

## ANNOTATION

for the degree of Doctor of Philosophy (PhD) in the specialty **6D061000** –  
**Hydrology** on the topic «Management and risk assessment of floods in the Yesil  
river basin»

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**Relevance of the topic.** Floods belong to the dangerous hydrological phenomena, this intensive flooding of the large territory water which causes material damage, causes a loss to health of the population or leads of people to death. The main criterion of a flood is the maximum level of water during its action. Rise in water level in the rivers, lakes and reservoirs depends on conditions of formation of a drain of water at its movement on a land surface or an underground way in the course of water cycle in the nature.

Floods to a greater or lesser extent are periodically observed on the majority of the rivers of Kazakhstan and win one of first place among natural disasters on the area of distribution and caused material damage. The beginning of the 21st century was marked in Kazakhstan by the whole cascade of catastrophic floods, occurring almost annually, causing extensive economic damage to the population, an object of economy and ecology of the republic.

Nowadays, it is important to study all the hydrological features of water bodies of strategically important regions to ensure the sustainable development of Kazakhstan. One of them is the basin of the Yesil River, which was chosen as the object of study.

Of particular importance is the determination of the extreme hydrological characteristics of the Yesil River due to the need to protect the city of Astana from the adverse effects of its waters.

Determining the flood zones of the densely populated basin of the Yesil River, taking into account the hydrological characteristics of recent years and climate change, is a very urgent and complex problem. A detailed study of the characteristics of the maximum runoff of the rivers of Kazakhstan was carried out in 1960-1970 of the last century were published in materials on the water resources of the USSR of individual basins and other sources. These materials are outdated, they need to be clarified taking into account the data of the last 40-50 years, the influence of anthropogenic and climatic factors.

Flood risk management and assessment is a very urgent task in ensuring the safety of objects in the social-, techno- and ecosphere.

**The purpose of the work:** to estimate risks of floods in a river basin Yesil and to make recommendations about decrease and prevention of negative impact a flood.

**Research objectives:**

- collection of hydrological data on the main sections of the Yesil river basin;
- statistical processing of hydrological data based on hydrological methods using computer technology;
- determination and assessment of flood formation factors (high water levels (HWL)) in the basin;

- creation of maps of the runoff layer and the runoff module for the entire basin using GIS technologies;
- assessment of the risk of floods in the Yesil River basin with different availability of maximum water discharges using the HEC-RAS software product;
- determination of zones of impact of flood risk by modern hydrological programs;
- creating a flood hazard map of the Yesil river basin;
- substantiation of flood protection measures recommended for implementation in the study area;

**Object of study:** Yesil river basin.

**Research methods.** At performing this dissertation work, the following were used: to restore the series of hydrological observations, regression analysis, the method of hydrological analogy, correlation analysis, as well as homogeneity criteria for checking data for homogeneity. In the work, one of the main methods was used in hydrological studies - the method of statistical analysis, since this method is widely used in hydrological calculations to restore the runoff, determine and evaluate statistical parameters.

To determine the impact of economic activity, the method of taking into account the influence of ponds and reservoirs on the annual runoff was used using the calculated drawdown coefficient, using the value of the useful volume of the reservoir. To assess fluctuations in water content, difference and total integral curves were constructed, which make it possible to identify changes in the maximum runoff. Changes in long-term fluctuations in air temperature and precipitation averaged over decades are analyzed. The dissertation work also uses the method of spatial data analysis and the cartographic method used to determine flood zones, considers the effectiveness of the use of GIS technologies in determining, clarifying hydrographic and hydrological characteristics, analyzing hydrological processes and phenomena, creating a cartographic and attributive database of water bodies. The map provides detailed information about the temporal and spatial distribution of any phenomenon and allows you to visualize the model of the phenomenon under study, summarize the results of previous studies, and is also a means of a deeper study of these phenomena.

**Description of the main results of the study:** In the dissertation work, a chronological analysis of the catastrophic floods that took place in the 19th, 20th and 21st centuries in the Yesil River basin was carried out. An analysis of the materials made it possible to identify floodplain areas, observed dates, causes and consequences of floods in the basin. Based on the opinion of many scientists, the flood causes were classified into 7 groups, which are typical for the flood formation conditions in this basin. As a result, the main factors leading to the flooding of territories were identified, which include the simultaneous passage of snow melt, precipitation and rising water levels. It was also noted that modern climate change and human economic activity also have a significant impact on the formation of floods. The scale and frequency of floods in the studied basin are determined.

In this work, based on the collection and analysis of hydrological data, the hydrological knowledge is considered and an assessment of the maximum runoff of

the main rivers of the Yesil River basin is made. Using well-known statistical methods for processing the series of observations of hydrological characteristics, the hydrological series of the studied rivers were restored, a check was made for the homogeneity of the series of maximum discharges, the statistical parameters of the series of maximum water discharges were calculated and their accuracy was assessed. Calculation of the characteristics of the maximum runoff of rivers in the basin of the Yesil river is produced for two periods: natural and disturbed. For each period, changes in the characteristics of the long-term series of maximum discharges of the main rivers of the Yesil river basin were revealed.

The data required for the use of GIS technology in the Yesil river basin were obtained from various sources (Earth remote sensing data, observational data on the hydrological runoff series related to the Kazhydromet network from the moment of instrumental observations until 2019). The values of the runoff layer and runoff modulus obtained as hydrological characteristics at 22 hydrological gauging stations located on the rivers of the Yesil basin were restored using well-known statistical methods in hydrology. The parameters of the river runoff layer of the basin were compared with previous published works in terms of the magnitude of the change in recent years. As a result of the comparison, a change in the range of fluctuations in the values of the runoff layer (h, mm) on the rivers of the basin and an increase in the values of the runoff layer in recent years were revealed.

As a result of the studies performed, the high efficiency of using GIS technologies for analyzing the conditions for the formation of surface runoff in the river basin was confirmed. One of the possibilities of GIS technologies in hydrological research is the creation of a predictable map of possible hydrological characteristics at all points (territories) of the study area using observational data at hydrological posts. As a result of using the «ArcGIS 10.x» software tool, a physical and geographical map of the basin and a map of the location of hydrological stations of the Yesil river basin at a scale of 1: 1,000,000, as well as digital maps of the layer and runoff module of the Yesil river basin were created.

The data needed to model the risk of flooding on the Zhabay river near Atbasar were included in the HEC-RAS program. Based on the simulation results, it was found that with a rare recurring probability, the village of Zarechnoye, the western parts of the city of Atbasar can be flooded, and the possible flood width can reach 4623 meters with a probability of 1%, the width of flooding with a probability of 5% can reach 3800 meters.

#### **The main provisions for defense:**

1. An analysis of all periods of flooding in the Yesil river basin was carried out, and types of floods were determined based on the study of hydrographs of catastrophic floods.

2. Using the data of recent years, the characteristics of the maximum runoff of the Yesil river basin were calculated, the impact of climate change and anthropogenic factors on it was quantified.

3. On the basis of modern GIS data and remote sensing of the Earth, digital maps of the Yesil River basin were created, the methodology for assessing the risk of flooding in relation to the Yesil river basin was adapted, the width of flooding

was determined using the example of the Zhabai river basin with possible values of maximum runoff with rare recurring availability of maximum water discharges, recommendations for justifying measures to reduce the adverse impact of floods.

**Scientific and practical significance of the work:** One of the important components of the safe development of the republic is the prevention and mitigation of the consequences of hazardous natural processes. On the Kazakhstan territory floods account for a significant proportion of natural disasters.

The use of the results obtained in the work will help in the implementation of practical tasks (preventive measures, etc.), the preparation of scientific generalizations, forecasts on issues related to risk assessment during the passage of catastrophic floods. In addition, they can serve as an addition to the formation of theoretical and practical skills and skills of students of educational institutions to protect against the harmful effects of water.

**Justification of the novelty and importance of the results obtained:**

Taking into account the data of hydrological characteristics of recent years, the series of the maximum runoff of the rivers of the Yesil basin for the entire period of observations has been reduced to the long-term (1945-2019) and their runoff characteristics have been refined;

By of computer technology, work was carried out to process the characteristics of the runoff using well-known statistical methods in hydrology, new values of maximum water discharges were identified for different availability;

A quantitative assessment of the impact of modern climate change and anthropogenic factors on the Yesil river basin was carried out and new statistical values are obtained.

By using modern GIS technologies and Earth remote sensing data, a new map of the location of the main hydrological posts in the Yesil river basin was created, and maps of the flood hazard, runoff layer and runoff module for the Yesil river basin were created for the first time on the basis of the spatial analysis module.

By using of the HEC-RAS model, the flood risk zone of the Zhabai river in the Yesil basin was modeled and the possible flood width was determined.

**The share of the author in scientific work.** During the study, the author analyzed the literature on this topic, identified the goals and objectives of scientific work, collected and statistically processed data, performed hydrological calculations and analyzed the results of the research. As well as personally participated in the writing and design of the dissertation.

**Communication with research work and government programs.** The dissertation work was carried out on the basis of the state program: «State program of water resources management of Kazakhstan for 2014-2020».

**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:

- VI International reading of Farabi. Materials of the international scientific conference of students and young scientists «Farabi Alemi» (Almaty, April 2-12, 2019).

- Materials of the international scientific and practical conference «The role of the President of Tajikistan in solving global problems: water is the source of life» (Almaty, 2019).

- IX International Student Forum «Green Bridge through Generations» (Almaty, April 21-22, 2022).

**Publication of research results.** 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 and 1 thesis - 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 1 article - published in the journal included in the international database Scopus: «News of the academy of sciences of the Republic of Kazakhstan».

**Structure and scope of work.** The dissertation consists of introduction, 4 chapters, conclusion, appendix, 131 references and contains 133 pages, 20 figures and 9 tables.