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Interstate Water Resource Risk Management: Towards a Sustainable Future for Transboundary River Basins of Central Asia

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ABSTRACT

The background for this study was the importance of the allocation and use of water resources of Transboundary Rivers in Central Asia. Firstly, for the equitable use of water resources by the countries of the region requires first the determination of the actual volume of water flow of Transboundary Rivers. This requires systematic monitoring of dynamics of change of water flow. The paper presents the results of study of dynamics of change of water flow of the Transboundary Zeravshan River for the period 1931-2011 and main tributaries of Amudarya the Vakhsh River. The significant change of the river flow and the impact of climate change on the state of glaciers of the Zeravshan river catchment observed

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INTERSTATE WATER RESOURCE RISK MANAGEMENT: TOWARDS A SUSTAINABLE FUTURE FOR TRANSBOUNDARY RIVER BASINS OF CENTRAL ASIA

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Abstract

The background for this study was the importance of the allocation and use of water resources of Transboundary Rivers in Central Asia. Firstly, for the equitable use of water resources by the countries of the region requires first the determination of the actual volume of water flow of Transboundary Rivers. This requires systematic monitoring of dynamics of change of water flow. The paper presents the results of study of dynamics of change of water flow of the Transboundary Zeravshan River for the period 1931-2011 and main tributaries of Amudarya the Vakhsh River. The significant change of the river flow and the impact of climate change on the state of glaciers of the Zeravshan river catchment observed

Keywords: *Transboundary River, Central Asia, Zeravshan River, Water flow, Meteorology*

1. Introduction

About 60% of the water that potentially flows to the lower Aral Basin originates in the high mountains of Tajikistan. The demand for winter hydropower generation in the upstream countries, where the dams are located, conflicts with the summer demand for irrigation in the downstream parts of the basin. The poor and inadequate information on the available water resources is leading to erroneous planning decisions and a biased distribution of water resources. Hence, these issues contribute to interstate Transboundary water sharing conflicts between the riparian states.

To provide sustainable water management, it is important to obtain reliable information on the present and future water resources and their evolution in relation to human activities, to global changes and to climate evolution affecting the hydrological and melting regime of the main tributaries to the Amu Darya and Sir Darya.

2. Literature Review

The Zeravshan River one of the tributaries of the Transboundary Amudarya Rivers formed on the territory of the Republic of Tajikistan and flows to the territory of the Republic of Uzbekistan Main hydrological characteristics of the river described in [1]. The average

annual flow of water of the Zeravshan river is 158 m³/sec and the average annual volume of runoff is about 5.0 km³ [2]. Monitoring meteorological conditions of the basin of the Zeravshan River and hydrological parameters of the river on the territory of the Republic of Tajikistan carried out in four meteorological and five hydrological stations. There is currently only hydrological station Dupuly. The total glaciation area of the Zeravshan river basin is 437.9 km². Among 632 glacier of the Zeravshan river basin, the largest is Zeravshan glacier by a length of 27.8 km and an area of 132.6 km².

According to the Hydrometeorology Agency of the Republic of Tajikistan, there was a substantial change of the geometric dimensions and mass loss of glacier Zeravshan for the period 1927 - 1991. Only for the period 1991-2009 years, the glacier retreated at an average annual 88-94 m and its area decreased by 700 Th. m² and by 2050 to decreases by 30-35% is expected [3].

The Vakhsh River is the main river of the Republic of Tajikistan that merging by the Pyanj River forms the Amu Darya – the largest river in Central Asia. Potential energy resources of Vakhsh represent 28.6 Mln. kWt (250 Bln. kWt·h/year of electricity). The formation of river flow determined by the

hydrological regimes of its tributaries. The main tributaries of the Vakhsh River is Surkhob and Obikhingou rivers. The Surkhob river is formed by the confluence of the Kyzilsu and Muksu tributaries.

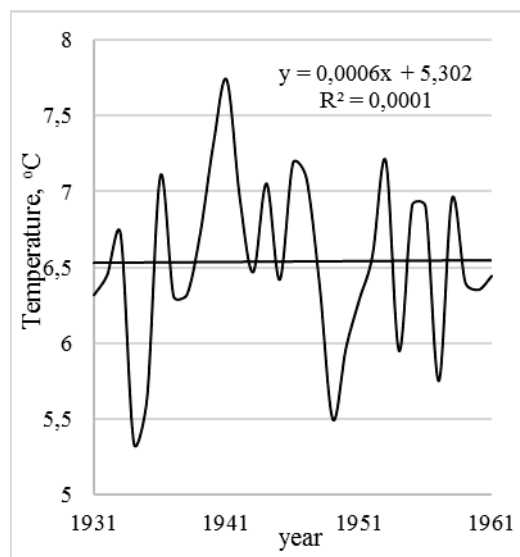
3. Research Methods

In the present paper were used the data of meteorological stations of Dehavz close to the Zeravshan glacier and Iskanderkul in the basin of the Yagnob river for the period 1931-2011. Measurement of hydrological characteristics of the Zarafshan River is at the station Dupuly that is the only hydrological post on the Zeravshan River. The influence of meteorological condition of the Vakhsh River tributaries basins on change of water flow carried out by used of meteorological data from stations Lyakhsh (Kyzilsu river basin), Tavildara (Obikhingou river basin) and Garm (the basin of the river Surkhob river basin) for the period 1960-1990.

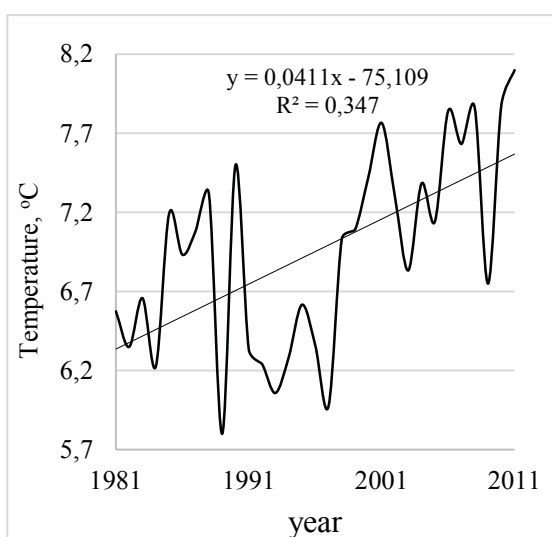
4. Discussion and Conclusion

The deviation of annual average temperature in the area of the Zeravshan glacier for the periods 1931-1961 and 1981-2011 presents on the Fig.1(a, b).

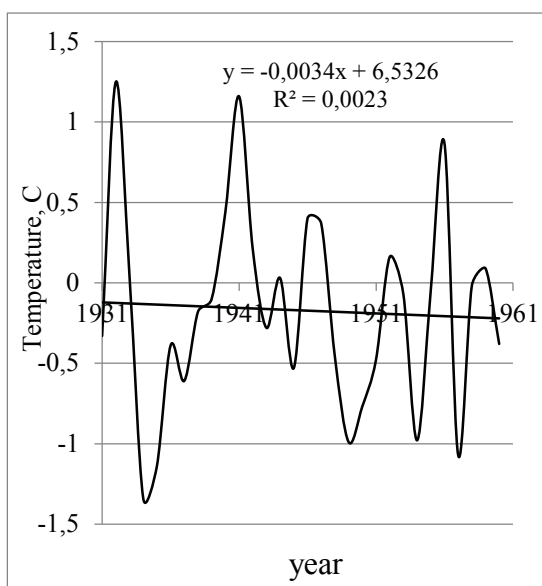
The considered period is characterized by abundant precipitation in the form of a solid phase (at a height of over 2500 m, precipitation falls only as snow). This suggests that the period 1931-1961 characterized by a favorable condition for the increase of glacier mass and not their degradation as follows from information of Agency on hydrometeorology of Tajikistan.



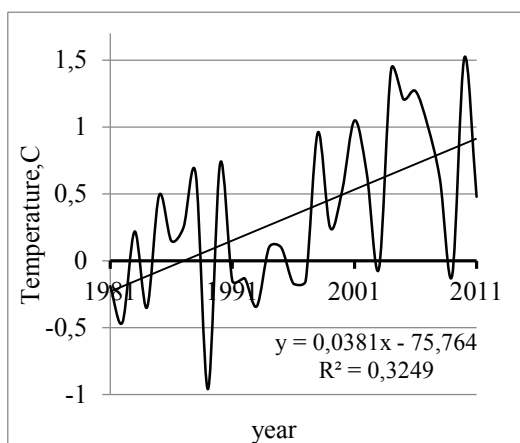
a



b



c

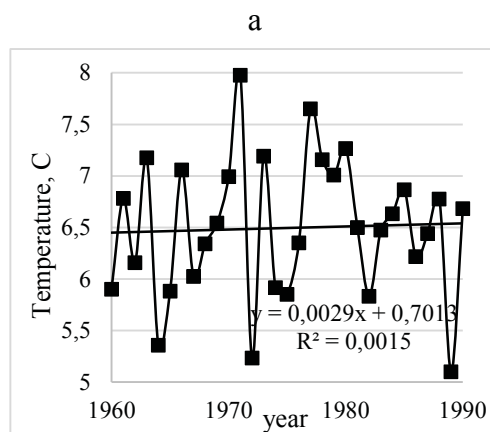
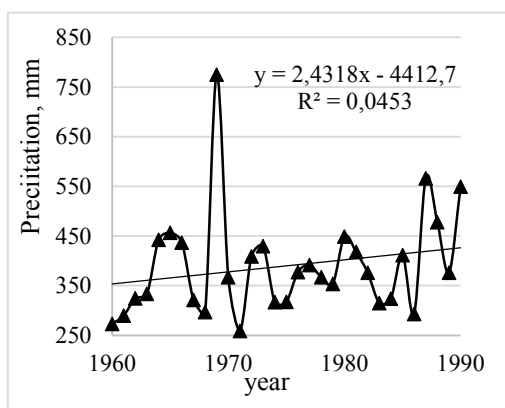


d

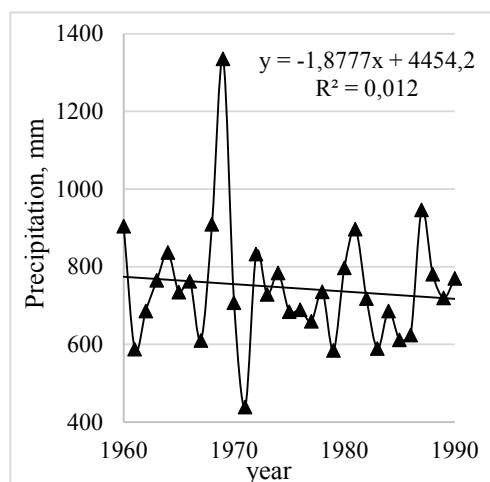
Fig.1. Change of annual average temperature for the periods 1931-1961 and 1981-2011 in the area of the Zeravshan glacier (a, b) and in the Yagnob river basin (c, d), respectively

The trend of change of temperature for the period 1981-2011 shows opposite character to comparison with the period of 1931-1961 while precipitation maintains its almost constant value (Fig.1b). The results of meteorological observations in the basin of the Yagnob river presented on the Fig.1(c, d) shows that the change in temperature for the period 1931-1961 remains almost unchanged value and as in the case of Zeravshan glacier region during the period 1981- 2011 a significant growth is observed.

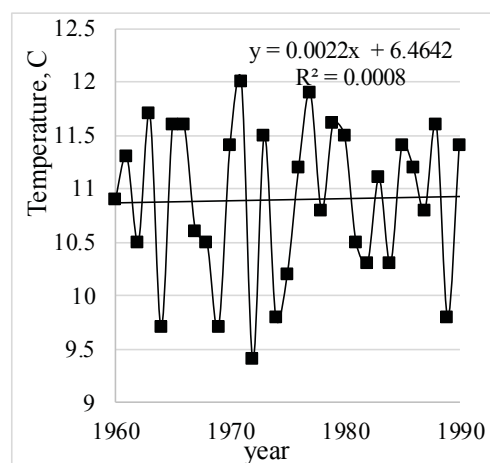
The results of monitoring of the meteorological condition of the Vakhsh River tributaries basins are present on the Fig.2. From the Fig. 2 it is obvious that if on the upstream of the Vakhsh River for the period 1960-1990 the precipitation characterized by increasing trend but on middle flow transformed to decreases trend.



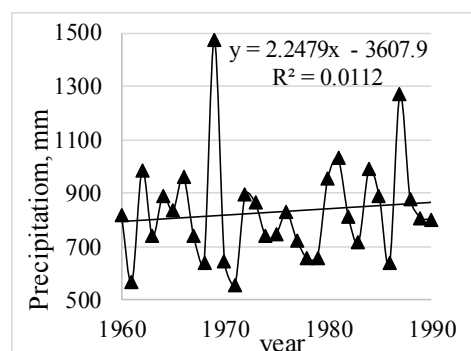
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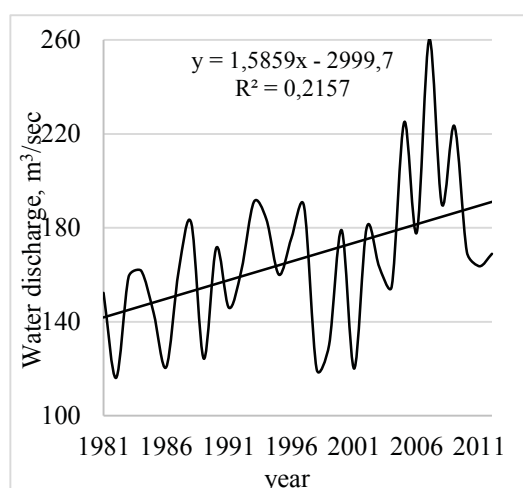
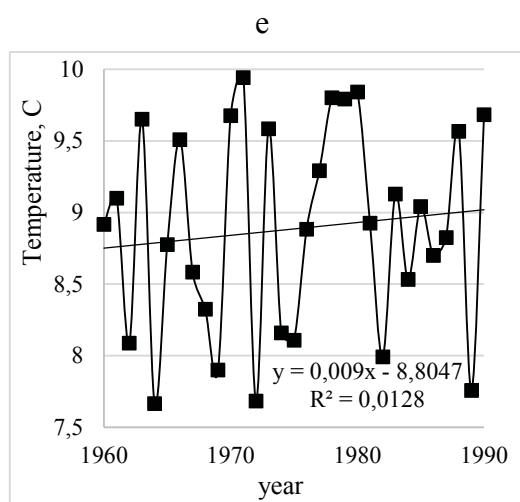


c



d

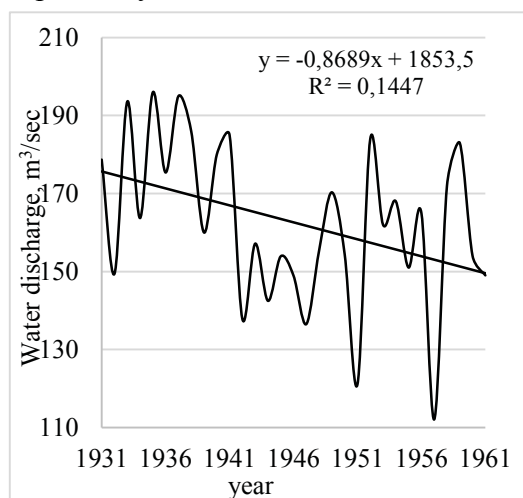




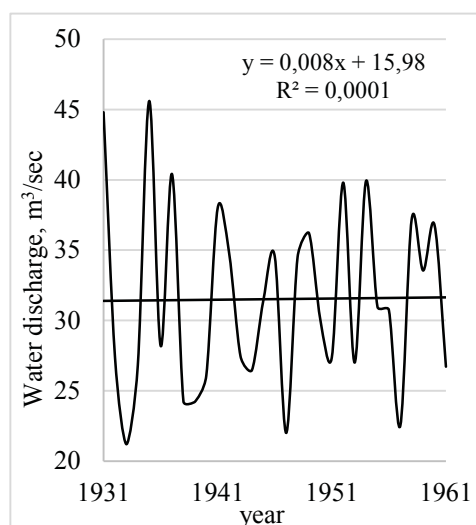
f

Fig.2. Annual average precipitation (▲) and temperature (■) on the data from meteorological stations Lyakhsh (a, b), Garm (c, d) and Tavildara (e, f) for the period 1960-1990.

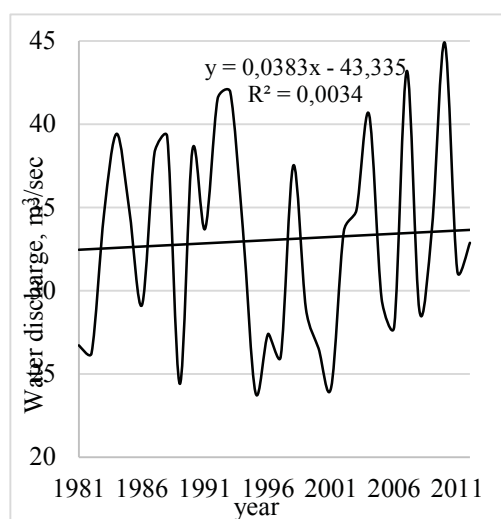
On the Fig. 3(a, b) presents an average annual flow of the Zeravshan river for the periods 1931 - 1961 and 1981-2011 years, respectively.



a



c



d

Fig.3. Zeravshan (a, b) and Yagnob rivers (b, d) water discharges for the periods 1931-1961 and 1981-2011.

The decrease trend of water discharge observed for the period 1931-1961 on the

Fig.3 can be explained by the fact that due to low and almost constant values of temperature, the precipitated solid precipitation not subject to aggregate transformation and, conversely, accumulate in the form of next layer of seasonal snow. Such scenario for the river Yagnob observed for the period 1931-1961 characterized by almost constant value of water discharge (Fig.3 c).

A completely different behavior of the Zeravshan river runoff changes that is significant increase of water discharge for the 1981-2011 is observed (Fig. 3b).

On the Fig. 4 present the actual hydrographs of the rivers Zeravshan and Yagnob rivers for the periods 1931-1961 and 1981-2011 years demonstrated that water discharge maximum of the Zeravshan and Yagnob Rivers occurs in July and June, respectively. It can assumed that different months of observation maximum water discharge of the rivers associated with the location of their catchment at different heights a.s.l.

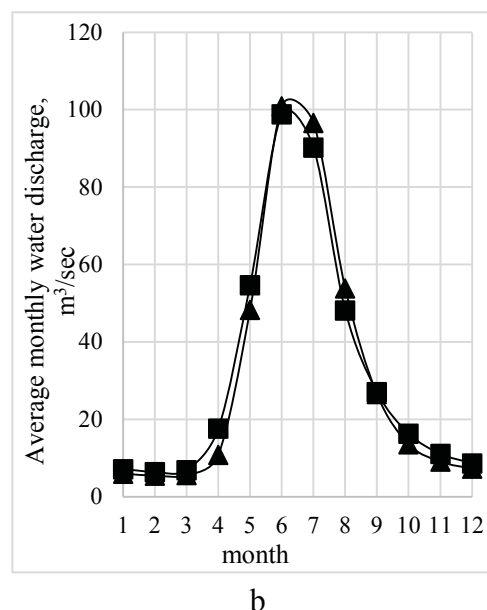
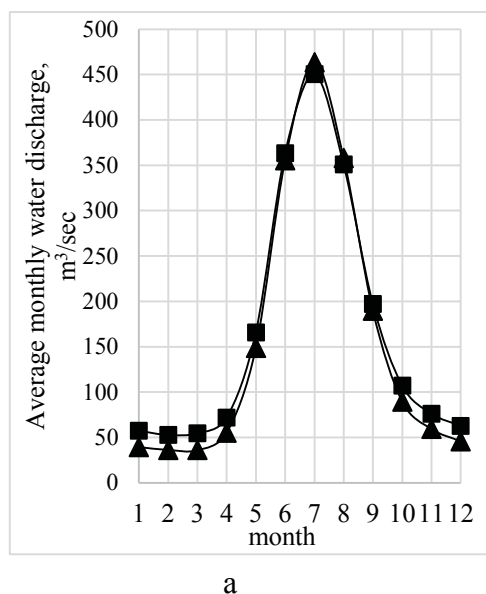


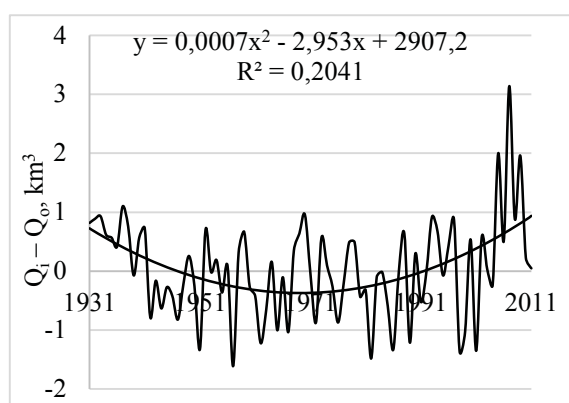
Fig.4. Zeravshan (a) and Yagnob (b) rivers hydrographs for the periods 1931-1961(▲) and 1981 - 2011 (■).

The period 1981-2011 in comparison with the period 1931-1961 characterized as follows from Fig. 4(a) by decreases of the Zeravshan River water flow. The average annual flow of the Zeravshan River according to calculation results for the periods 1931-1961 and 1981-2011 are 5.352 and 5.182 km³, respectively and for Yagnob River are 1.02 and 1.04 km³.

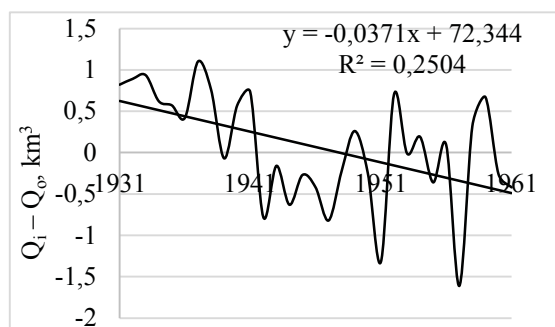
For estimation of the climate change impact on water availability in the river Zeravshan on the Fig.5 present is changes of annual runoff of river at hydrological station Dupuly for the period 1931-2011, in the form of the time dependence of deviation values of the volume of annual runoff from mean annual values:

$$\Delta Q = Q_i - Q_o.$$

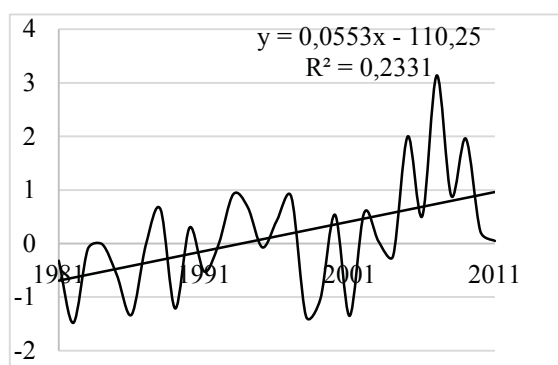
Where Q_i is the total water runoff for i year, Q_o is the mean annual water runoff for the period 1931-2011.



a



b



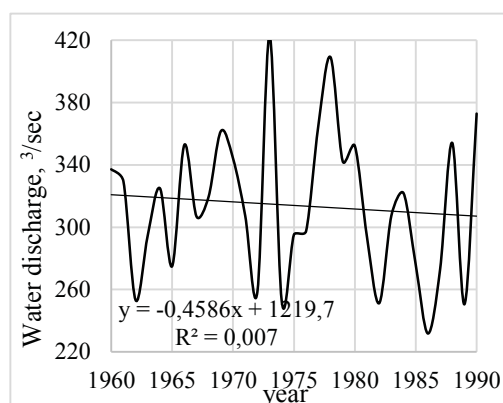
c

Fig.5. The actual water content of the Zeravshan river(a) for the period 1931-2011 and for the periods 1931-1961(a) and 1981-2011 (b).

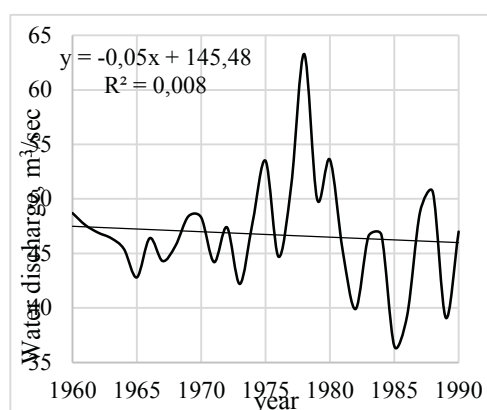
The trend of changes of the Zeravshan river flow for the periods 1931-2011 (5a) and the periods 1931-1961 and 1981-2011 separately presented on the Fig. 5(b) and Fig.5(c) respectively.

On the Fig.6 (a, b & c, d) the dynamics of water flow changes in Kyzilsu, Surkhob & Muksu, and Obikhingou the tributaries of the Vakhsh Rivers for the period 1960-1990 is present. Analyses of presented on the Fig.6 dependencies show that for the considering periods (1960-1990) the Vakhsh river tributaries flow have not changed

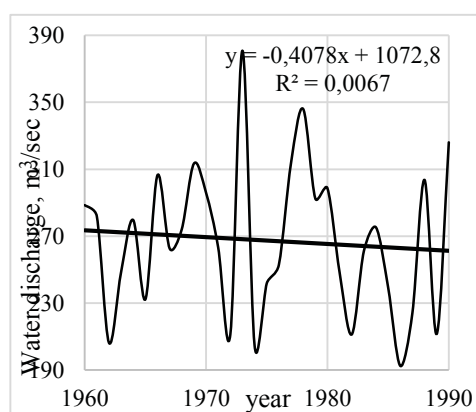
significantly and characterized by decreasing trends.



a



b



c

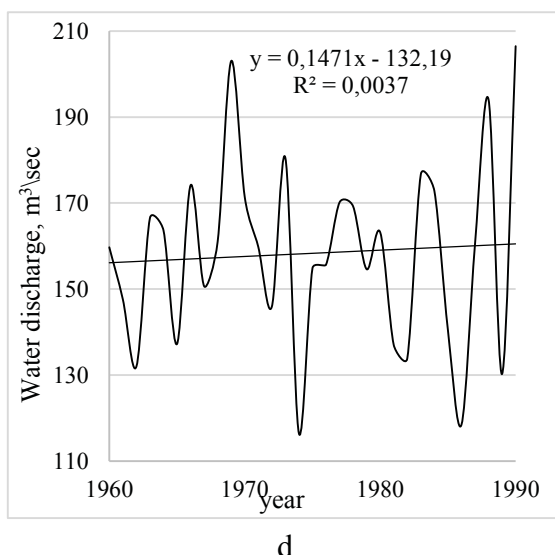
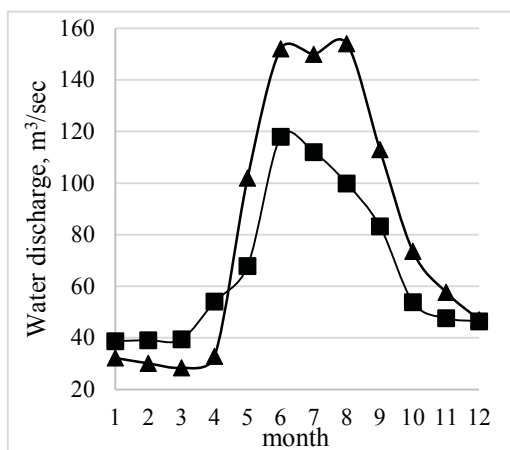
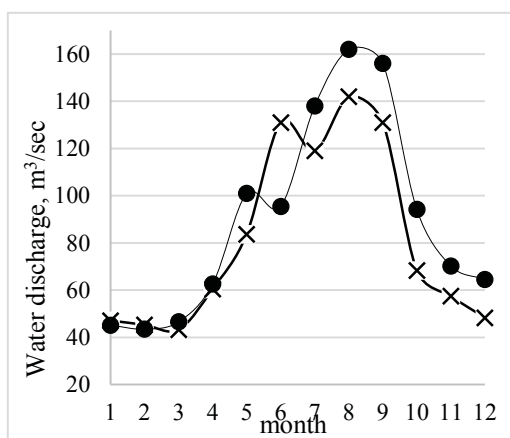


Fig.6 Dynamics of changes of the Kyzilsu (a), Surkhob (b), Muksu(c) and Obikhingou (d) rivers water flow for the period 1960-1990, respectively.

The Kyzilsu river hydrograph shown on the Fig.7 confirms the observed and present on the Fig. 6(a) decreases trends of runoff for the period 1960-1990.



a



b

Fig.7. Hydrograph of the river Kyzilsu 1960 (▲), 1990 (■), 1970 (X) and 2000 (●).

In addition, shows that river hydrograph in 1960 is characterized by two peaks of water flow corresponding to the June and August months. We can assume that the maximum value of runoff in June associated with the processes of melting of seasonal snows and rainfalls and in August in which the maximum value of the runoff more than in June with the contribution of glacier runoff. In turn, the Kyzilsu river hydrograph is indistinct by maximum value of runoff in June. The river hydrograph for 1990 characterized by camber and an expanded parabola seems to be associated with mixing of seasonal snow and glacial runoff. The same pattern observed for the Surkhob and Obikhingou rivers hydrograph.

At a comparative representative analysis of meteorological conditions of the Zeravshan glacier area for the periods 1931-1961 and 1981-2011 are observe different trend of temperature change of the considered periods. At almost constant temperature for period 1931-1961, significant growth for the period 1981-2011 observed. Almost a similar picture was observed in the Yagnob river basin of the Yagnob River. It was found that the decrease trend of water flow of the Zeravshan river in the period 1931-1961 to transit to a significant increase in the period 1981-2011. Finds a reduction in the volume of runoff from 6.08 km³ of the period 1931-1961 to 5.36 km³ for the period 1981-2011. Thus, mismatch data of Agency of Hydrometeorology of the Republic of Tajikistan on the degradation of glacier Zeravshan and results of meteorological observations can only speak for 1931-1961.

Study of the hydrological characteristics of the main tributaries of the Vakhsh River-Kyzilsu, Muksu and Obikhingou and meteorological conditions of the river basins. Despite the main contribution of thawing waters of a glacier on the formation of river flow it was found that for the period 1960-1990 years the water discharge dynamics have decreasing character. Taking into

account this phenomenon it was suggested that glaciers in basins of tributaries of the Vakhsh River despite the overall global warming have not changed significantly. For monitoring of meteorological parameters of the river basins were used a data of meteorological stations Lyakhsh, Tavildara and Garm for the period 1960-1990. The choice for the research period 1960-1990 is justified by the fact that the period covers the years of the construction of the Nurek reservoir with hydroelectric power station, its content and generate electricity.

According to the obtained results, the trend of changes of the precipitation in the basins of tributaries of the Vakhsh River has the increasing character, with minor increase of average temperatures. This indicates that the reduction in river flow not related to rainfall. The hydrograph of rivers-tributaries of the Vakhsh River found two extreme corresponding to May-June and August-September months of the year, respectively. It suggested that they are associated with the contribution of spring rainfall and the melting of the glaciers, respectively.

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