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Khikmatov F.Kh.
DSc. professor
Land hydrology department
National University of Uzbekistan named after Mirzo Ulugbek
Uzbekistan, Tashkent
Ziyaev R.R.
associate professor
Land hydrology department
National University of Uzbekistan named after Mirzo Ulugbek
Uzbekistan, Tashkent

STATISTICAL ASSESSMENT OF THE ROLE OF CLIMATE FACTORS IN THE FORMATION OF RUNOFF ZERAVSHAN RIVER

Annotation: the article defines the elements of the flood of the river. Zeravshan for two calculation stages. A statistical assessment of the relationship between the volume of floods and climatic factors - precipitation and air temperature was made. The resulting regression equations are recommended to be used in hydrological calculations and to determine the volume of river flow during the filling period.

Keywords: river, river basin, flood period, water flow, water volume, climatic factors, precipitation, air temperature, static relationships, regression equations, accuracy of equations.

Introduction. According to UN data, more than 20 liters of water are needed for normal human activities in one night, and another 50 liters are needed for the use of sanitary systems. Currently, 1.1 billion people in the world use only about 5 liters of water a day. In European countries, people use 200 liters of water a day, and in the United States, 400 liters. By 2025, about 3 billion people around the world will suffer from a lack of water. Today, 261 river basins in the world contain territories of two or more countries. Such areas cover 45.3% of the earth's surface. 40% of the world's population lives in these areas [3].

Nowadays, as a result of the global climate change, the scarcity of water resources is felt more strongly every year on our planet, especially in its arid regions. Since the second half of the last 20th century, on a global scale, as a result of climate change, more precisely, warming, the air temperature is increasing, which is causing a decrease in atmospheric precipitation. This process applies to the Central Asian region, including the Zarafshan river basin. Due to this, it is necessary to conduct serious hydrometeorological studies to determine the consequences of the increase in air temperature in the river basin and draw appropriate practical conclusions from it [8, 9, 11].

In the mountain rivers of Central Asia, including the Zarafshan River, 80-85 percent of the annual flow flows during the flood season. The period of flooding in the river starts from the end of April, the beginning of May and lasts until October. The study of the connection of the volume of the flow during the filling period with atmospheric precipitation and air temperature is one of the actual hydrological issues related to the effective organization of the use of water resources of the Zarafshan River.

The issues of the formation of river flows and their quantitative assessment depending on climatic factors have been considered in the researches of many scientists. In particular, studies aimed at studying this problem were carried out by V.L.Shults, O.P.Sheglova, L.N.Babushkin, V.A.Bugaev, A.M.Ovchinnikov, N.K.Lukina. Currently, researches in this direction V. E.Chub, E.I.Chembarisov, B.K.Tsarev, F.H.Hikmatov, Z.S.Sirlibaeva, L.M.Karandaeva, D.Yu.Yusupova, B.D.Salimova, D.P.Aytbaev, G'.Kh.Yunusov and others are continuing their research. In these researches, the main attention is focused on researching the characteristics of river flow formation in Uzbekistan and adjacent regions.

In the above-mentioned studies, the influence of atmospheric precipitation and air temperature on the formation of the Zarafshan River flood season flow was not considered as a separate research object. More specifically, the annual and interannual changes of the total volume of the Zarafshan River flood season, as well as the conditions of its formation in relation to climatic factors, including air temperature and atmospheric precipitation, have not been thoroughly studied.

The main goal of this research work is focused on statistical assessment of the effects of climatic factors - atmospheric precipitation and air temperature on the formation of the Zarafshan river flow.

In order to achieve the goal of the work, we used the standard data on water consumption observed at the Dupuli hydrological station of the Zarafshan River and atmospheric precipitation and air temperatures recorded at the Dekhauz meteorological station located in the river basin. These data were first processed and summarized and divided into two periods, namely the first base period (1931-1960) and the second base period (1961-1990).

Main results and their discussion. In order to determine the elements of the recharge cycle of the Zarafshan River, flow hydrographs were drawn for two periods based on the daily water consumption data recorded in the river [1, 10]. Using these hydrographs, basic elements such as the beginning and end of the flood period, the total duration time, the flow volume during the flood period and its share in relation to the annual flow volume were determined (Table 1).

It is known that the beginning of the filling period in rivers and its total duration depend on the location of the river basin, its natural-geographical and climatic-meteorological conditions of the area. If the amount of atmospheric precipitation in the studied year is more than the average long-term norm, then the amount of water in the river will be more [4, 5, 6].

The Zarafshan River belongs to the type of rivers fed by snow-glacial waters [5, 6]. That is why the role of waters formed from the melting of eternal snow and glaciers is important in its saturation. In the Zarafshan river, the period of replenishment usually begins at the end of April. The maximum water consumption in the river is observed in the end of July and the beginning of August in the years of high water, and in the years of low water, the maximum water consumption is observed earlier, in June and July.

Table 1. The main elements of the Zarafshan river (Dupuli hydrological station) of the flood period flow

Years of observation	Time to continue, day	Q_t medium, m^3/s	W_t, 10^6 m^3	Year-on-year, %	Years of observation	Time to continue, day	Q_t medium, m^3/s	W_t, 10^6 m^3	Year-on-year, %
1931	153	265,9	3514,9	78,5	1961	159	283,5	3894,6	82,3
1932	153	303	4005,4	81,4	1962	127	268	2940,7	75,2
1933	153	297,2	3928,7	83,0	1963	151	277	3613,9	80,7
1934	153	288,7	3816,4	81,8	1964	141	351	4276	81,0
1935	153	262,4	3468,7	79,7	1965	140	263,3	3184,9	76,8
1936	150	299,6	3882,8	82,1	1966	148	317	4053,5	80,5
1937	153	279,5	3694,8	82,8	1967	125	281,6	3041,3	73,6
1938	150	255,6	3312,6	78,4	1968	146	353,2	4455,4	81,3
1939	162	266,1	3724,5	84	1969	153	348,3	4604,2	80
1940	129	315,5	3516,4	78,1	1970	174	344,8	5183,6	85,2
1941	169	373,6	5455,2	85,8	1971	155	308,3	4128,8	80,5
1942	161	383,9	5340,2	84,9	1972	141	268,6	3272,2	76,6
1943	131	292,2	3307,2	73,2	1973	160	400,3	5533,7	86,6
1944	155	273,6	3664	81,4	1974	133	266,6	3063,6	77,1
1945	155	303,5	4064,5	83,2	1975	124	294,5	3155,2	75,8
1946	178	260,4	4004,7	84,5	1976	141	301,4	3671,8	78,4
1947	141	284,2	3462,2	80	1977	139	326	3915,1	79,6
1948	157	302,7	4106	82,9	1978	161	334,7	4655,8	82,8
1949	151	339,5	4429,3	81,9	1979	179	302,4	4676,8	83,2
1950	137	329,9	3904,9	79,7	1980	152	288,7	3791,4	80,7
1951	138	241,7	2881,3	74,9	1981	156	292,7	3945,1	81,5
1952	167	342,5	4941,9	85,2	1982	141	220,3	2683,7	72,9
1953	157	316,6	4294,6	83,4	1983	155	311,7	4174,3	82,6
1954	169	304	4438,9	83,1	1984	124	374,3	4010,1	78,3
1955	152	292,4	3840	80,1	1985	141	293,7	3578	78,5
1956	154	327,4	4356,3	83,1	1986	128	261,8	2895,3	75,4
1957	134	234	2709,2	76,3	1987	154	314,5	4184,6	81,4
1958	173	311,8	4660,5	85,5	1988	168	334,5	4855,3	84,2
1959	177	329,1	5032,9	86,2	1989	127	262,1	2876	73,0
1960	143	319,5	3947,5	81,1	1990	160	328	4534,3	83,4
Average	154	299,9	3990,2	81,5	Average	147	305,8	3895,0	79,6

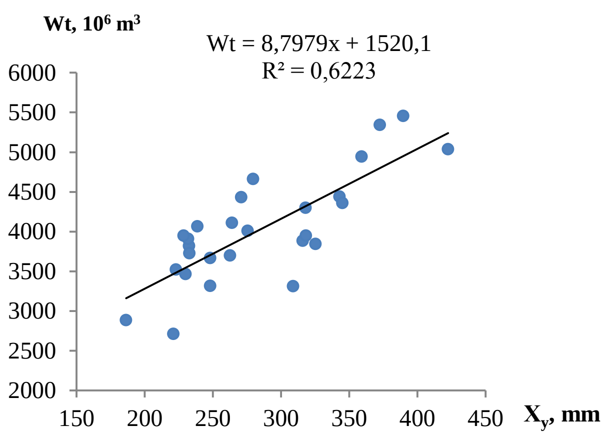
For the two base calculation periods under study, based on flow hydrographs, the total duration of the filling period in the river and the volumes of flows during this period were determined. For example, in the first accounting period (1931-1960), the largest flow volume during the filling period was equal to 5455•10^6 m^3, which corresponded to 1941. For this interval, the smallest flow volume (2709•10^6 m^3) during the filling period was observed in 1957. So, 1957 was a year of low water in the river.

The second accounting period, i.e., during the period of 1961-1990, the largest amount of flow (5533.7•106 m3) was recorded in 1973. In this year, about 87% of the annual flow from the river flowed during the flood season. This value is the largest indicator for both accounting periods (Table 1).

At the next stage of the work, the relationship between the volume of the Zarafshan River flood season and the annual atmospheric precipitation was studied (Fig. 1). Calculations were performed using standard computer programs. Regression equations representing the relationship between the flow volume of the Zarafshan river and climatic factors were created and their accuracy was evaluated (Table 2).

Taking into account the above, the relationship between the size of the flood flow observed in the river and the annual atmospheric precipitation in the basin was studied. For this purpose, the results of statistical evaluations of the relationship between the flow volume of the flood season and the annual atmospheric precipitation were analyzed (Figure 1).

a)



b)

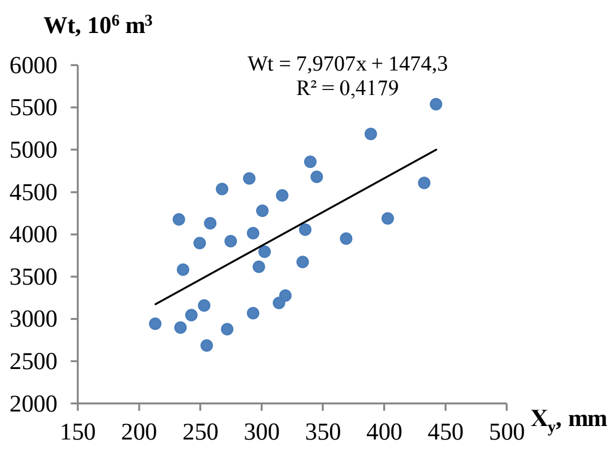


Figure 1. Zarafshan River with the flow volume of the flood period
Connections between atmospheric precipitation:
a) the first accounting period, 1931-1960 years;
b) the second accounting period, 1961-1990.

Regression equations representing the above associations were constructed and their accuracy was assessed (Table 2).

As mentioned above, the Zarafshan River belongs to the type of rivers fed by snow-glacial waters [5, 6]. As a result of the gradual rise in air temperature in the river basin from early spring, first, the snow cover accumulated in the basin during autumn and winter, and then the glaciers formed from them, begin to melt. The highest air temperature in the river basin is mainly observed in the second and third decades of July. This leads to an increase in the water content of the river.

Taking these circumstances into account, in the next stage of the work, the relationship between the volume of the flow during the filling period and the average annual air temperatures was studied. For this purpose, graphs of the relationship between the volume of flow during the recharge period and the average annual air temperature were drawn for two calculation periods (Figure 1.). Regression equations were also constructed for these graphs and their accuracy was assessed (Table 2).

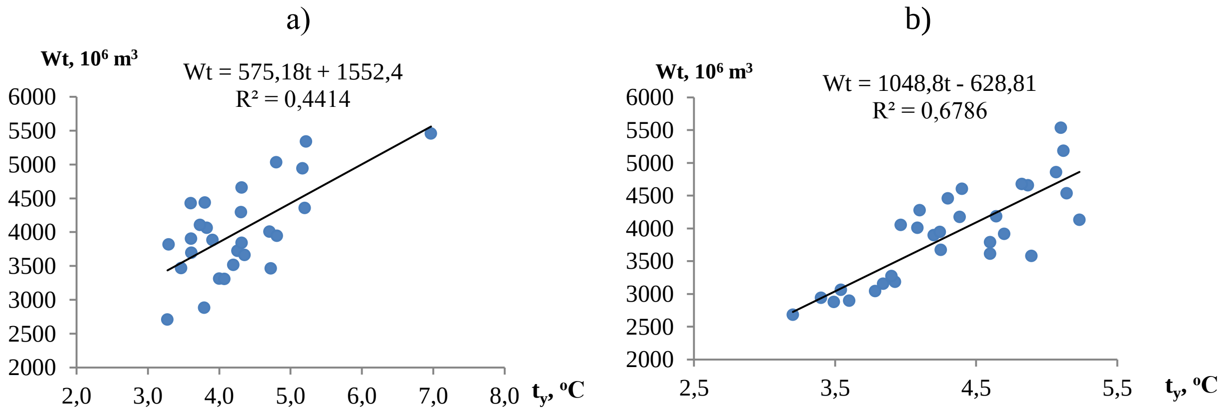


Figure 2. Relationships between Zarafshan River flood volume and average annual air temperatures:
a) the first accounting period, 1934-1960 years;
b) the second accounting period, 1961-1990.

We will analyze the accuracy of graphs (Figures 1 and 2) and their regression equations representing the above two types of connections. The results of the calculations are presented in Table 2.

Table 2. Regression equations representing the relationships between flow volume and atmospheric precipitation and air temperature during the flood period and their accuracy

Periods	The regression equation	Correlation coefficient and its error $r_o \pm \sigma_{ro}$
Relationship with atmospheric precipitation		
First accounting period	W_t = 8,7979x + 1520,1	0,79 ± 0,049
Second accounting period	W_t = 7,9707x + 1474,3	0,65 ± 0,071
Correlation with air temperature		
First accounting period	W_t = 575,18t + 1552,4	0,66 ± 0,073
Second accounting period	W_t = 1048,8t - 628,81	0,82 ± 0,039

As can be seen from the table data, the value of the correlation coefficients representing the relationship between the volume of flow that flowed from the river during the filling period and the annual atmospheric precipitation is equal to 0.79 for the first calculation period and 0.65 for the second calculation period. We can conclude from this that in the period of the first calculation, the influence of the atmospheric precipitation in the basin on the formation of the volume of the river during the filling period was great.

As can be seen from the second type of connections, the pair correlation coefficient for the first calculation period, which represents the density of the connection between the volume of flow during the filling period and the average annual air temperature, was r = 0.66, and its error was $\sigma_r = \pm 0.073$.

The value of the correlation coefficient obtained for the second calculation period was r = 0.82, and its error was equal to $\sigma_r = \pm 0.039$. It can be concluded that the process of melting of glaciers in the Zarafshan basin is accelerating due to the effect of air temperature on the global and, accordingly, regional scale.

It is recommended to use the regression equations obtained as a result of the statistical evaluation of the connections between the volume of the Zarafshon River flood season and climatic factors in hydrological calculations and to determine the volume of the river's flood season flow.

Summarizing the results obtained in the study, the following can be noted as a conclusion:

1. The elements of the Zarafshon River flood period were divided into two basic periods. The highest value of the volume of flow during the filling period determined for both periods was 5533.7•10^6 m^3 in 1973. In this year, about 87% of the annual flow from the river flowed in this period;

2. The relationship between the flow volume of the Zarafshan river and the annual atmospheric precipitation was studied. Regression equations of these relationships were constructed and their accuracy was assessed. The values of the pair correlation coefficients representing the relationship between the flow volume and annual atmospheric precipitation during the filling period of the Zarafshan River were equal to 0.79 for the first calculation period and 0.65 for the second calculation period. These results show that the contribution of atmospheric precipitation was significant in the formation of the Zarafshan River floodplain flow during the first accounting period;

3. The graphs of the relationship between Zarafshan river flow volume and average annual air temperatures were analyzed. The values of the pairwise correlation coefficients representing these relationships were equal to 0.66 in the first calculation period and 0.82 in the second calculation period. This result indicates that the process of melting of glaciers in the basin has accelerated due to a certain increase in air temperature in the last 30 years;

4. It is recommended to use the regression equations representing both types of connections in the implementation of relevant hydrological calculations, including in the estimation of the flow volume of the Zarafshan River during the flood period.

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