

ANNOTATION

for the degree of Doctor of Philosophy (PhD) in the specialty
6D061000-Hydrology on the topic "**Assessment of changes in water resources and the prospects for forecasting the water content of the main rivers of the Ile-Balkash basin in the context of modern climate warming**",
performed by **Amirgaliyeva Ainur Serikkazievna**

General description of the work. The dissertation work is devoted to the study of long-term fluctuations in annual water discharge, restoration of gaps in observations of hydrometric data and bringing to long-term series of observations on analogous rivers, the influence of economic activity and modern climate warming on runoff characteristics of the main rivers of the Ile-Balkash region over the observation period since the 1930s years to 2015-2018, inclusive. The work included "Degree-Day" method approbation for the conditions of runoff formation on the example of the Ileyskiy Alatau and Northern Pribalkash rivers with insufficient data on snow reserves, and a preliminary long-term forecast of water availability was presented using the example of the Kishi Almaty river for the period of 2000-2014. The work uses generally accepted methods for calculating characteristics of average annual water discharge, to assess significant anthropogenic impact on the Ile, Shelek, Sharyn and Kurty rivers under the influence of economic activities in the region. To assess changes in water resources the influence of meteorological elements (an increase in the average annual temperature air and the amount of annual precipitation) were taken into account in a simple empirical "Degree-Day" approach for a long-term forecast of water availability in the mountain rivers of the Ileyskiy Alatau.

Relevance of the work. The Ile-Balkash basin has great economic and social importance in the Republic of Kazakhstan. It is home to 16% of the country's population, 16% of industrial production and 13% of agricultural products are concentrated in this region. The territory possesses 22% of water resources, of which 42% falls on the share of hydropower resources, the area of irrigated agriculture here is about 350 thousand hectares. In the region under consideration large cities such as Almaty, Taldykorgan, Kapshagai and Almaty region are located, and 833 water consumers and water users are officially registered. In the future, it is planned to develop the region, which will lead to an increase in water consumption due to intensive industrial growth. In connection with the above, the issue of predicting changes in water resources in the context of modern climate warming and an increase in economic activity and their rational use in the basin under consideration is already acute. The hydrological study of the Ile river basin began in 1910-16, and for the rest of the main watercourses from the late 1920s and early 1930s. Analysis of fluctuations in runoff characteristics over a fairly long period made it possible to assess the impact of human economic activity and climatic changes. In this regard, the work carried out study and restoration of runoff observation series in the main stations of the Ile-Balkash basin since the beginning of the operation to 2015-2018, inclusively. Analysis of the values of the average annual water discharge for the entire observation period makes it possible

to trace the periods of different water content and trends in the change of water regime in rivers in the future under different scenarios of the development of climatic conditions. The study of the characteristics of the flow of the rivers of the Ile-Balkash basin and their economic use made it possible to identify the most qualitative data, restore gaps in observations and analyze the influence of channel regulation on the annual flow of rivers.

In addition to anthropogenic loads, the natural water regime of rivers also changes due to climatic changes. The work considered changes in the long-term temperature regime and annual precipitation for 14 representative meteorological stations for different regions of the Ile-Balkash basin, differing in the average height of the area, remoteness and their influence on the characteristics of the annual runoff of the basin's rivers. Studies have been carried out to assess the influence of fluctuations of meteorological factors on the water regime of the rivers in the basin.

The characteristics of the average long-term annual river flow are calculated taking into account climate change.

Along with global warming and an increase in the average annual air temperature, which is observed everywhere, the share of the snow component in the water content of the rivers of the studied region will decrease, while the share of rainfall, on the contrary, will increase. This is an important point in determining the impact of climate change on water resources in general. In the future, as snow reserves decrease, it will be important to be able to assess their contribution to the assessment of water resources.

Object of the study. Average annual water discharge of the main rivers of the Ile-Balkash basin with a long observation period. The calculation period from the 30s of the last century to 2015-2018, inclusive. Average annual air temperatures and amount of annual precipitation for representative meteorological stations located in the zone of their climatic influence in the basin. Average daily air temperatures, precipitation and snow depth for the designated drainage basins and meteorological stations located in the zone of their influence.

Subject of the study. It includes issues of restoration and bringing of a number of runoff characteristics to long-term observation series, determination of statistical parameters of annual runoff, assessment of significant changes in the regime of the Ile, Sharyn, Shelek and Kurty rivers under the influence of economic activities in the region, assessment of changes in water resources of the main rivers in the Ile-Balkash basin with taking into account the increase in air temperature and the amount of annual precipitation, the application of the "Degree-Day" method on the example of the rivers of the Ileyskiy Alatau and the Northern Pribalkash region, the lack of hydrometric data on snow reserves.

Research methods: when performing the dissertation work, the following methods were used: to restore and bring a number of hydrological observations to a long period and calculate the runoff, the method of pair regression, regression analysis, the method of hydrological analogy, correlation analysis, as well as the criterion of homogeneity (stationarity) were used to check the data for homogeneity through Microsoft Excel and Stokstat. In hydrological research, one

of the main methods is a statistical method, which is widely used in hydrological calculations to restore the flow, determine and evaluate statistical parameters. To determine the impact of economic activities, the method of accounting for the effect of ponds and reservoirs on the annual runoff was applied using calculated reduction and drainage factors, using the value of the useful volume of the reservoir. To assess the fluctuations in water content, difference and total integral curves were constructed, which made it possible to identify changes in the annual runoff. Changes in long-term fluctuations in air temperature and precipitation averaged over decades and over altitude zones are analyzed. The total integral curves were constructed to reveal the tendency of changes in air temperature, atmospheric precipitation and annual runoff of rivers in the basin, taking into account changes in meteorological factors that form the runoff. To apply the "Degree-Day" method for calculating runoff modeling, graphical and statistical parameters of the input hydrometeorological data were calculated, the parameters were calibrated and, using QGIS program, maps of a digital elevation model of the drainage basins of the Kishi Almaty, Turgen, Tokrauyn and Aktogay rivers were created. To predict the water content, a simple empirical degree-day method was used. The hydrometeorological characteristics were calculated, the graphs of the relationship between the proportion of snow melt runoff in the total flood volume during the growing season were plotted.

Purpose of the work: the purpose of the dissertation work is to study and analyze long-term fluctuations in the annual flow of the most significant rivers of the Ile-Balkash region, taking into account the influence of anthropogenic factors and climatic changes on their water regime, which now clearly affect the runoff characteristics.

In accordance with this goal, **the main tasks of the study** were formulated:

1. research of literature sources and analysis of general trends in climate and runoff changes;
2. collection of information on river flow and on meteorological elements affecting the flow in the formation zone of the rivers of the Ile-Balkash basin in its main sections for the entire observation period up to 2015-2018;
3. calculations of the annual runoff of water resources for the characteristic periods of the studied basin;
4. assessment of changes in the current state of water resources in the Ile river basin under conditions of climate change and anthropogenic influence;
5. results of application of the "Degree-Day" method in case of insufficient meteorological observations of snow cover on the example of some rivers of the Ile-Balkash basin;
6. The maximum volume of water output of snow cover is calculated for the preliminary forecast of the flood volume of the studied basin.

Scientific novelty: in the process of research, new scientific results were obtained:

- refined and processed data for a modern long-term period (1990-2015) since the change in water availability by increasing the amount of precipitation of major rivers of the Ile-Balkash basin;

- calculated and recommended characteristics of runoff and calculated values of annual runoff various probabilities basic rivers of the region with the estimate accuracy of the calculations;
- estimated the impact of economic activity on the flow of the rivers of the region in the first place, rivers Ile, Sharyn, Shelek, and Kurty, due to the channel control;
- first held testing method «Degree-Day» for the determination of the amount of snow melting, which made a long-term water availability forecast for Ile Alatau rivers.

Scientific and practical significance of the work: Calculations performed to restore gaps in observations on analogous rivers; study of long-term changes in the annual runoff of the main rivers, taking into account the influence of anthropogenic activity and assessment of significant changes in runoff characteristics along the Ile, Sharyn, Shelek and Kurty rivers under the influence of economic activities in the basin; studies of long-term meteorological regimes of the average annual air temperature and the sums of the amount of annual precipitation in the context of averaging over decades and for different altitude zones by representative meteorological stations; application of the 'Degree-Day' method in conditions of insufficient hydrometric observations on snow reserves and the results of which the parameters of the maximum amount of snow melting are calculated, which makes it possible to reveal the relationship between the volume of flood during the growing season and the calculated maximum values of snow melt runoff, using it in the absence of data on snow reserves in nearby catchment areas river basins, as an analogue river, was carried out at a reasonable level.

Since all work is aimed at reassessing changes in water resources, taking into account climate change and economic activities in the region, the whole emphasis is made on changes in fluctuations in runoff characteristics and meteorological elements.

The results obtained can be used for the preparation of annual and long-term cadastral reference books, in scientific research projects, in scientific works and research taking into account changes in climatic changes and anthropogenic activities, for forecasting purposes, etc.

The main provisions for the defense:

1. The results of the evaluation of the annual runoff of the main rivers of the Ile-Balkhash basin for different periods, taking into account climate change and human impact.
2. The regression equation for reconstructing gaps in observations and calculating the conditionally natural runoff of rivers in the region, obtained from the most reliable relationships of the values of the annual runoff of analogous rivers.
3. Recommended modern calculation period for assessing the runoff characteristics of the rivers in the basin since the beginning of the 1990s, obtained on the basis of an analysis of the homogeneity of the series of average annual water discharges over the observation period and spatial-temporal studies of the effect of

an increase in the amount of annual precipitation, which makes it possible to take into account a steady increase in the water content of the rivers in the basin.

4. Using the "Degree-Day" method for long-term forecasting of flood runoff by simulating the maximum volume of water yield from the snow.

Author's share in scientific work. In the course of the study, the author analyzed the literature on this topic, identified the goals and objectives of scientific work, was engaged in the collection and statistical processing of data, carried out hydrological calculations and analyzed the results of the study. She also personally took part in the writing and presentation of the dissertation.

Communication with plans of scientific works. The dissertation work was carried out on the basis of a scientific project: "Floods and flooding threats of riverside territories of Kazakhstan" (№4259/ΓΦ4) in 2016-2019.

Approbation of work. The main provisions and results of the dissertation work are set out in the reports of republican and international scientific and practical conferences:

- IV International Farabi Readings. Materials of the international scientific conference of students and young scientists "Farabi Alemi" (Almaty, April 10-13, 2017).

- Proceedings of the All-Russian Conference "Hydrometeorology and Ecology. Scientific educational achievements and development prospects" (Russian Federation, St. Petersburg, December 19-20, 2017)

- VI International Farabi Readings. Materials of the international scientific conference of students and young scientists "Farabi Alemi" (Almaty, April 08-10, 2019).

Publication of research results. The manuscript of the dissertation was thoroughly prepared at the Department of Meteorology and Hydrology, Faculty of Geography and Environmental Sciences, Al-Farabi Kazakh National University and after a preliminary consideration of the dissertation at an extended meeting of the department, it was recommended for defense. According to the main results of the research work, 7 scientific articles were published in domestic and foreign scientific journals, including 2 articles and 1 thesis - in collections of scientific conferences held in Kazakhstan and abroad, 3 articles - in publications recommended by the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, in the journals "Vestnik KazNU" (geographic series) and "Hydrometeorology and ecology" (RSE "Kazhydromet") and 1 article - published in the journal included in the international database Scopus: "International Journal of Geomate".

The structure and scope of the thesis. The dissertation consists of an introduction, a review of domestic and foreign scientific and technical literature, four chapters, a conclusion, a list of sources used. The total volume of the thesis is 127 pages of computer typed text 30 Figures, 20 tables, 161 titles of used literature and appendix.