

ANNOTATION

dissertation for the degree of Doctor of Philosophy (PhD) specialty 6D061000 –
Hydrology

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“Impact of modern and prospective climate changes on the water resources of the Ile river Basin ”

Relevance of the research topic. One of the prerequisites for the sustainable development of society is the provision of water to the population and sectors of the economy. However, due to the uneven distribution of water in the world, various crises and even conflicts between states occur. The main reason is that the supply of fresh water on earth is only 3 percent. The shortage of fresh drinking water in the world has been known to mankind since ancient times, and since the last decade of the 20th century it has been constantly considered as one of the global problems of our time. According to the United Nations (UN), almost half of the world's population lives in conditions of water scarcity. According to experts, more than 780 million people on earth do not have access to clean drinking water. And 1.7 billion people need fresh water sources. There are 263 transboundary rivers in the world that cross the political borders of two or more states. About 40 percent of the world's population depends on these reservoirs.

The Republic of Kazakhstan is among the countries with a shortage of water resources due to its geographical location, the main reason for which is our dependence on neighboring countries. Obviously, the smaller the water reserves in the country, the more detailed should be the approach to assessing and forecasting changes occurring in the water system associated with changes in natural and anthropogenic factors. According to the UN Millennium Program, one of the seventeen goals of the country's sustainable development plan, as you know, is the equal provision of the population with safe and cheap drinking water by 2030. The main way to eliminate the shortage of water resources and reduce the associated load is its saving and efficient use. When developing a strategy aimed at the efficient use of water resources and their protection, addressing issues of water supply, including the optimal regulation of river flow and its territorial redistribution, first of all, there should be scientifically based assessments in connection with modern and prospective climatic and anthropogenic changes.

The Ile transboundary river is a large strategic reservoir connecting the territories of China and Kazakhstan. The Ile River is the main artery of Lake Balkhash, i.e. it accounts for 80% of the runoff flowing into the lake. In addition to the climatic changes of recent years, the decrease in water resources and the level of Lake Balkhash is influenced by an increase in anthropogenic loads on the river. Global climate change, population growth, development of urbanization and agriculture, production, environmental degradation and natural disasters complicate the water problem in our country. Among these issues, if we focus on global climate change, now global warming is an inevitable fact, because the

increase in the temperature of the earth's surface is observed all over the world. According to the results of studies by Kazakh climatologists, there is a rapid increase in temperature on the territory of Kazakhstan. For example, the rate of increase in the average annual air temperature in Kazakhstan is 0.32°C every 10 years, the largest increase in temperature was 0.52°C every 10 years in the western region of the country. Thus, it is necessary to predict current and future changes in climatic characteristics and evaluate river runoff taking into account these changes.

Assessment of the future state of water resources is one of the urgent problems of hydrology and is directly related to the future change in the factors that form river runoff in natural conditions. When forecasting natural water resources, meteorological parameters (atmospheric precipitation and air temperature) are taken as the main predictors of their formation. Somewhat close to these requirements are the Atmospheric-Ocean General Circulation Models (AOGCM). In the world practice of hydrological calculations, a long-term forecast of river runoff is, from a methodological point of view, of a scenario nature.

The influence of anthropogenic factors on river flow is very difficult to predict, except for future climate change. However, in many countries two scenarios of future water consumption are used: a conditional scenario and a sustainable development scenario. The first scenario predicts the development of water consumption in the world along the lines of the last decades. The scenario of sustainable development is based on the application in the future of effective measures to improve the technology of using fresh water in irrigation and industry, taking into account the main factors that determine the specifics of each region.

In the process of efficient use, distribution and planning of water resources between the two countries, it is necessary to develop a science-based strategy, taking into account current and future climatic and anthropogenic factors. The work uses modern methods of complex analysis and integration of statistical processing of hydrometeorological information, mathematical modeling, regularities of physical and geographical distribution, complex water-balance calculations, based on modern world trends in the study of prospective forecasting of water resources.

The purpose of the work is to assess the impact of modern and prospective climate changes and economic activities on the water resources of the Ile River basin.

Research objectives. To achieve this goal, a number of tasks were considered in the dissertation work:

- - assessment of modern regional climate changes;
- assessment of the impact of modern climate change and anthropogenic factors on the water resources of the Ile river basin;
- forecast of water resources of the Ile river basin, taking into account future climate change and anthropogenic pressures.

Object of study. River runoff resources of the transboundary basin of the Ile River.

Research subject. Impact of modern and prospective climate changes on the water resources of the rivers of the Ile basin.

Research method. System analysis and synthesis, statistical methods, hydrological similarity method, water balance methods, long-term forecasting methods based on climate scenarios. To assess the current state of river runoff resources, methods of statistical analysis of hydrological data, hydrological and water management reporting, including the method of linear runoff equations, the method of hydrological similarity, water balance and the method of hydrological and geographical generalization, were used. Recent climate change has been estimated using statistical methods, linear trend coefficients, and non-parametric Mann-Kendall and Seine slope tests. To assess the impact of agricultural activities on river runoff, the channel water balance method and statistical data on water use, the coefficient of irreversible water consumption were used. Taking into account climate change, the forecast values of air temperature and precipitation, which are considered as the main predictors in assessing the prospective state of natural water resources, were obtained from the 5th report of the General Circulation Models of the Atmosphere and Ocean (GCM) based on two climate scenarios, as well as statistical modeling hydrological series, i.e. canonical classification method.

Scientific novelty of the work:

- refinement of spatial and temporal changes in the main climatic parameters (air temperature, precipitation, evaporation) at the regional level (Ile river basin) from the moment the meteorological station was opened until 2019;
- assessment of trends in air temperature and precipitation using statistical tests (Mann-Kendall criterion, slope of the Seine);
- assessed the prospective state of water resources in the context of water management areas under various climatic scenarios;
- for the first time, based on the canonical expansion method, a long-term forecast of changes in river flow within a year was compiled;
- a long-term forecast of river runoff resources was obtained, taking into account the anthropogenic impact in the context of the water management area.

Theoretical and practical significance of the research. The importance of the work lies in increasing the level of water security and the economic efficiency of decisions made in the field of long-term forecasting of a transboundary water basin, which is of strategic importance for the economy of Kazakhstan, taking into account the expected climatic and anthropogenic changes in water resources in the future.

The main provisions for defense:

- based on the results of the analysis of modern climate changes in the Ile River basin, the statistical significance of the trend line in the course of long-term air temperature and precipitation was assessed;
- the impact of modern climate change and economic activity on the water resources of the Ile river basin was revealed;
- the methods used in forecasting the expected changes in the natural and actual runoff of the Ile river basin can serve as a basis for assessing the impact of climate change and economic activity on water resources in the future and making effective decisions and proposals.

The connection of the dissertation topic with the plans of scientific research. The dissertation work was carried out on the basis of the scientific and technical program: "Scientific and technological justification for the rational use of water resources with an increase in the areas of regular and estuary irrigation in all water management basins of the Republic of Kazakhstan until 2021" State registration No. 0118RK01222, under the budget program 267 "Improving the availability of education and scientific research" was carried out within the framework of scientific projects "Assessment and forecast of annually renewable water resources that can be used for irrigation purposes in the water management basins of the Republic of Kazakhstan" (2018-2020).

The contribution of the author to scientific work. In the course of the dissertation, the author used data obtained as a result of scientific research conducted in the laboratory of water resources of the Institute of Geography and Water Security. Some of the results presented in the dissertation were obtained as a result of joint work with laboratory staff, about which the relevant references are indicated in the text of the dissertation. As a personal contribution of the author, one can attribute the formulation of working tasks, the substantiation of the general concept and the development of specific methods for their solution, the analysis and generalization of the results obtained and the preparation of scientific articles.

Approbation of work. The main principles and results of the dissertation research were presented and discussed at international conferences held in Kazakhstan and abroad:

- The Impact of Human Activity on River Runoff in Transboundary River Ili // International Scientific-Practical Conference «Integration of the Scientific Community to the Global Challenges of Our Time" February 13-15, 2019 Sapporo (Japan) Volume II Sapporo, 2019

- Materials of the international scientific conference of students and young scientists "Farabi", Almaty, Kazakhstan, April 6-9, 2020

- Impact of modern and future climate changes on water resources of the Ile River Basin / I International Student Forum: "Green bridge through generations", Almaty, Kazakhstan, April 4-15, 2022

Publications. The manuscript of the dissertation work was thoroughly prepared at the Department of Meteorology and Hydrology of the Faculty of Geography and Environmental Sciences of the al-Farabi Kazakh National University and after preliminary consideration of the dissertation at an extended meeting of the department, it was recommended for defense. Based on the main results of the research work, 7 scientific articles were published in scientific publications, of which 2 articles - in the collections of international scientific and practical conferences, 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 «Bulletin of KazNU» series Geographic, «Hydrometeorology and ecology» RSE «Kazhydromet» and «Issues of geography and geoecology» Institute of Geography and water security and 2 articles published in the journal included in the international database Scopus:: 1 "Ecological Earth Sciences"; 2. Arabian Journal of Geosciences.

The volume and structure of the dissertation. Dissertation work consists of introduction, 5 chapters, conclusion, references and appendices. The total volume of the dissertation is 135 pages, the work contains 29 figures, 15 tables, 216 references and 8 appendices.