

## ANNOTATION

Dissertation for the degree of Doctor of Philosophy (PhD)  
in the educational program «8D05203-Hydrology»

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**«Investigation of the influence of environmental changes on the erosion-  
channel systems of the Ile Alatau rivers»**

**Relevance of the Dissertation Research.** Erosional-channel processes represent a complex of interrelated phenomena, which include erosion, sediment transport, and accumulation. These processes shape the morphology of river basins, determine channel dynamics, floodplain formation, as well as the stability of infrastructures and river ecosystems.

The erosional-channel systems of the Ile Alatau rivers are part of the Ile River basin. The hydrological specificity of this region lies in the juxtaposition of arid lowlands with scarce water resources on the one hand, and humid mountain ranges on the other. The hydrography of the range is represented by mountain rivers with fast flows and intense erosional activity during floods. Although relatively small in watershed area, their valleys are distinguished by complex morphological features, often forming large gorges with depths reaching 800-1000 m. The rivers studied include the Kaskelen, Aksay, Kargaly, Ulken Almaty, Kishi Almaty, Talgar, Esik, and Turgen.

Erosional-channel systems are an integral part of the water balance and play an essential role in water supply, biodiversity conservation, and regulation of hydrological processes. However, their morphological structure is significantly influenced by both natural and anthropogenic factors, affecting ecosystem stability, water quality, and various sectors of the national economy. In this regard, forecasting changes in channel systems becomes a pressing task for effective water resources management and the development of environmental protection measures.

The morphological structure of the studied rivers is characterized by a diversity of forms and processes, such as meanders, floodplains, and elements of channel dynamics. These structures are formed under the influence of internal (geological, tectonic) and external (climatic, hydrological, anthropogenic) factors. Forecasting their changes makes it possible to determine the trajectory of river development, assess risks such as flooding, bank erosion, and ecosystem degradation, as well as reconsider development strategies for various sectors of the economy.

The study of the morphological structure of small rivers is an important scientific direction for understanding their dynamics, predicting channel changes, and managing water resources. This is particularly relevant for mountainous regions such as the Ile Alatau, where channel processes are influenced not only by natural factors but also by the impact of urban areas. In Kazakhstan, research on river morphology and erosional-accumulative processes is still in the stage of formation and gradual development. Meanwhile, the experience of CIS countries and international studies demonstrates that integrated application of field observations, GIS modeling, and remote sensing data allows for a more accurate characterization

of channel dynamics and provides opportunities to forecast river morphology under conditions of environmental change.

The rivers considered in this research flow through urban territories. The main feature of urban areas is their high and continuously changing population density. Moreover, the transformation of erosional-channel systems in urban settings presents significant challenges for city planning, stormwater drainage, and sewage system design.

Assessment and forecasting of spatial and temporal transformations of erosional-channel systems under the influence of natural changes using modern GIS technologies and remote sensing data represent a novel direction in such studies.

Predicting the morphological transformations of rivers and their floodplains provides a basis for regional development planning in the context of global climate change and contributes to ensuring the sustainable development of the study area.

**The aim of the dissertation** is to assess the impact of environmental changes on the erosional-channel systems of the Ile Alatau rivers based on hydrological monitoring data, modern GIS technologies, and remote sensing materials.

### **Research Objectives**

Description of the concept of erosional-channel systems and their main components;

Collection of hydrological observation data and statistical processing using computer technologies;

Determination of channel-filling and channel-forming discharges for the studied rivers;

Construction of dependency graphs based on liquid and solid runoff data for the Ile Alatau rivers, with refinement of solid runoff information;

Determination of stream power by establishing the relationship between liquid runoff and slope of the studied rivers;

Digitization of channel outlines of the Ile Alatau rivers (Kaskelen, Aksay, Kargaly, Ulken Almaty, Kishi Almaty, Talgar, Esik, Turgen) and preparation of maps;

Identification of the impact of environmental changes (climatic and anthropogenic) on the erosional-channel systems of the Ile Alatau rivers;

Forecasting of channel changes in the Ile Alatau rivers.

**Research Object** – the rivers of the Ile Alatau (Kaskelen, Aksay, Kargaly, Ulken Almaty, Kishi Almaty, Talgar, Esik, Turgen).

**Research Subject** – assessment of the impact of environmental changes on erosional-channel systems.

### **Research Methods:**

Statistical analysis of hydrometeorological data influencing erosional-channel systems;

Remote sensing of the intensity of changes in channel morphodynamics;

Cartographic analysis of temporal and spatial changes in river channels in chronological sequence;

Spatio-temporal analysis of erosional processes in small river channels;

Comparative assessment of channel-filling and channel-forming discharges established for small rivers;

Forecasting of the morphodynamic structure of rivers.

### **Scientific Novelty of the Research**

As a result of the study, the morphological and hydrological characteristics of the erosional-channel systems of the Ile Alatau rivers were, for the first time, comprehensively refined, and their spatial and temporal dynamics were assessed. The scientific novelty of the research is as follows:

The concept of the erosional-channel system was adapted and specified for the Ile Alatau rivers, with their main morphological components and structural types (conditionally meandering and conditionally braided) identified for the first time on the basis of QI diagrams.

Channel-filling and channel-forming discharges were established for the Ile Alatau rivers. The ranges and differences between these indicators were determined, the influence of flow regime on morphodynamics was assessed, as well as the features of their spatial distribution within the study area.

Relationships between solid runoff and water discharge were evaluated separately for each river, and regional characteristics were described based on correlation coefficients.

The impact of climate change on erosional processes was demonstrated for the first time using the Kaskelen River as an example, showing that rising temperatures and changes in precipitation over recent decades have led to increased channel instability.

For the first time, spatial changes in river channels and rates of erosion/accretion were quantitatively assessed using the DSAS 5.1 extension in the ArcGIS environment. This method was applied to sections of the Ulken Almaty and Talgar rivers, and the results, obtained on the basis of the Kalman filter method, were presented as predictive channel outlines for the next 10- and 20-year periods.

The findings have practical significance for the automation of channel process monitoring, planning of engineering structures, and delineation of water protection zones.

### **Scientific and Practical Significance of the Research**

Assessing the impact of natural and anthropogenic factors on small rivers is one of the most complex, least studied, and pressing issues, with considerable scientific, socio-economic, and applied importance.

The research contributes to the development of the theoretical foundations of hydrology and geomorphology through the analysis of climatic and anthropogenic impacts on the erosional-channel systems of the Ile Alatau rivers. Statistical analysis based on collected observational data has made it possible to identify characteristic discharges that exert the greatest influence on channel processes.

The analysis of runoff variations and channel processes in small rivers is of particular relevance for water resources management and the delineation of water protection strips and zones. In urban areas, erosional changes in river channels play an important role in housing construction, infrastructure development, and

engineering planning. Such data can serve as a foundation for ensuring the sustainable development of settlements and urban agglomerations.

The findings of this study provide an opportunity to forecast natural and technogenic changes occurring in the channels of the Ile Alatau rivers, as well as to optimize the placement of hydraulic structures, sewage systems, and stormwater drainage networks. Moreover, the data obtained have been visualized through cartographic tools, thereby facilitating informed decision-making in ecological monitoring and environmental management processes.

**Main provisions submitted for defense:**

I. The concept of erosional-channel systems for the small rivers of the Ile Alatau, defined through channel-forming and channel-filling discharges established from the relationship between river channel slope and water discharge.

II. The regularities of distribution of climatic and anthropogenic factors affecting the erosional-channel systems of the Ile Alatau small rivers, identified using hydrometeorological observation data, remote sensing, and GIS technologies.

III. The results of forecasting changes in the erosional-channel systems of the Ile Alatau small rivers for the next 10- and 20-year periods, obtained through digital shoreline analysis and grounded in the morphodynamic characteristics of river channels over recent decades.

**Author's contribution to scientific work.** In the course of fulfilling the aim and objectives of the dissertation research, the author defined the theoretical and practical foundations for studying the erosional-channel systems of the small rivers of the Ile Alatau. The collection, processing, and analysis of hydrometeorological data; the assessment of spatial changes in channel morphology; and the preparation of cartographic materials using GIS technologies and remote sensing data were carried out with the author's direct involvement. The determination of channel-filling and channel-forming discharges, the construction of the QI diagram, and the morphodynamic forecasting calculations were performed by the author. The writing, formatting, and approbation of the dissertation text were also accomplished through the author's individual contribution.

**Approbation of work.** The research results on the topic of the dissertation have been presented at international scientific and practical conferences:

Tursyngali M.N. Eroziyalyk-arnalyk zhuiyelerge adamnyn sharuashylyk is-areketinin aseri. "Farabi alemi" atty studentter men zhas galymdardyn halyqaralyq gylymi konferentsiia materialdary. 6–8 sauir 2023 zh. Kazak universiteti, Almaty, Kazakstan. 121 b.

Tursyngali M.N. Ile Alataýynyn kishi ozen-derinin sui-yk zhane katty agyndysy arasyn-dagy taueldilik grafikteri zhaiynda. "Farabi alemi" atty studentter men zhas galymdardyn halyqaralyq gylymi konferentsiia materialdary. 4–6 sauir 2024 zh. Kazak universiteti, Almaty, Kazakstan. 55 b.

Tursyngali M.N. Eroziyalyk-arnalyk zhuiyelerge klimattyk ozgeristerdin aserin bagalau. "Tsifriylyk shynailyk: kartografiia, geoaqparattyk zhuiyeler zhane zherdi kashyktan zondtaudagy zh-ana suranystar" birinshi halyqaralyq gylymi-tazhiribelik konferentsiiasynyn makalalar zhinagy. 7–8 karasha 2024 zh. Kazak universiteti, Almaty, Kazakstan. 73–82 bb.

### **Publications of the Research**

Based on the research results, a joint article with domestic and foreign scientific supervisors was published in the journal *Hydrology Research* (No. 54(11), 2023; indexed in Scopus) under the title “Study of temporal changes in the hydrographic network of small mountain rivers in the Ile Alatau, Kazakhstan.”

Together with the domestic scientific supervisor, an article entitled “Assessment of the current state and temporal changes of glacial-moraine lakes in the Central and Eastern part of the northern slope of the Ile Alatau, Kazakhstan” was published in the *Journal of Water and Land Development* (No. 63(X–XII), 2024; indexed in Scopus).

In the final stage of the research, a joint article with domestic and foreign scientific supervisors was published in the journal *Water* (No. 17(13):2029, 2025; indexed in Scopus) under the title “Forecasting Channel Morphodynamics of the Ulken Almaty River (Ile Alatau, Kazakhstan).”

**Scope and structure of the dissertation.** The dissertation consists of 183 pages, including 27 tables and 44 figures. Its structure comprises an introduction, four chapters, a conclusion, a list of 241 references, and nine appendices.