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DEVELOPMENT OF A GEOSPATIAL DATABASE FOR PLANNING LAND PROTECTION MEASURES AGAINST WIND EROSION

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Development of a geospatial database for planning land protection measures against wind erosion

This study describes the development of a structure that provides an opportunity to systematize and accumulate geospatial and attributive data. In the course of the research, a geospatial database model was developed, which ensures the accumulation of data to solve the problem of spatio-temporal analysis and support the justification of land protection measures against wind erosion. The geospatial database model is developed using a UML class diagram that illustrates not only the main design components, but also details the attributes and their data types.

The article structured an algorithm for analyzing geospatial data, structured and accumulated in a geospatial database, to determine lands that may be threatened by wind erosion. The algorithm is presented through a functional model.

The research developed a model of the knowledge base as a component of the geospatial database, which contains both standards and additional influencing factors that affect the increase or decrease of the risk of wind erosion.

The work presents a geoimage of the studied territory with the selection of territories that may be subject to wind erosion in different seasons.

The results of the work can be used in the process of planning land protection measures to protect against wind erosion.

***Key words:** geospatial database, wind erosion, geoimages.*

Introduction. The formation of soils took place in conditions that are incomparable with their modern use in human activity. A feature of erosion processes is their permanence, and the intensive use of soils in agriculture, human intervention in long-established landscapes accelerates them many times over, triggering an avalanche-like process of soil erosion. The redeposition of washed soil particles affects small rivers and provokes their siltation, and the blowing of soil forms dust storms, which has a direct impact on the quality of human life. Erosion processes are irreversible in a short period of time, eroded soils can only be taken out of use to stop degradation processes with high costs of afforestation or liming, and further use will be stopped for years. The occurrence of dust storms and wind erosion of soils is influenced by a number of factors, including the economic use of soils, the presence of vegetation as a continuous cover directly on the soils in relation to which the occurrence of erosion is considered, as well as in the adjacent territories. In order to carry out a comprehensive analysis and determine the areas of possible occurrence of wind erosion, it is necessary to develop an information structure capable of supporting the solution of the problem of land protection in relation to wind erosion.

Analysis of recent research and publications. Many works are devoted to the study of issues related to land protection, as well as to the modeling of geospatial databases. The current global state of soil erosion modeling in the world is outlined in the study [1]. In [2], a hierarchical structure of multi-criteria analysis of soil degradation risk assessment was created, reflecting the components of the environment that have an impact on the formation of erosion processes. In article [3], a geoinformation modeling approach to wind erosion determination is proposed. In the study [4], the authors propose a conceptual modeling of the geospatial database for the cadaster of natural medicinal resources. In work [5], a part of the logical model of the database for monitoring damaged areas is demonstrated. In article [6], the process of developing a structure of databases and a knowledge base for monitoring the qualitative state of agricultural land was considered, its components were described, and thematic maps were created.

In studies [7-9], the state of field protection forest strips, windbreak properties, features of location, trends of changes in their design are considered. The article [7] indicates the remedial effectiveness of field protection forest strips, and the study [8] describes the dependence of soil resistance to wind erosion and the content of clay in it. The state of protective forest strips for various purposes and objects of forest reclamation are indicated in work [9].

The objective of the research is to substantiate the main components of the geospatial database for the protection of lands that may be affected by wind erosion.

Research methodology. To achieve the goal, the work justified and developed a database of geospatial data for the protection of lands that may be affected by wind erosion. Models are developed using UML (Unified Modeling Language). Geoimages are made in the ArcGIS software using overlay operations, slope analysis, and construction of buffer zones.

The main materials. Soil is a component of the environment and at the same time is the basis for agricultural production. Soil erosion leads not only to economic losses for farms, but can cause the deterioration and loss of the fertile soil layer. The analysis of recent publications and studies showed that when planning land protection measures against wind erosion, it is necessary to take into account not only the soil cover, but also the factors that have an impact on the increase or decrease of erosion.

In the course of the research, a model of the geospatial database for the protection of lands that may be affected by wind erosion was developed, which takes into account not only agricultural groups of soils and their resistance to erosion, but also the steepness and exposure of slopes, the direction of prevailing winds, the presence of protective plantings (Fig. 1).

In the developed model, the Field class is the main class of spatial objects for which erosion resistance is determined. A part of the field, which is uniform in terms of soil cover and uniform in relief, is represented through the class FieldPlot - erosion resistance is determined in relation to this part. Soil, Slopes, and Wind classes are associated with the FieldPlot class. The Soil class contains information about the codes of agricultural production groups of soils and their granulometric composition, which

is directly related to erosion resistance. The Slope class contains information about the steepness of the slope and its aspect.

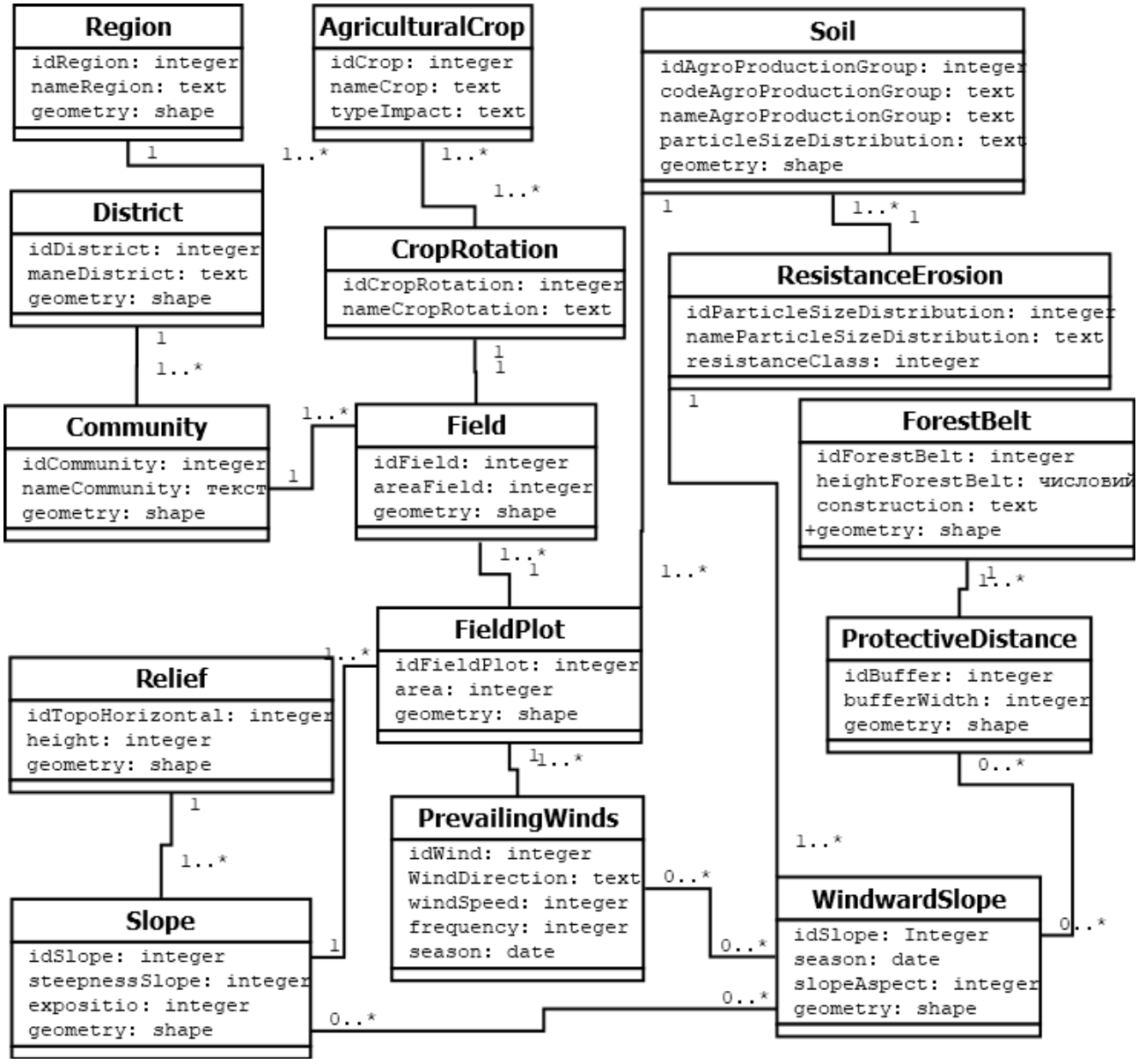

Fig. 1. The Logical model of the geospatial database

Classes affecting erosion control are ForestBelt and CropRotation. The ForestBelt class contains information about the height, structure and integrity of the forest strip, which affects the distance of the protective effect. The CropRotation class contains information about the crops sown in the area and their effect on resistance to wind erosionThe general scheme for determining the resistance of fields to erosion is presented through the UML activity diagram (Fig. 2).

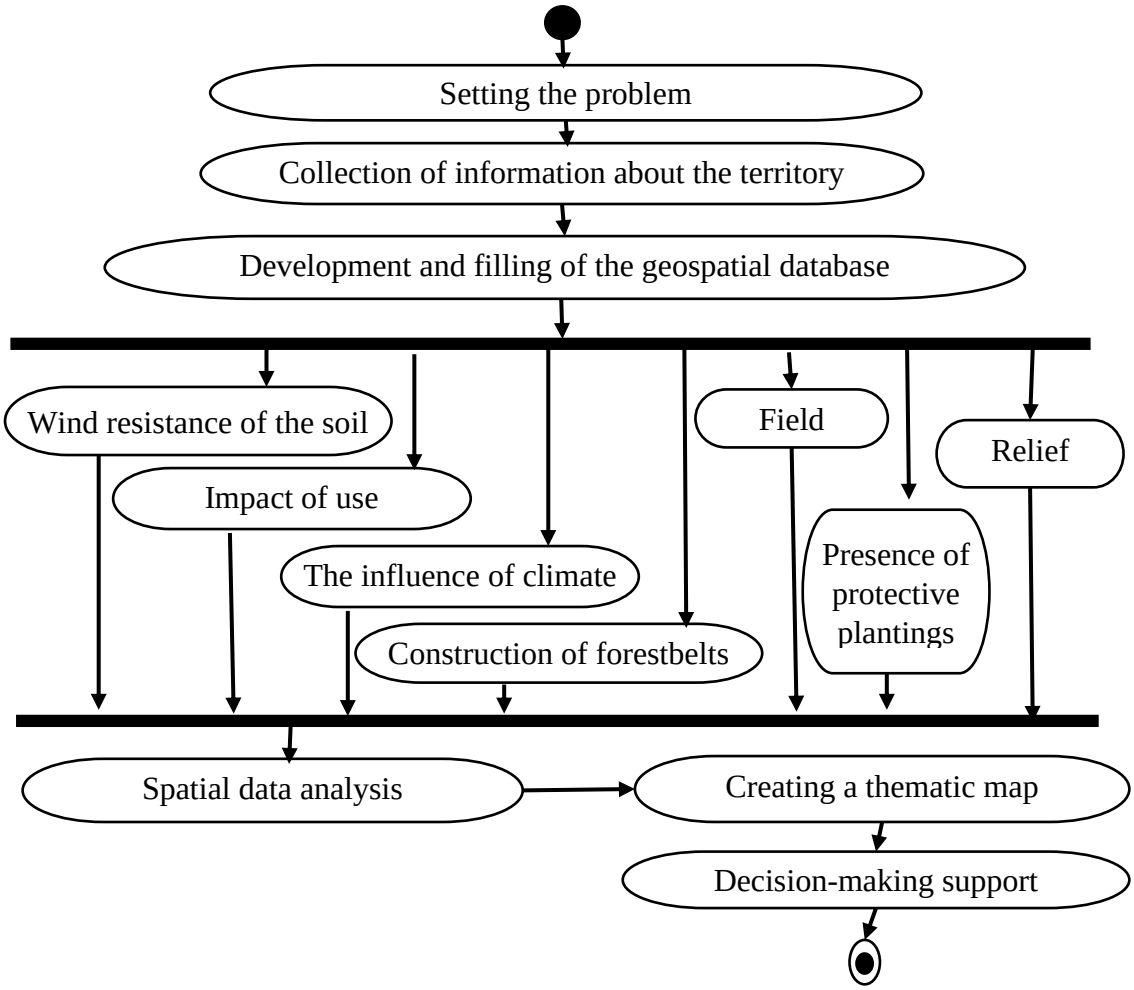

Fig. 2. The functional model for determining the resistance of fields to wind erosion.

The setting of the problem consists in determining the territory of the study. The next step is the collection of information about the territory that fills the geospatial database. The geospatial database accumulates spatial and descriptive information about the territory, and in the next step, areas under the influence of negative factors are determined, among which the following groups can be distinguished: wind resistance of the soil, the impact of economic use, the presence of protective plantings, their type and construction, the presence the slope of the surface (relief), the influence of the climate, which is analyzed due to the presence of high-speed winds. The next step is to carry out a spatial analysis and form a thematic map taking into account the factors influencing the development and containment of erosion (Fig. 3).

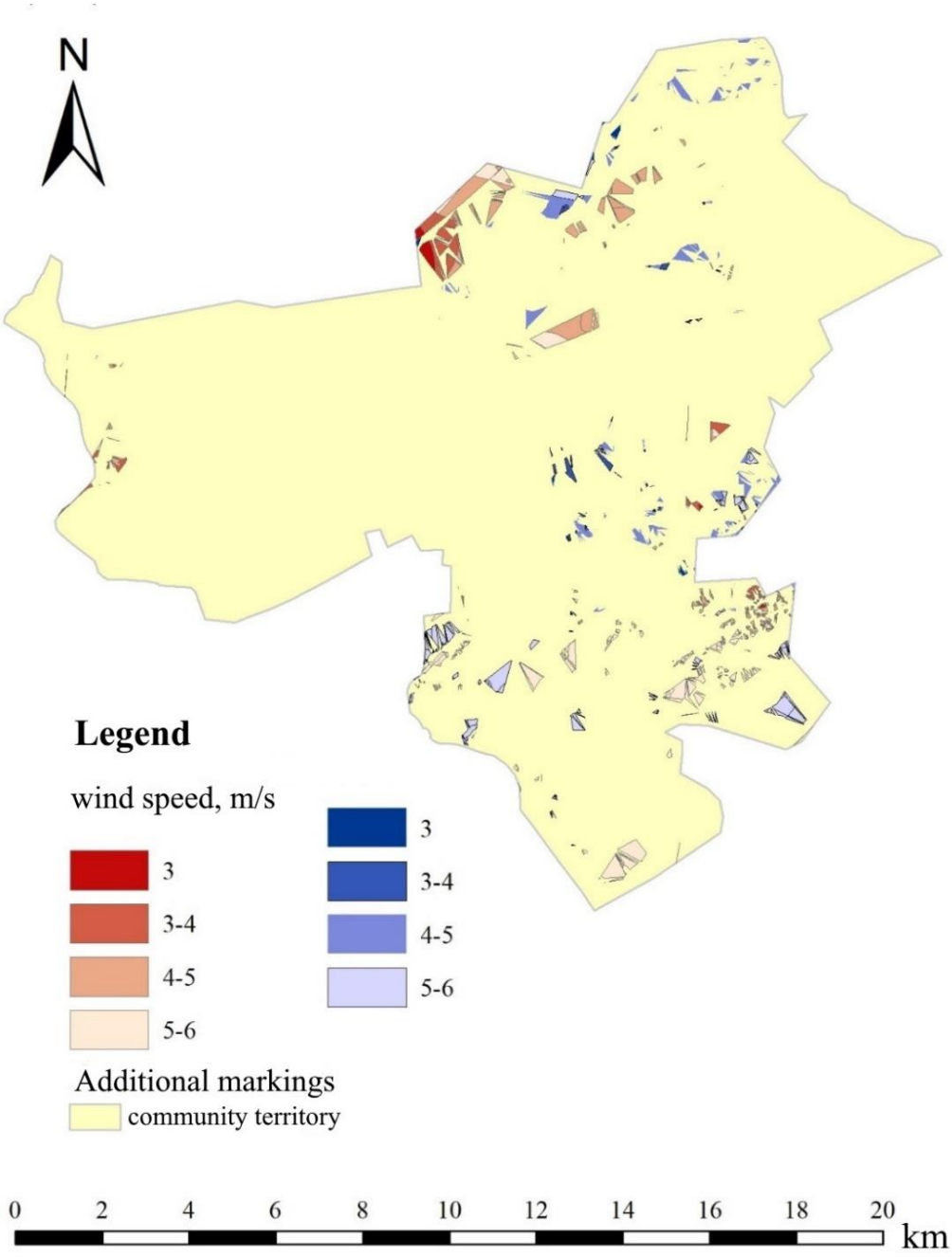

Fig. 3. The cartographic representation of the community territory that can be affected by the destructive effects of wind in different seasons (shades of red - in summer, shades of blue - in winter)

The final stage is decision-making support regarding the use of land plots and the planning of land protection measures. At this stage, it is necessary to take into account not only the presence of dust storms, but also the duration of high-speed winds, the slope of the surface (the presence of windward slopes), the presence and type of

vegetation. In addition to spatial data, the geospatial database should include the catalog of variation in factors influence, as well as a catalog of possible land protection measures. In order to effectively take into account all factors when studying the resistance of soils to negative phenomena, it is necessary to systematize all indicators in the knowledge base (fig. 4.).

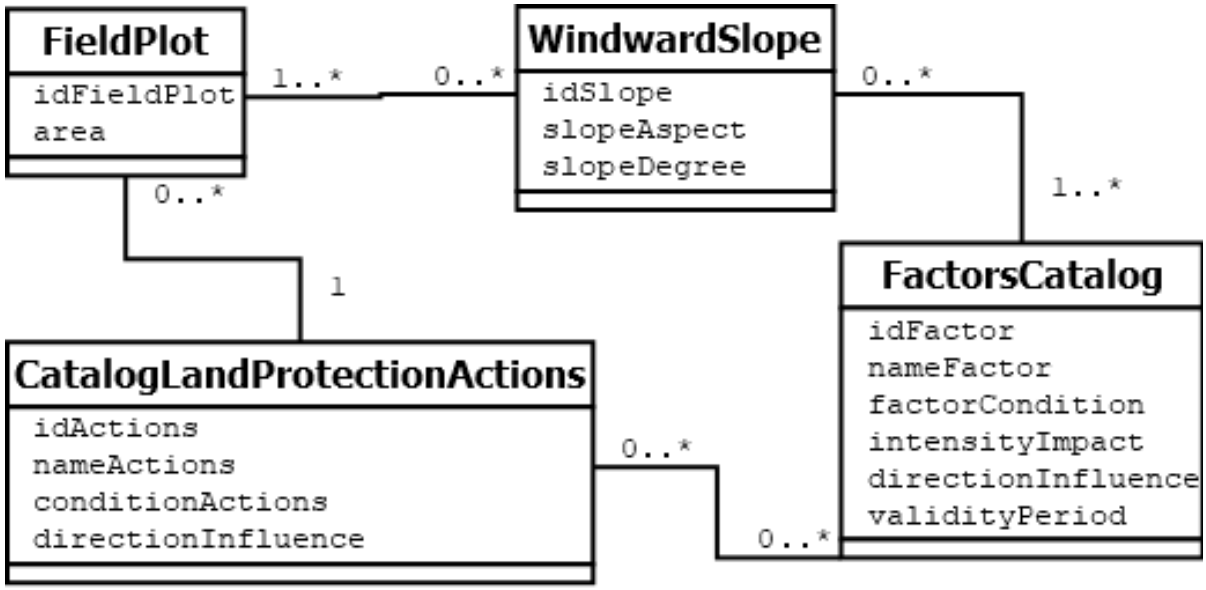

Fig. 4. The model of the knowledge base for planning land protection measures

Conclusions. In the course of the study, a model of the geospatial database of land protection has been developed. The model was aimed to accumulating data for the purpose of further analysis of the occurrence of wind erosion on agricultural lands. The model takes into account not only soils, but also additional factors that can have both a restraining and an increasing effect on the risk of erosion. Based on the results of modeling, erosion-dangerous areas of arable land, which can be subject to wind erosion when the wind affects the soil not covered by plants, were identified in the studied territory.

The results of the development can be used for the formation of spatial decisions regarding the effective use of land plots and the formation of crop rotations.

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РОЗРОБЛЕННЯ БАЗИ ГЕОПРОСТОРОВИХ ДАНИХ ДЛЯ ПЛАНУВАННЯ ЗАХОДІВ З ОХОРОНИ ЗЕМЕЛЬ ЩОДО ВІТРОВОЇ ЕРОЗІЇ

У роботі подано розроблення структури, яка надає можливість систематизувати та накопичити геопросторові та атрибутивні дані. В ході виконання дослідження розроблено модель бази геопросторових даних, що забезпечує накопичення даних для вирішення задачі просторово-часового аналізу та підтримати обґрунтування заходів з охорони земель щодо вітрової ерозії.

Модель бази геопросторових даних розроблена з використанням UML-діаграми класів, що ілюструє не лише основні складові розробки, а й деталізує атрибути та їх типи даних.

В статті було структуровано алгоритм здійснення аналізу геопросторових даних, що структуровані та накопичені в базі геопросторових даних, для визначення земель, яким може загрожувати вітрова ерозія. Алгоритм подано через функціональну модель.

В дослідженні розроблено модель бази знань, як компоненти бази геопросторових даних, що містить як нормативи так і додаткові фактори впливу, які впливають на збільшення або зменшення ризику розвитку вітрової ерозії.

На досліджувану територію в роботі подано геозображення з виділенням територій, що можуть зазнати вітрової ерозії в різні сезони.

Результати роботи можуть бути використані в процесі планування заходів з охорони земель щодо захисту від вітрової ерозії.

Ключові слова. *база геопросторових даних, вітрова ерозія, геозображення.*