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NEW TRENDS IN WATERING THE CHU RIVER DELTA (KAZAKHSTAN) UNDER CLIMATE CHANGE

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Abstract. The unique features of the water regime in the Chu River delta region (Southern Kazakhstan) and their changes under the impact of climate warming are considered. Based on remote sensing data from the Sentinel-2 and Landsat-8-9 satellites, it was noted that in the absence of severe frosts in the winter of 2024-2025, there was no accumulation of large quantities of ice in the head (Moiynkum) part of the deltaic region (in so-called "delta spills"). This significantly accelerated the progress of the autumn-winter flood and ensured the flooding of these most important forage lands for Kazakhstan over an area extending over 400 km. At the same time, it was possible to weaken such powerful degradation processes as soil salinization and desertification.

Key words: Chu River, delta, hydrology, desertification, salinisation

Introduction. The lower reaches of the Chu River are of great importance to Kazakhstan as a major source of feed for livestock farming. This river originates in the northern spurs of the Tien Shan (Fig. 1) west of Lake Issyk-Kul and flows through Kyrgyzstan (57% of the basin's area) and Kazakhstan (43%).

Within Kazakhstan, the lands of the middle reaches of the river are used for irrigation (sugar beets and other crops), and the lands of the lower reaches are used for livestock farming. The average annual river flow is estimated at 3.58 km³ [4, 5]. The maximum flow in the middle reaches (Tash-Utkul) was 2.26 km³/year, and the inflow into the delta (Furmanovka gauging station, now renamed Moiynkum) was 1.96 km³/year [6]. Flowing through the alluvial fans of the foothill plain, the Chu River loses a significant amount of water through filtration, part of which is released into the riverbed in the lower reaches. Water is also lost to filtration in irrigated fields, and some of it ends up in the riverbed as return water. Therefore, a special hydrological regime has developed in the lower reaches of the river, when the maximum inflow of water into the delta region occurs in the autumn-winter and spring months. At the same time, depending on the severity of the winter, a large amount of water accumulates in the head

(Moyynkum) part of the delta region in the form of multi-layered ice. And only in spring does this water spread further along the chain of delta spills.



Fig. 1. The Chu River

Object and methods of research. The object of our research was the lower reaches of the Chu River, which is a successive chain of delta-like extensions in which water flows from one link to another through narrow channels. We call this entire territory the “delta region” of the Chu River, and each element of this chain is a separate part or section of the delta region. We subjectively consider the term “delta” used in scientific publications in relation to each part of this chain to be unconvincing. Based on the geomorphological and hydrological characteristics of these territories, it is not entirely correct to call them separate deltas.

The predominant method of investigating the problem stated in the title of this article has been remote sensing of the delta region by the Sentinel-2 and Landsat satellites over a number of years. Also, publications of materials from field researches and office studies by scientists from the Kazakhstan Academy of Sciences [1-6], including the authors of this article [7-10], were analyzed.

Results of the study. The nature of the delta region's water supply was influenced by the geomorphological features of the Chu River basin, which flows through powerful proluvial-alluvial fans. During floods, large volumes of water in the upper and middle reaches of the river were lost to filtration into boulder-pebble deposits. By autumn they had partially wedged into the river bed and replenished the groundwater in the lower reaches. However, regulation of river flow and water diversion for irrigation had already impacted the hydrological regime of the lower reaches in the 1960s. Water inflow into the delta region increasingly shifted to the autumn and winter months, accumulating primarily in the uppermost Moyynkum “extension”. Water arrived later and in smaller volumes in the lower parts of the delta region. The farthest (Tasty) part began to dry out, followed by the Kamkaly part, and signs of landscapes desertification appeared. This process was already noted in the 1960s by soil scientists [6] and botanists [1, 2], but in the very upper part of the delta region, back in 1964, we observed the rich nature of the delta with vast areas of reeds 3-5 m high, meadows and channels filled with water.

A real environmental disaster in the delta region of the Chu River erupted in the 1970s, when the low water levels of those years coincided with the reconstruction of the Tashutkul reservoir in the middle reaches of the river and an increase in the

diversion of water for irrigation. Between 1972 and 1975, rapid desiccation affected the entire delta region [7, 8]. Even in the head (Moiynkum) part of the delta, water filled only the channels and areas of low floodplain with reed vegetation. And the meadow vegetation of the previously flooded areas of the middle and high floodplains experienced oppression [1, 2], the soil cover began to quickly become salinized and dry out [7, 9, 10]. In the narrow Ulanbel “extensions” (floodplain) in 1972, the water did not flow out of the riverbed onto the floodplain even in their eastern part, and further to the west, for about 50 km, our route by car passed along a dry riverbed with dried-out peat-bog soils. The continuation of the route along the Kamkalinskaya and Tastinskaya parts of the delta (150 km) was through deserted territory with rare isolated water stretches surrounded by a narrow strip of reeds and reed grass. This dire environmental situation in the delta region continued until 1976, when the reconstruction of the Tashutkul reservoir was completed and the flooding improved somewhat. But it remained extremely insufficient (except in certain years) and did not significantly change the landscapes of the delta region until the 1990s.

With the collapse of the USSR in 1991, the socio-economic situation changed dramatically, including the hydrological regime of the lower reaches of the Chu River. The reorganization of water management in the river basin, land privatization, and changes in priorities in irrigated agriculture temporarily reduced the allocation of water for irrigation and allowed for an increase in water releases into the delta region [3, 4]. However, flooding of the lower reaches remained unstable due to annual fluctuations in river flow. The hydrological regime in the lower reaches began to approach that of the 1950s and 1960s, when flooding of the delta region depended heavily on the accumulation of river water in the Moiynkum part of the delta in the form of ice during the winter. During severe frosts, water accumulated here until spring, and only then moved further down the river valley. As a result, it only reached the Kamkaly and Tasty parts of the delta in the second half of the growing season, and often in insufficient quantities. This is precisely what happened, for example, after the cold winter of 2023/2024, when water arrived in the Kamkalinskaya part of the delta only in July and flooded a small area. And in the Tastinskaya part of the delta, water did not arrive at all, resulting in a lack of hay harvest and even grass for pastures (Fig. 2).

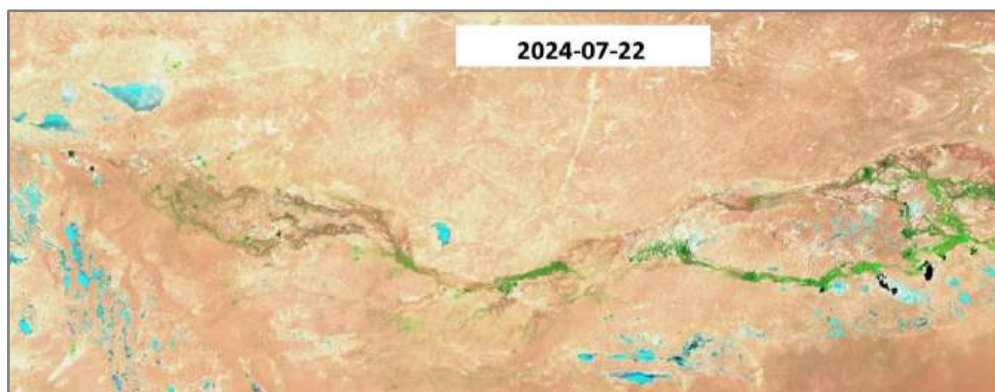


Fig. 2. Water reaching the Kamkaly part of the delta 22-07-2024, (ESA, Sentinel-2).

Taking into account the forecasts of hydrologists [4, 5] about climate warming, we analyzed the change in the flooding regime of the Chu River lower reaches in the relatively warm winter of 2024/2025 (Fig. 3) and the features of water movement from the Moyynkum “extension” to the final runoff area (Ashchikol lakes). According to Sentinel-2 satellite images, it was noted that the flood began to flow into the delta region in October 2024, and the water reached the Ulanbel part at a fairly high speed (1-1.5 km per day) already in February. Here, the speed of its advance along the narrow valley increased to 2 km/day and for the first time in the last decade, by April 18, 2025, the water flooded the Kamkaly part of the delta, and by May 13, 2025, the Tasty part (Fig. 4). This means that river water reached the entire delta region two months earlier than usual, ensuring high yields of forage lands.

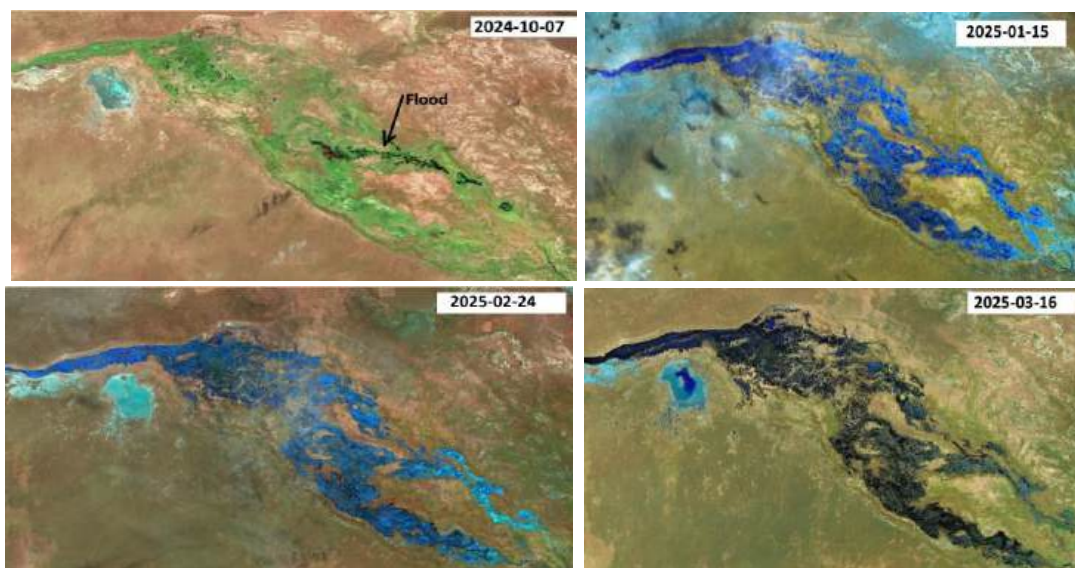


Fig. 3. Flooding regime of the Moyynkum part of the delta region in the warm winter of 2024/2025.

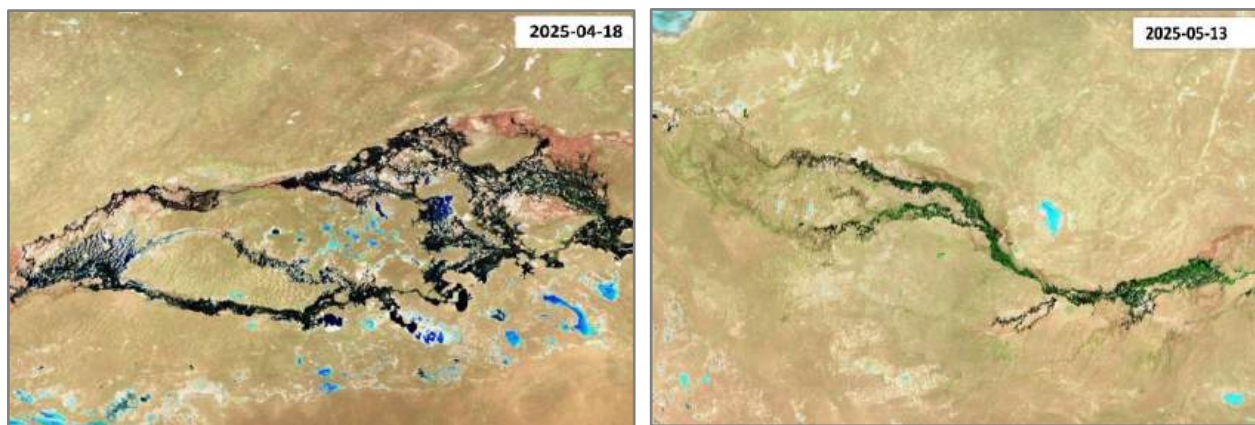


Fig. 4. Dates of flooding of the Kamkaly (April 18, 2025) and Tasty (May 13, 2025) parts of the delta region

To confirm the reliability of the identified trend in connection with climate change, we continue monitoring the flooding regime of the Chu River delta region

taking into account the forecast of hydrogeologists [4, 5]. The flow of water into the head of the delta region this autumn (2025) also began in early October, the water is moving at a speed of about 2 km per day with the prospect of successfully flooding the lower reaches of the river.

Conclusion. The predicted climate warming in the lower reaches of the Chu River opens up prospects for significantly improving flooding in the delta region and increasing the productivity of forage lands for the development of livestock farming. Remote sensing data showed that in the absence of severe winter frosts, river water entering the delta region in autumn does not accumulate as ice in the Moyynkum part of the delta region. It moves along the chain of “extensions” (parts of the delta) quite quickly (at a speed of 1-2 km per day) and reaches the western part of the delta approximately 2 months earlier than in previous years. And if in 2024 the river water only reached the Kamkaly, then in 2025 it practically reached the Ashchikol lakes, that is, it advanced 90 km further, increasing the area of flooded meadows.

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МЕТОДИКА ГІС-АНАЛІЗУ ТРАНСПОРТНОЇ АВАРІЙНОСТІ ДОРОЖНЬОЇ МЕРЕЖІ ЗА ДОПОМОГОЮ ВІЗУАЛІЗАЦІЇ ДАНИХ У ТРИВИМІРНОМУ ПРОСТОРИ

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Анотація. У сучасному суспільстві питання безпеки дорожнього руху набувають все більшої актуальності. Зокрема, за даними -ArcGIS Pro-проекту «Determine the most dangerous roads for drivers» просторово-часовий аналіз аварійності дозволяє ідентифікувати найбільш небезпечні ділянки дорожньої мережі. Проблема дорожньо-транспортної аварійності (ДТП) залишається однією з найгостріших у сфері громадської безпеки в Україні. У 2024 році було зафіксовано 25 781 ДТП з потерпілими, внаслідок яких загинуло 3 202 людини і травмовано 32 023 особи.

За перші сім місяців 2025 року кількість ДТП з потерпілими сягнула 13 738, а загиблі — 1 663 особи. Більше того, рівень смертності на дорогах України у п'ять разів перевищує середньоєвропейський показник.

Такі тривожні тенденції вказують на нагальну потребу впровадження сучасних аналітичних підходів до оцінки та управління аварійністю. Зокрема,