitation was noted, incl. and in the mountains, and [7] speaks of an almost universal decrease in them [7]. On the basis of the analysis of the runoff of the Zarafshan and Vakhsh rivers, it is concluded that the reduction in the area of glaciation does not have a noticeable effect on the water content of the rivers, since this effect, firstly, falls within the accuracy of annual runoff measurements, and secondly, runoff due to the melting of snow accumulated in the area of the basin freed from ice is more important than ice under the measure at the ends of glaciers. Obviously, such a statement is difficult to agree with.

It contradicts the well-known estimates established on the basis of numerous studies and cited in generalizing monographs in various regions [8] that with an increase in the proportion of glaciers in the total catchment area:

- the drain modulus increases;
- the variability of annual runoff sharply decreases;
- in the annual distribution of runoff, the share of runoff increases for July-September, when there is an acute shortage of irrigation water during irrigated agriculture.

This article is devoted to the study of these differences based on the assessment of changes in the main elements of the flow of some rivers of the Ferghana Basin during global warming. For the characterization of runoff with a large share of glacial nutrition, the data on r. Sokh. Its watershed is located on the northern slopes of the Alai Range, it is characterized by a high degree of glaciation; about 10% of the catchment area, equal to 2480 km^2, is covered by glaciers. Therefore, the river belongs to the type of glacial-snow supply, is characterized by increased water content among the rivers of the Ferghana Valley.

Initial data

The area of glaciation of the river basin Sokh was first calculated by I.A. Ilyin on the basis of topographic maps of 1948 (with clarification by expeditionary research) [9]. According to the materials of topographic maps, aerial photographs until 1968, and expeditionary studies, the condition of these glaciers was determined by A.S. Shchetinnikov [10]. Subsequently, on the basis of aerial photographs of 1975 [11] and satellite images of 1980 [12], he repeated his calculations. And, finally, the next calculation was made from satellite images of ACTER TERRA in 2001 [13]. Their data are summarized in table 1 n fairness, it should be noted that some authors consider these changes in the area of glaciers to be the result of inaccuracies. Here we should mention the conclusion of A.S.Schetinnikov that all glaciers are shown on topographic maps, but their images do not always correspond to the truth [10]. But here we can hope for a sharp decrease in the total error when summing up the areas of a large number of glaciers.

Table 1. Glacier areas in the Sokh river basin

Year	Glacier area, km^2	Change, km^2	Annual change in glacier area, km^2
1948	170	-	-
1968	258,7	88,7	4,44
1975	282,7	24,0	3,43
1981	244,1	-38,0	-6,44
2001	198,3	-45,8	-2,20

The data table 1 show an increase in the area of glaciers in the river basin. Sokh until the mid-seventies, and then reducing their area. This means that the change in the area of glaciation occurred in accordance with the periods of cooling and warming; in the cold period there was an increase in the area of glaciers, in the cold period there was an increase in the area of glaciers, in the period of warming - its decrease.

When studying the regime p. Sokh, data from observations of the only Sarykand gauging station on this river were used for the observation period from 1927 to 2018. During this period, at this gauging station in hydrological yearbooks, there are no average annual runoff values only for

1931 and 1942 due to a break in the observations for June 1931 and July 1942, attempts to calculate them according to the relationship between the runoffs of neighboring months and neighboring rivers for these months did not give the desired results.

Therefore, the possibility of accepting runoff over these months equal to their mean long-term values was checked. The check showed that with this method the average error in calculating the annual runoff is 3,6%, the maximum error in the absence of data for July can be 13%, for June - 9%. Thus, a full range of Sokh river runoff was obtained for 1927 - 2018.

For other rivers, the restoration of missing data was carried out on the basis of correlation between the flow of neighboring rivers at

$r = 0{,}86 \div 0{,}92$. [14].

Based on these data, the chronological course of the annual runoff, its values smoothed over five years, and the integral difference curves (Fig. 1), which indicate the presence in the runoff of the river, were compiled. Sokh of two main periods - low-water (until 1976) and high-water (since 1976).

The same figure shows for comparison the integral-difference curves of the annual runoff of the Tentaksay River, collecting its waters on the southwestern slopes of the Ferghana Range, and the river. Padshaata - on the southeastern slopes of the Chatkal Range. In the basins of these rivers, the areas occupied by glaciers are insignificant - less than 1% of the catchment area. As can be seen from fig. 1, curve p. Padshaata is directly opposite to the curve p. Sokh, and r. Tentaxai, whose water collection is more favorably oriented with respect to moisture-bearing air masses, has a more frequent change in low-water and multi-water periods. It should be noted that the flow of these rivers is mainly formed due to precipitation of a given hydrological year.

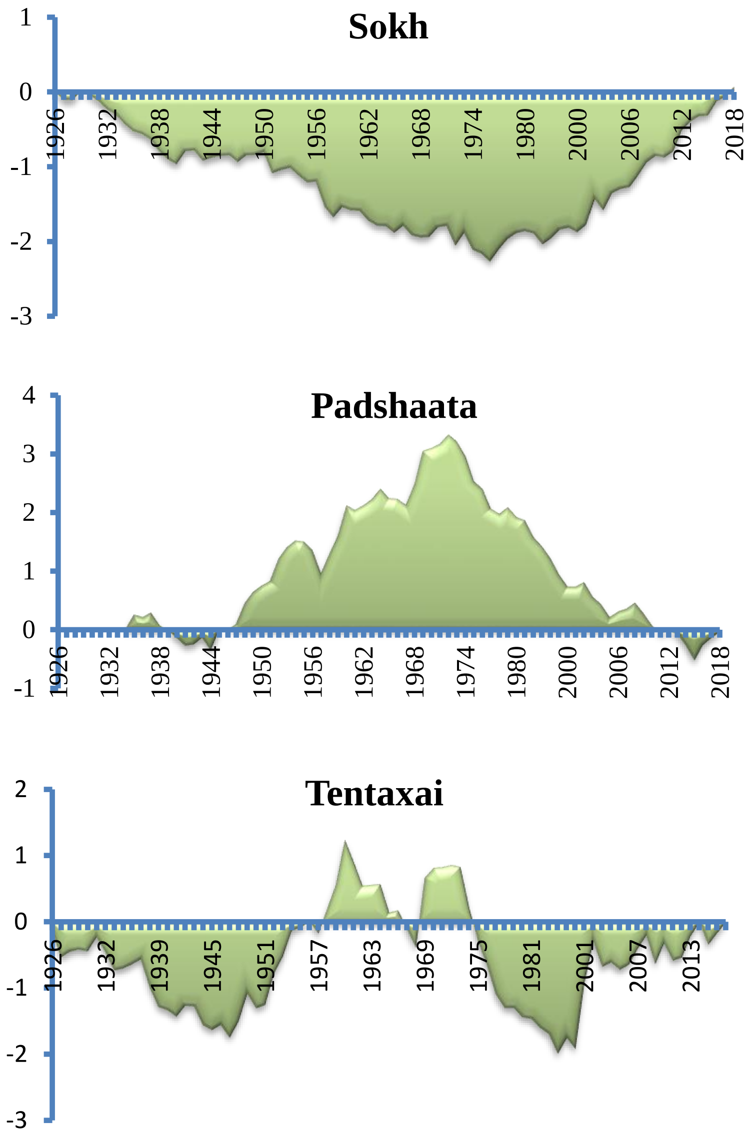

Figura 1. Integral-difference curves of the annual runoff of the Sokh, Padshaata and Tentaxai rivers.

Discussion

1. In hydrology, it has been established that glaciers are regulators of the annual flow of rivers - in years with low rainfall they replenish the flow of rivers; and vice versa - in snowy years, part of the precipitation falls on the replenishment of the consumed glacier reserves [8,15]. Therefore, the runoff of rivers with a large share of glacial nutrition is characterized by small coefficients of variation of C_v. For example, at r. Sokh C_v = 0,13. Comparison of the data table 1 and fig. 1 allows us to conclude that glaciers are not only regulators of the annual flow of rivers; such ability of glaciers is manifested even in thirty-year climatic periods. For example, on the river Sokh during the warming period (1975 - 2018), the average annual flow was higher than the cool period (1945-1974) by 12%, while on the river. Padshaata, in

the catchment of which there are few glaciers, we have a 16% decrease in runoff.

2. An important feature of runoff from glaciers is its flow mainly in July - September, when the demand for irrigation water is greatest. Therefore, as the main indicator of the classification of mountain rivers by type of food V.L. Schultz [8] proposed the ratio of runoff for July - September to runoff for March - June $\delta = W_{VII-IX} / W_{III-VI}$. The integral-difference curves W_{VII-IX}, W_{III-VI} and δ are shown in Fig. 2. Stock for July-September is 60%, for March - June - 23% per annum. As can be seen from fig. 2, the integral-difference curves W_{VII-IX}, W_{III-VI} repeat the course of the integral-difference curve of the annual runoff: the period of their low values before 1976 and high values - during the period of warming after 1976 are highlighted. W_{VII-IX}, this situation can be explained by the increased melting of glaciers during the warming period.

The increased runoff W_{III-VI}, which is formed mainly due to precipitation from the previous winter-spring period, during the warming period cannot be explained by changes in the precipitation regime, since an increase in precipitation was not observed by meteorological observations. This is confirmed by data on the flow of the rivers of the Ferghana Valley, with a small proportion of glacial nutrition. In them, both W_{III-VI} and W_{VII-IX} significantly decreased during the warming period [14]. In this situation, the increased runoff for the period March - June can be explained only by the earlier onset of melting glaciers and replenishment of runoff of this period due to the melting of long-term ice reserves. For this reason, it is possible that the influence of climate warming on δ by its integral-difference curve is clearly not detected (Fig. 2c).

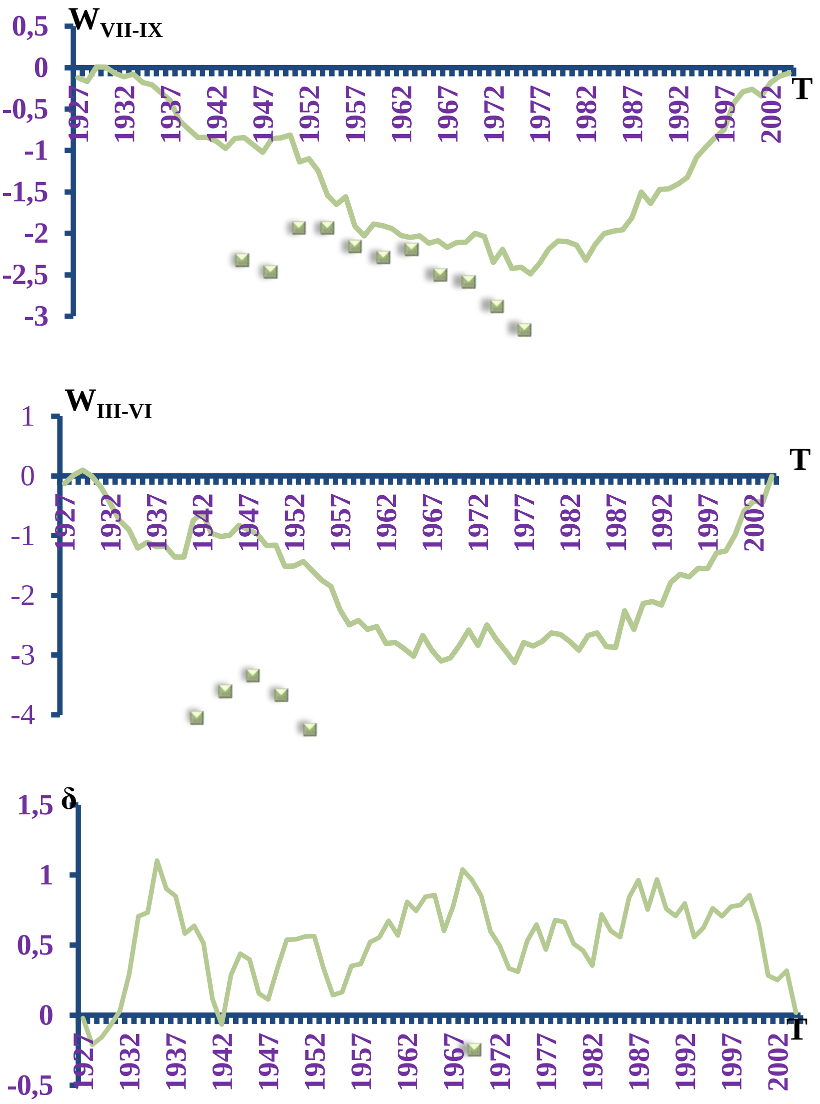

Figura 1. Integral-difference curves W_{VII-IX}, W_{III-VI} and и δ p. Sokh.

3. It should be noted that there is a close relationship between the annual runoff of Q and $Q_{VII\text{-}IX}$ of glacial rivers: the correlation coefficient r = 0,87 ± 0,15, which is explained by the large share of runoff for VII-IX in the annual runoff. The relationship $Q = f(Q_{III\text{-}VI})$ is slightly weaker, but also has a high r = 0,79 ± 0,11. Moreover, the relationship $Q_{III\text{-}VI} = f(Q_{VII\text{-}IX})$ is rather weak, R = 0,47 ± 0,27.

4. Since July - September accounts for 60% of the annual flow of the river. Sokh, we have the right to rely on determining the value of δ by the drain of this period. However, the calculations showed that there is no connection between δ and $\Sigma Q_{VII\text{-}IX}$ - r = 0,13 ± 0,01. And the dependence $Q_{III\text{-}VI} = f(Q_{VII\text{-}IX})$ has R = -0,75 From here the following conclusion suggests itself . The long-term average δ value is determined by the share of glacier runoff in the long-term average runoff, and the annual δ values are mainly a function of the total precipitation for a hydrological year. This is confirmed by the fact that the runoff of the river. Sox for the period July - September has a small coefficient of variation; C = 0,25, and in March C = 0,42.

5. The subsequent decrease in the area of glaciers can lead to a noticeable decrease in the flow of the corresponding rivers. This is already observed in river flows with a small fraction of glaciers in the total catchment area.

For example, in the river basin Isfayram with a catchment area of 2220 km^2, where in 1957 89 km^2 was occupied by glaciers, a decrease in their area by 25% led, starting in 1985, to a noticeable decrease in the annual flow of this river. This can be seen from the table 2, which presents data on the trend of runoff of the Sokh and Isfayram rivers.

It should be noted that the estimation of the linear trend βi (angular coefficient of the straight line) in river flows, carried out using the criterion $t\ (K_l) = /\beta/\ a$, where K_l is the sample size, σ_β is the variance of β_i, showed its statistical insignificance in most cases, regardless of the length of the row. The relative contribution of trend a to the total variance of the series is also insignificant. Despite this, on the river in recent decades, it has become negative to Isfayram, and in the period 1995-2004 even significant at 0,95.

Table 2. Trend *β* of the annual flow of the Sokh and Isfayram rivers

Period	Number of years	β_i	t(k-1)	*a*	Period	Number of years	β_i	t(k-1)	*a*
r. Isfayram									
1926-1960	35	0,15	-0,07	0,005	1955-2018	50	0,104	-0,346	0,065
1926-1970	45	0,05	-0,08	0,044	1965-2018	40	0,198	-0,616	0,129
1926-1980	55	-0,02	0,016	0,009	1975-2018	30	0,23	-0,219	0,087
1926-1990	65	0,02	0,115	0,066	1985-2018	20	-0,23	0,237	0,038
1926-2004	79	0,06	-0,273	0,085	1995-2018	10	-1,20	3,78	0,278
1926-2018	92	0,05	0,163	0,024	2000-2018	18	-0,28	1,89	0,087
r. Sokh									
1927-1960	34	-0,005	0,0006	0,0001	1955-2018	50	0,2	-1,35	0,24
1927-1970	44	0,02	0,019	0,007	1965-2018	40	0,19	0,75	0,15
1927-1980	54	0,05	0,069	0,025	1975-2018	30	0,17	0,38	0,08
1927-1990	64	0,08	0,24	0,077	1985-2018	20	0,12	0,08	0,02
1927-2001	78	0,10	0,617	0,172	1995-2018	10	0,2	0,103	0,02
1927-2018	91	0,07	0,064	0,081	2000-2018	18	0,21	0,083	0,12

As a result of degradation of glaciers in the river basin. In Isfiram, the variability of its runoff during the thirty-year period of warming C_v increased by 78% compared with the previous thirty-year period, whereas on the river. Sox she decreased by 15%; on the river Isfayram the largest and smallest annual runoff values were recorded in the last two decades - 36 m^3/s in 1994 and 14,3 m^3/s in 2016, respectively.

Conclution

Based on the foregoing, it can be concluded that glaciers are powerful regulators of not only annual runoff, but also for climatic periods, and their degradation during warming can lead to some complications in the water supply of irrigated areas.

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