ANNOTATION

of the dissertation for the degree of Doctor of Philosophy (Ph.D.) on educational program 8D050204 - " 8D05202 - Geography"

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on the topic: " **Geospatial modeling of salt-affected soils in Kazakhstan** "

General characterization of the work. The dissertation is aimed at geospatial modelling of saline soils in Kazakhstan.

The relevance of the dissertation research is due to several key factors. Soil salinization is a serious environmental and economic problem that negatively affects agriculture, water resources and biodiversity, and under conditions of intensive use of land resources, soil salinization is becoming an increasingly widespread phenomenon requiring an integrated approach to its monitoring and management. Kazakhstan has significant areas of saline soils and faces the need to develop effective strategies to rehabilitate them and prevent their further spread. Geospatial modelling allows the integration of various data, such as satellite imagery, hydrological and climatic parameters, and soil characteristics, to create highly accurate and up-to-date maps of saline soils. The introduction of remote sensing techniques, machine learning and spatial analytics opens up new opportunities for studying and predicting soil salinization processes at a high level of detail.

Geospatial modelling is a powerful tool for assessing the state of land resources and developing strategies for their rational use. It allows systematizing heterogeneous data, identifying the main factors influencing soil salinization and developing recommendations for their sustainable use.

The use of modern predictive tools increases the accuracy and efficiency of modelling, ensuring timely identification of land degradation risks. This, in turn, contributes to rational land management, development of preventive measures to reduce salinization and improve the sustainability of agro-ecosystems.

Thus, this study is aimed at solving one of the urgent problems of agricultural and environmental nature related to the degradation of soil cover in Kazakhstan. It has a significant practical significance for the development of strategies for sustainable land management, as well as scientific significance in the context of the development of methods of geospatial analysis and prediction of salinization processes. The results obtained will contribute to improving environmental sustainability and ensuring food security of the country.

The aim of the study – study the spatial distribution of saline soils in Kazakhstan and to create a map of the degree of soil salinity in Kazakhstan using field data and geospatial modeling methods with subsequent integration of the results into the LDN National Geoportal to ensure effective monitoring and land management.

To achieve this goal, the following tasks were defined:

- analyze the factors affecting the distribution of saline soils;

- analyze existing geospatial modelling techniques used to analyze the distribution of saline soils and adapt the most effective ones to the present study;

- create a soil database with analyses of soil salinity;

- perform geospatial modelling of soil salinity in Kazakhstan and assess the accuracy of the modelling used;

- integrate a map of soil salinity into the LDN National Geoportal.

The objects of the study: salt-affected soils in Kazakhstan.

The subject of the study: geospatial modeling of soil salinization processes in Kazakhstan.

Sources of research materials

Archival materials, including data on physical and chemical properties of soils, were obtained from the database of RGP on PCV 'State Institute for Land Surveying' of the Ministry of Agriculture of the Republic of Kazakhstan, MODIS space images - from open sources, cartographic materials were kindly provided by Dr. N.B. Khitrov.

Research Methods

The theoretical and methodological basis of the dissertation research is comparative-geographical, cartographic, GIS-technological, route and semi-stationary-field approaches, field observations, interpretation of remote sensing data, statistical processing of the results of geographical research. The dissertation research is interdisciplinary.

The work is based on the results of 10 years of research by the author, carried out on the territory of Kazakhstan on the basis of expeditions of the Department of Geography, Genesis and Soil Assessment of the Kazakh Research Institute of Soil Science and Agrochemistry named after U. U. Uspanov, Ministry of Agriculture of the Republic of Kazakhstan. Modern computer technologies were used to systematize and analyse the initial information, prepare the research work. QGIS, Google Earth Engine software was used to process space images and create maps. Modelling was carried out in the Rstudio program.

Scientific and practical significance of the research work consists in the development of geospatial model for predicting soil salinization in Kazakhstan and introduction of the model (map) into the National Geoportal on neutral balance of land degradation (LDN) of Kazakhstan

The scientific novelty of the study lies in the application of geospatial modelling for the development of a map on the degree of soil salinization in Kazakhstan and in the assessment of the accuracy of the results obtained. The obtained results are integrated into the National Geoportal to ensure effective monitoring and management of land resources.

Key provisions presented for defense:

1. In geospatial modelling of saline soils of Kazakhstan using principal component analysis using the principal component method (PCM), the most informative prognostic indicators are the five principal components, which explain more than 85% of the data variance.

2. According to the compiled map of saline soils of Kazakhstan, the area of saline soils in the republic is 1,472,811 km2 and the accuracy is R 0.68.

3. The introduction of the saline soil map into the National Geoportal on Land Degradation Neutrality (LDN) contributes to the fulfilment of commitments on the neutrality of land degradation in Kazakhstan until 2030 and contributes to the harmonization of geospatial data on soil salinity in the world.

The outcomes of the study support the following conclusions:

1. The scientific and methodological foundations of geospatial modelling of saline soils were analysed and systematized.

2. As a result of the conducted research, an integrative model was adapted that uses remote sensing data, soil maps and digital soil mapping methods. This ensured the construction of a digital map of saline soils with the ability to assess the spatial variability of salinization.

3. The use of the principal component analysis made it possible to identify the key factors influencing the spatial distribution of saline soils. The first five principal components explain more than 85% of the data variance, which confirms their high information content: PC1 (45%) - spectral indices (characteristics of the reflectivity of the Earth's surface); PC2 (20%) - topographic characteristics (slope, altitude) and vegetation indices; PC3 (15%) - soil parameters (moisture, mechanical composition, total amount of salts); PC4 (8-10%) - spectral index SI5, reflecting the characteristics of different soil types; PC5 (7%) – climatic and geological factors.

4. A unified soil database of saline soils of Kazakhstan has been created.

5. Analysis of the geospatial distribution of soils by the content of total salts made it possible to determine the areas corresponding to different degrees of soil salinization. It was found that non-saline and slightly saline soils occupy the largest area, while areas with a high degree of salinization are much less common. According to the data obtained:

1. Non-saline soils (≤ 0.25%) - 1,253,389 km²;
2. Slightly saline soils (0.25–0.5%) - 972,137 km²;
3. Moderately saline soils (0.5–1.0%) - 463,193 km²;
4. Highly saline soils (1.0–2.0%) - 36,325 km²;
5. Solonchaks (>2.0%) - 1,156 km².

The obtained results indicate the prevalence of soils with low levels of soil salinity, which is important for assessing the agroecological potential of territories and developing sustainable land use strategies.

6. The compiled thematic map clearly reflects the spatial distribution of soils classified by the degree of salinity. The total area of saline soils in Kazakhstan, according to this map, is 1,472,811 km².

7. The compiled map of saline soils has been implemented in the National Geoportal on Land Degradation Neutrality (LDN) of Kazakhstan

The author's personal contribution to solving the tasks of the dissertation research is:

– developing the idea, formulating the goals and main objectives of the study, collecting and systematizing the initial data;

– selecting and laying out soil profiles on the territory of Kazakhstan;

– organizing and conducting field work together with research associates of LLP "Kazakh Research Institute of Soil Science and Agrochemistry named after

U.U. Uspanov";

– creating a soil database of saline soils of Kazakhstan based on retrospective data and new field data;

– processing the obtained field data and materials of remote sensing of the Earth from various years of survey, preparing and publishing the obtained scientific results on the topic of the conducted study in rating journals. The main provisions of scientific articles are reflected in the sections of the dissertation for the degree of PhD.

Relation of the thesis with research and government programs

Partially, the field research of the dissertation work was carried out within the framework of the projects:

1. Program-targeted financing for 2021-2023 on the topic: "Scientific and technological support for the conservation and reproduction of the fertility of agricultural lands". Task 3 "Creation of a database of waterlogged and saline soils" (IRN BR 10764865);

2. FAO/GEF international project "Integrated Natural Resource Management in Dry and Salt-Affected Agricultural Production Landscapes in Central Asia and Turkey (CACILM-2)", component 2 - "Mapping of soil resources using GIS technologies";

3. The latest research results were carried out within the framework of program-targeted financing of the Ministry of Education and Science of the Republic of Kazakhstan for 2023-2025. «Sustainable Development of Natural-industrial and Socio-economic Systems of the West Kazakhstan Region in the Context of Green Growth: A Comprehensive Analysis, Concept, Forecast Estimates and Scenarios» (IRN BR21882122).

Approbation of practical results of the work

The main results and provisions of this dissertation research were reported and discussed:

– at the first International Geographical Congress of the Turkic World, April 18-20, 2024, Turkestan, Kazakhstan;

– the second meeting of the International Network on Salt-Affected Soils (INSAS), organized by the Global Soil Partnership (GSP) and the Subregional Eurasian Soil Partnership (EASP) (May 22-26, 2023, Tashkent and Nukus, Uzbekistan).

Structure of the dissertation. The dissertation work is presented on 111 pages, consists of an introduction, 4 sections, a conclusion, a list of references 129, appendices 1, 17 tables and 48 figures.