MONITORING OF CHANGE OF THE VAKHSH RIVER AND TRIBUTARIES HYDROLOGY IN CONDITION OF CLIMATE CHANGE

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Abstract— Present the results of studies of the hydrological characteristics of the main tributaries of the Vakhsh river-Surkhob, Obikhingou and meteorological conditions of the river basins. It was found that for the period 1932-2012 the water discharge dynamics in main tributaries of the Vakhsh river have increasing character. For monitoring of meteorological parameters of the river basins were used a data of meteorological stations Lyakhsh, Tavildara and Garm for the period 1960-2012. The trend of changes of the precipitation in the basins of tributaries of the Vakhsh river has the decreasing character at increasing trend of average temperatures. 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 is suggested that they are associated with the contribution of spring rainfall and the melting of the glaciers, respectively.

Keywords— Tributary, Vakhsh River, Glacier, Hydrograph, Precipitation, Temperature, Glacier Lake.

I. INTRODUCTION

The Vakhsh River is main river of Republic of Tajikistan (one of tributary of the Transboundary Amudarya River in Central Asia) by length of 691 km and the area of the basin 39160 km^2-almost a quarter of the area of the Republic of Tajikistan. The tenth part of Vakhsh River Basin occupy by glaciers and water supply source of Vakhsh river is glaciation area the altitude of 4685 m a. s. l. The Vakhsh River there are 6276 inflows and lakes in its basin are twenty covering the total area of 4 km^2.The average use of Vakhsh river in Vakhsh valley (at head construction Vakhsh main channel) 2273 m^3/sec, the high - 4500 m^3/sec, the least - 1420 m^3/sec. The high water that is abundance of water on Vakhsh River proceeds from March - October, average duration of a high water 221 day. For this time on the river passes 87 % of an annual flow. The average water discharge in the middle reaches of 660 m^3/sec, the highest (in July) — 3120 m^3/sec, the smallest (in February) — 130 m^3/sec. The total hydropower resources of Vakhsh River make 28.6 Mln. kWt, it can give of 250Bln. kWt·h of the electricity per year [1-7].

The Vakhsh River is born at merge of the Surkhob on the right and Obikhingoy at the left rivers that in turn are formed by merging of two or more tributaries. Surkhob and Obikhingoy merge at height of 1151 m a. s. l., the mouth of Vakhsh is at height of only 316 m a. s. l. Right inflow of the Vakhsh Rivers -the Surkhob by the length of 81 km, area of basin 1760 km^2, average height of 3140 m above sea level there are 246 glaciers in Sorbog river basin with total area of 105.6 km^2.
The left component of Vakhsh - the river Obikhingoy has length of 196 km, the area basin of 6660 km^2. There are 756 glaciers in its basin with the total area of 712 km^2. In Obikhingoy River Basin, there is a largest glacier of Pamir - Garmo, giving rise to the same river coming down. Its length is 34 km, the area of 114 km^2. Now this glacier having the western layout, intensively receding, its surface is going down, the big ice blocks are separating from a glacier. River Garmo is coming out from the icy grotto (cave) and after twenty kilometers, other to rivers joins to Garmo: from the right side- Kirgizob and from the left side- Bohud. After merging this river formed Obikhingoy River.

Feature of hydrological regime of water objects significantly affect economic activity, safety and living conditions of the population. For safe and effective use of resources of the rivers, it is necessary to assess water resources areas or specific water objects, determination of the maximum, minimum and other characteristic water consumption, assessment of the impact of economic activities on the regime of rivers, dangerous hydrological processes. Reassessing the modern resources of surface and underground waters in connection with the currently observed climate change is one of the urgent tasks of hydrology and hydrogeology [8-11]. Low-flow assessment and minimum flow is particularly important to prevent environmental problems. Study of spatial–temporal regularities of runoff formation, the features of the hydrological regime of rivers allows identifying the main relations between the elements of the water balance. Particularly of underground and surface waters and the formation of their natural resources under existing and future climate conditions. The aim of this work was to identify the main trends in annual and low-flow runoff of the Vakhsh; the nature of intra-annual distribution of runoff, assessment of the current natural resources surface [12].

II. THE HYDROLOGICAL CHARACTERISTICS OF TRIBUTARIES AND TRANSBOUNDARY VAKHSH RIVER

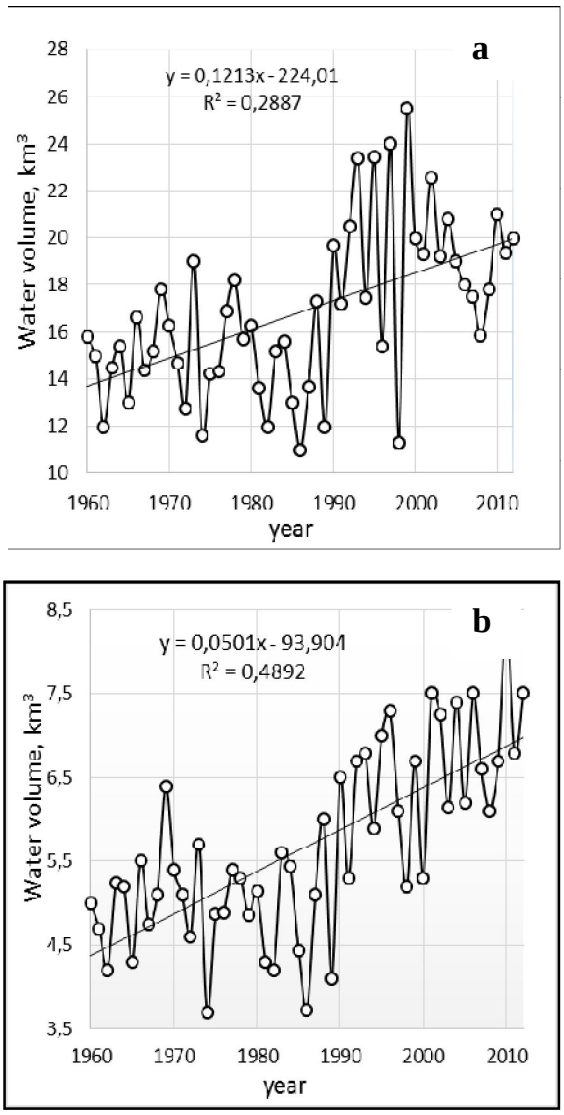


Fig.1. The water volume change of the Surkhob (a), Obikhingou (b) rivers for the period 1960-2012

The increase of water volume of the Vakhsh river and its tributaries-Surkhob and Obikhingou rivers, as shown on the Fig.1 in tune with the statements that currently there is a reduction of glaciations area of Tajikistan, probably due to an increase in the overall temperature of the background in the region and changing precipitation patterns.

In the Surkhob river basin intensively melting small glaciers of the Northern slopes in the Western part of a ridge of Peter great. On the southern slopes of Alay ridge, glaciation decreases slower as there are larger glaciers. In the Obikhingou river basin intensively melting the largest glacier Garmo. During the XX century, it became shorter by almost 7 km, having lost more than 6.0 km^2 area. He is currently retreats at an average speed of 9 m/year, the surface settles due to the melting of up to 4 m/year. Another glacier in the same basin - Skogach retreats annually on 11 m.

It should be borne in mind the existence of another but important aspect of the hydrology of the rivers - the cyclical nature of the water flow.

In hydrology from the point of view of the forecast of water flow, an important issue is the assessment of long-term fluctuations of annual runoff and hidden in this periodicity. On the other hand, attempts to link fluctuations in water availability with various geophysical processes. The lack of a clear periodicity in long-term fluctuations of flow does not rule out the tendency to the formation of more or less continuous alternating groups of high water years, called cyclical fluctuations of water flow. The length of the cycle, their sequence and the degree of deviation from the mean value inside the loops over a period of years various. It is not always possible to make clear boundaries between wet and dry groups.

A characteristic feature of changes in the volume of runoff in the Vakhsh river for the period 1932-2012 as seen in Fig.2 is its cyclical nature.

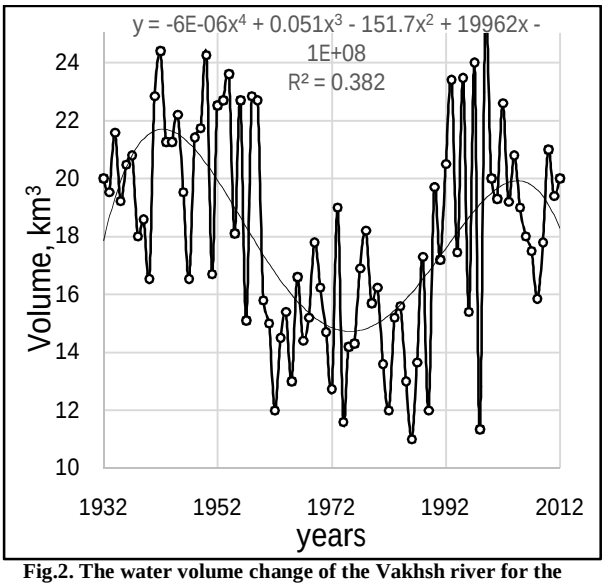


Fig.2. The water volume change of the Vakhsh river for the period 1960-2012

For allocation of periods with high and low water content are used differential integral curves of average annual discharge. Differential integral curve takes into account the fluctuations of the flow over some relatively short periods. It defined by summing the deviations of modular coefficients from the middle, i.e. the ordinates are calculated as Σ (K-1). Thus, the ordinates of the curve give in the end of each i-th year, the cumulative sum of deviations of the annual modular coefficients from the long-term average (K=1). Foe comparison long-term fluctuations of runoff of different rivers eliminated the influence of temporal flow variability by reflected of coefficient of variation (variability) of a set of observations (C_v), i.e. Σ (K-1)/C_v. The use of differential integral curves give a vision of cyclical fluctuations without the effect of the displacement of the boundaries between the phases of the cycles of low and high duration [3].

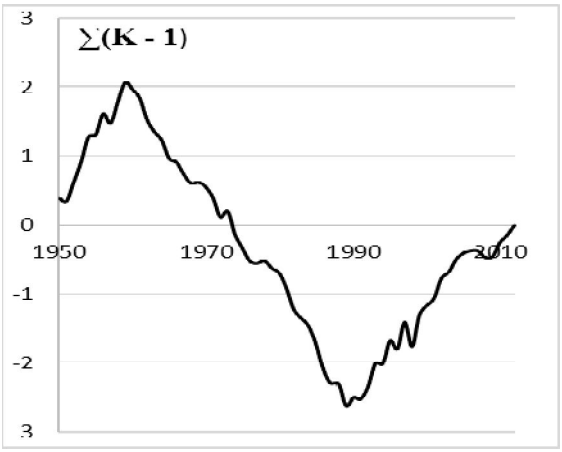


Fig.3. Differential integral curve of average annual water discharge of the Vakhsh river

Present on the Fig.3 differential integral curve of average annual water flow allows defining periods of high and low water availability of the Vakhsh river.
It should be note that the appearance of cyclicality in the water flow of rivers allows predicting future scenarios of changes in the water flow of the river. From the Fig.4 can see that the harmonic law changes the Vakhsh river volume of water for the period 1932-2012. Hence, the continuation of the right part of the harmonics may indicate the volume of water by 2030.

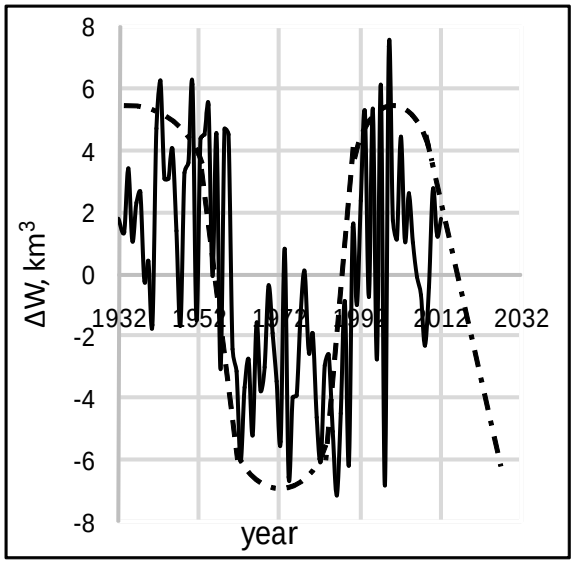
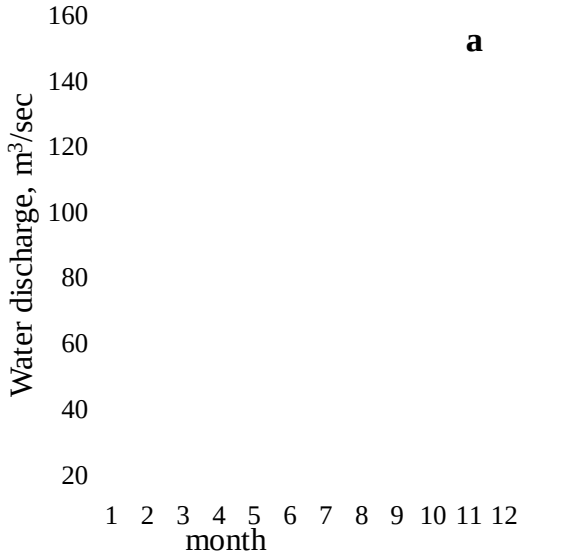


Fig.4. Cycle of the Vakhsh river water flow for the period 1932-2012.

As noted above for the period 1960-2012 water runoff in most of the rivers of the basin of the Vakhsh river has a tendency to increase. Thus, the increase of water volume in rivers and reduce the amount of atmospheric precipitation in river basins give reason to believe that in the Vakhsh river basin continued reduction of the area of glaciation.

A detailed study of the process and the establishment of the relationship of water resources in glacial lakes with the formation of water flow of rivers is important from the point of view of planning the efficiency of hydropower facilities and irrigation activity in agriculture.



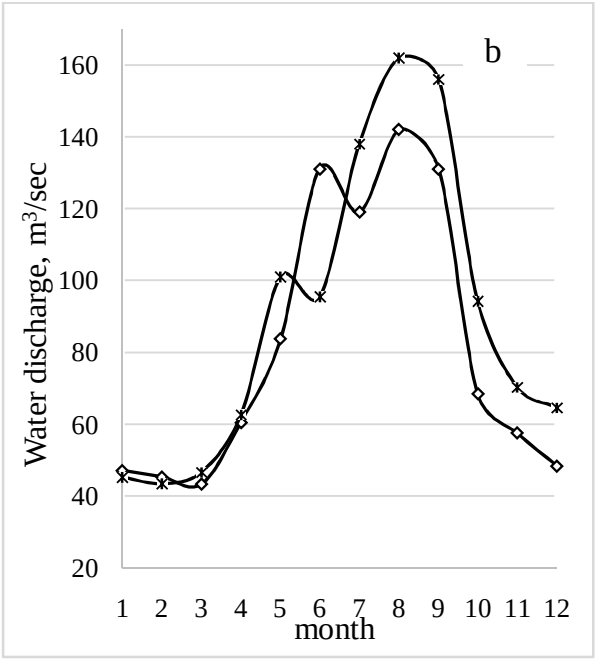


Fig.5. The hydrograph of the river Kyzilsu for years: 1960 (▲), 1990 (■), 1970 (Ж) and 2000 (◊)

The hydrograph of the Kyzilsu river for 1960 and 1990 years present on the Fig.5 (a) that is characterized by the presence of two maxima in June and August months, respectively. The hydrograph of the river in 1990 has an extensive character with maximum in June. On the curve of the hydrograph is observed weak high ccorresponding to August indicating about mixing of the flows formed at the melting of seasonal snow and seasonal precipitation with glacial feed. This is more evident on the hydrograph of the Kyzilsu river for the 1970 and 2000 (Fig. 5 b).

CONCLUSION

Thus, the water objects of the Vakhsh river basin respond to the effects of climate change. Analysis of change trend in rainfall and temperature in the basins of tributaries of the Vakhsh are established that the increasing trend of water volume in the rivers of the basin caused by the melting glaciers of the relevant river basins. It is assumed that formation of glacial lakes significantly affect the displacement of the periods of floods and low water in the rivers

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