Brief information about the project

Title	Risk assessment of atmospheric droughts and development of an early warning system for Northern Kazakhstan based on machine learning.
Relevance	In the countries of Central Asia, droughts are a frequent and familiar climatic phenomenon. In recent decades, the region has experienced a noticeable increase in average annual temperatures, accompanied by a slight decrease in precipitation. Atmospheric droughts pose a serious threat to agriculture in Northern Kazakhstan. Climate change is leading to an increase in the frequency and intensity of droughts, creating risks for food security and the economic stability of the region. Agricultural enterprises in this area depend on atmospheric precipitation, and periods of drought cause significant damage to grain and other crop yields. Droughts such as those that occurred in 2012 and 2018, when farmers lost up to 40% of their harvests, underscore the need to implement an early warning system. Forecasts of likely droughts would enable farmers to prepare in advance for changing weather conditions, plan irrigation, adjust agronomic practices, and minimize losses.
Goal	The development of an early warning system for atmospheric droughts in the agricultural regions of Northern Kazakhstan, based on the integration of climate data and satellite monitoring using machine learning. The system will aim to improve drought forecasting efficiency and reduce risks for the agricultural sector by providing timely and accurate information about adverse climate conditions.
Tasks	The project involves the following tasks: ***Task 1.*** Analysis of current temperature, precipitation, and humidity patterns, and assessment of atmospheric drought risks in Northern Kazakhstan. 1.1 To identify the key climate factors that influencing the occurrence of atmospheric droughts in the region, meteorological data from national and international databases over the last 30 years will be collected and processed. 1.2 Weather and climate data for the past 30 years will be analyzed to identify conditions leading to droughts, followed by an assessment of the likelihood of their occurrence. ***Task 2.*** Development of atmospheric drought forecasting using machine learning. 2.1 Assess the impact of droughts on vegetation and soil conditions using remote sensing data. This will enable the creation of more accurate forecast models and adaptation measures.. 2.2 Based on the results obtained from meteorological parameters and remote sensing data, machine learning methods will be used to train algorithms to drought forecasting by identifying hidden relationships between various climate factors and the occurrence of droughts. ***Task 3.*** Development and testing of the early warning system for atmospheric droughts, and creation of practical recommendations.

	3.1 Based on drought forecasting, create tool which will be developed for assessing, monitoring, and issuing warnings about drought risks. The system will be supported by an information platform providing data access and disseminating warnings to farmers and local authorities. 3.2 To test the early warning system on the example of two regions of Northern Kazakhstan to assess its effectiveness and adaptation to real-world conditions. 3.3 To develop practical recommendations for adaptation measures to droughts for farmers and local authorities.
Expected and Achieved Results	-For 2025: Identification of the optimal drought index for Northern Kazakhstan through a comparative analysis of five existing drought indices (SPI, HTC, SPEI, MCZI) to determine their effectiveness under regional conditions. Development of a catalog of drought years based on each meteorological index. -For 2026: Assessment of vegetation conditions as a result of drought impacts. -For 2027: Based on atmospheric drought forecasting, a comprehensive tool will be developed for the assessment, monitoring, early warning, and rapid notification of drought risks, using two regions of Northern Kazakhstan as a case study. -For 2025–2027: Dissemination of results in at least two (2) articles published in journals ranked in the top three quartiles by impact factor in the Web of Science database, or in journals with a CiteScore percentile of at least 50 in the Scopus database. Achieved results: -The optimal drought index for Northern Kazakhstan was identified through a comparative analysis of five existing indices (SPI, HTC, SPEI, MCZI).
Names and Surnames of Research Group Members with Their Identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and Links to Corresponding Profiles	1) Ryssaliyeva Laura: ORCID ID 0000-0002-4730-9545 (https://orcid.org/0000-0002-4730-9545), Researcher ID ABX-7598-2022 (https://www.webofscience.com/wos/author/record/ABX-7598-2022) Salnikov Vitaly: h-index Scopus -6, Author ID Scopus 6602504406 (https://www.scopus.com/authid/detail.uri?authorId=6602504406). ORCID ID 0000-0003-3392-4587 (https://orcid.org/0000-0003-3392-4587). Researcher ID C-3228-2013 (https://www.webofscience.com/wos/author/record/C-3228-2013)
Publications list with links to them	1) Ryssaliyeva L.S., Salnikov V.G. Investigation of atmospheric drought in Central Asia // Geographical bulletin = Geographical bulletin. 2021. No 2(57). pp. 110-120. https://doi.org/10.17072/2079-7877-2021-2-110-120. 2) Sarsembayeva, A.; Ryssaliyeva, L. Solar Magnetic Activity and Its Terrestrial Impact through Correlations with Drought Indices. *Physical Sciences and Technology.* **2025**, *12*, 38–44. https://doi.org/10.26577/phst20251214
Patent information	—