

DYNAMICS OF CHANGES IN LONG-TERM AVERAGE ANNUAL RIVER RUNOFF IN THE LAKE SEVAN BASIN

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Abstract. In the work, long-term fluctuations in the annual runoff of rivers flowing into lake Sevan were identified, analyzed and evaluated. As the source material, daily data of long-term actual instrumental observations of the annual runoff of rivers flowing into the lake, as well as air temperature and atmospheric precipitation of the lake basin for the entire observation period were used.

1 Introduction

Climate change, which began in the last century, will undoubtedly have its effect on the river runoff in Armenia. And lake Sevan is a strategic storage of fresh water of the Republic of Armenia, at the same time, the lake basin is one of the richest and most unique regions of the Republic of Armenia in terms of recreational resources.

The aim of the work was to investigate, analyze and evaluate the current multi-year fluctuations in the annual values of the average runoff of rivers flowing into lake Sevan, the average air temperature and the amount of atmospheric precipitation of the lake basin.

2 Study areas, Data and Methods

To solve the tasks posed, the corresponding scientific research works served as a theoretical basis. Actual data from Armhydromet's many-year observations of air temperature, precipitation and water discharge (from the data of observation to 2018) were used as starting material. In the work, long-term fluctuations in air temperature and precipitation were discussed separately for meteorological stations, and changes in water flow rate for river sections of rivers. Note that over time, both the number of observed rivers and the number of hydrological posts, meteorological stations and posts located on them have changed.

28 rivers and 2 large springs flow into lake Sevan, 24 of them were carried out over the years in different years. Most of the rivers in the basin have a small length and catchment

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area. In the basin there are 930 rivers up to 10 km long, of which only Argichi is 51 km long. The relatively large rivers, whose catchment area is more than 100 km², are as follows: Masrik, Karchakhpyur, Vardenis, Argichi, Bakhtak, Gavaraget (table 1).

The change in the quantitative and qualitative characteristics of water objects is most strongly influenced by direct anthropogenic impact, as well as a change in climatic conditions especially manifested in recent decades [5, 8, 16]. Assessment of these changes in various regions of the world, including the territory of the Sevan basin, is the subject of a number of works by various authors [4, 6–8, 12–14, 16].

Table 1. Basic hydrometric characteristics of rivers and their catchments in lake Sevan basin

River – point	Distance from the mouth, km	River length, m	Main catchment characteristics		
			Square, km ²	Average height, m	Average slope, %
Dzknaget – Tsovagyugh	1.0	22.0	82.6	2220	211
Masrik – Tsovak	2.8	45.0	673	2310	158
Karchaghbyur – Karchaghbyur	1.1	26.0	116	2650	174
Wardenis – Wardenik	4.1	28.0	117	2680	279
Martuni – Geghovit	7.2	27.0	84.5	2760	285
Argichi – Getashen	6.0	51.0	366	2470	144
Bakhtak – Tsakqar	6.0	30.0	144	2570	123
Gavaraget – Noratus	7.0	24.0	467	2430	133

In work mathematical-statistical, extrapolation, analytical, correlation methods are used.

3 Results and discussion

As a rule, the water regime of rivers is determined by the geographical position of the basin, relief, average height of the basin, geological structure, soil and vegetation cover, and nutritional conditions. Due to the influence of these factors, an uneven distribution of both the river network of the lake Sevan basin and runoff is manifested. The rivers of the northeastern part of the basin are significantly inferior in their water content to the rivers of the southern and western parts (Masrik, Argichi, Gavaraget) (table 2).

Table2. Main characteristics of the annual runoff of rivers flowing into lake Sevan

River – point	Average annual water consumption, m ³ /sec	Drain module, l/sec.km ²	Drain layer height, mm	Maximum flow, m ³ /sec	Minimum flow, m ³ /sec
Dzknaget – Tsovagyugh	1.09	13.2	416	2.14	0.41
Masrik – Tsovak	3.33	4.95	156	4.38	2.15
Karchaghbyur – Karchaghbyur	1.06	9.14	287	1.52	0.37
Wardenis – Wardenik	1.58	13.5	425	3.17	0.47
Martuni – Geghovit	1.68	19.9	628	3.20	0.82
Argichi – Getashen	5.46	14.9	471	11.2	2.81
Bakhtak – Tsakqar	0.65	4.51	142	1.30	0.11
Gavaraget – Noratus	3.50	7.49	236	4.82	2.77

The work considers the time course and trends of the annual river runoff of the lake basin for the available observation periods for the year with an assessment of their significance (fig. 3, fig. 1), that is conclusions are drawn about the main trend of observed changes in river runoff.

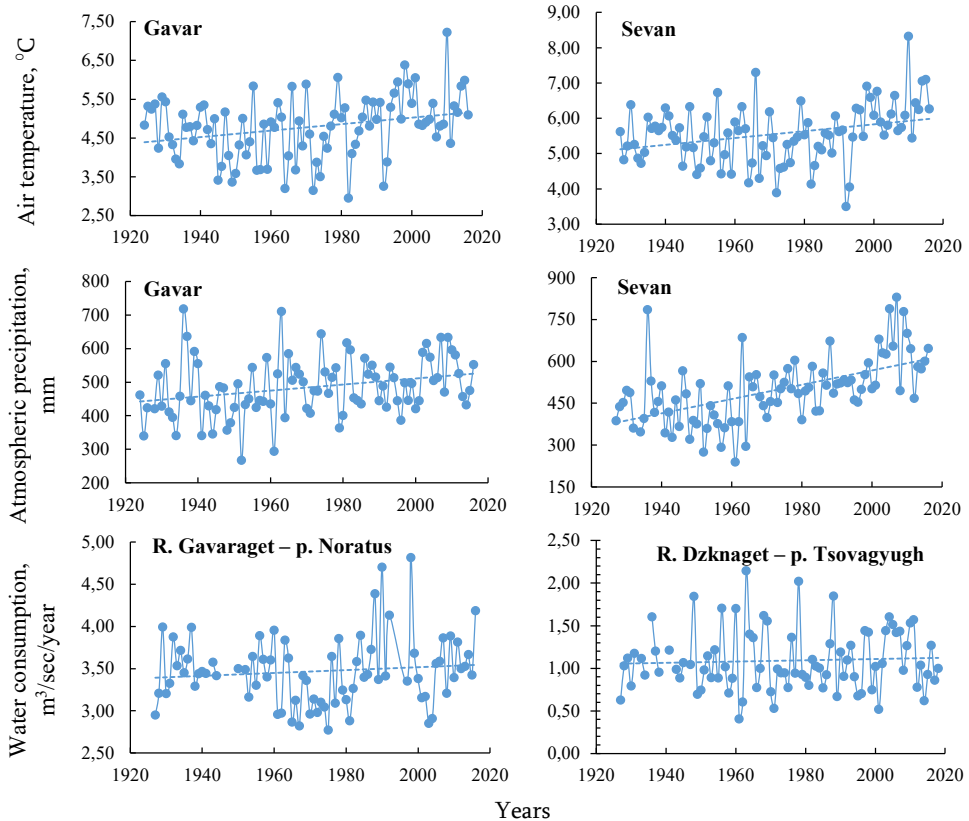


Fig. 1. Long-term fluctuations in average annual river water discharge, average annual air temperature, annual rainfall

Table 3 shows the equations of linear trends, statistical characteristics (trend coefficients), standard errors, etc). As follows from tab.3, the linear trend coefficient is the largest in the Masrik river – Tsovak point, which is equal $\beta = 0.11 \text{ m}^3/\text{sec} / 10 \text{ years}$, which in terms of 100 years gives an increase in annual river runoff by $1.1 \text{ m}^3/\text{sec}$.

For clarity, fig. 2 shows the graphs of the time course of the annual river runoff, on which trend lines are plotted. In the basin, according to the data of actual observations of the annual river runoff, they mainly show an upward trend. It turned out that in a number of long-term observations in the basin, a predominant growth trend was observed in annual river runoff. The only exceptions are the Vardenis and Bakhtak rivers, that is, a decreasing trend is observed by 17% of the rivers under discussion.

To assess the long-term fluctuations of the annual river runoff under the conditions of climate change, we also discussed the dynamics of changes in air temperature and precipitation. Changes in air temperature and precipitation are estimated for each meteorological station separately for the entire observation period.

Table 3. Linear trend equations and statistical characteristics for the annual river runoff of the lake Sevan basin

River – point	Linear trend equation	Statistical characteristics			
		β (m ³ /sek /10 years)	ΔQ_{90} , m ³ /sek	Autocorrelation, r(1)	Standard errors
Dzknaget – Tsovaghyugh	$y = 0.0007x + 1.053$	0.007	0.063	0.02	0.039
Masrik – Tsovak	$y = 0.0111x + 3.037$	0.11	0.99	0.46	0.11
Karchaghbyur – Karchaghbyur	$y = 0.0084x + 0.774$	0.084	0.76	0.72	0.077
Wardenis – Wardenik	$y = -0.0078x + 1.816$	-0.078	-0.70	0.44	0.11
Martuni – Geghovit	$y = 0.0037x + 1.562$	0.037	0.33	0.44	0.098
Argichi – Getashen	$y = 0.0078x + 5.093$	0.078	0.70	0.25	0.19
Bakhtak – Tsakqar	$y = -0.0005x + 0.663$	-0.005	-0.045	0.02	0.031
Gavaraget – Noratus	$y = 0.0008x + 3.467$	0.008	0.072	0.20	0.060

The research results show that under the conditions of climate change at all meteorological stations of the basin territory, there is only a tendency for an increase in average annual air temperature (and significantly over the past decades) and annual precipitation. Over the entire observation period, the highest average annual air temperatures were observed in 2010 (fig.1). Long-term fluctuations in air temperature and precipitation also have their manifestation in fluctuations in the river runoff of the study area.

It turned out that in the study area over the entire period of instrumental observations the average annual air temperature increased by 0.5-1.5 °C or 10–30%, and atmospheric precipitation by 80-150 mm or 15–40%.

Note that the study area has a mixed continental climate with a pronounced ascending zonality. Climate formation is greatly influenced by the isolation of the basin and the presence of the lake. As a result, being bordered by mountains, the amount of precipitation in the basin is relatively small. Winter is long, cold, stable snow cover forms. The summer is warm, the weather is mostly cloudy. In January, the average monthly temperature ranges from -4.5 °C (Shorzha) to -8.5 °C (Vardenyats), the absolute minimum reaches -38.1 °C (Masrik). Summers are cool and short, in July the average monthly temperature is from 14.0 °C to 17.1 °C (Shorzha), the absolute maximum reaches 35.2 °C (Masrik).

In the lake basin, precipitation is distributed extremely unevenly [2]. In the northern and northwestern parts of the basin, a significant amount of precipitation falls than in other parts. This is explained by the fact that the northern and especially northwestern part is more accessible for the flow of external air masses. Annual precipitation in the mirror and coastal zones is 390–450 mm. Higher in the mountains, the amount of precipitation increases, reaching 800–900 mm. Most precipitation falls in the Dzknaget basin (635 mm – Tsovaghyugh, 724 mm – Semenovka), and in the Masrik valley – relatively less (435 mm – Masrik).

4. Conclusions

Thus, under the current climate change in the study area, the average annual air temperature, annual precipitation, and average annual river discharge have increased over the entire observation period. In general, an increase in the amount of precipitation and river runoff in the study area in the development of various spheres and branches of the economy is assessed positively. Nevertheless, it is necessary to develop economic mechanisms for the efficient consumption and conservation of water resources, to create a full-fledged database of reliable data on water resources and climatic characteristics.

In the study area over the entire period of instrumental observations, the average annual air temperature increased by 0.5–1.5 °C or 10–30 %, and atmospheric precipitation by 80–150 mm or 15–40 %.

The reported study was funded by Russian Foundation for Basic Research (No.18-47-242002), Government of Krasnoyarsk Territory, Krasnoyarsk Regional Fund of Science, to the research project: «The development of technology for creating intelligent information systems of object-oriented monitoring of territories based on remote sensing data».

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