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GEOINFORMATION MODELING FOR WIND EROSION

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Possibilities of application of geoinformation modeling to determine areas that may be affected by wind erosion is considered. An analysis of publications on the application of modeling to solve various problems was carried out, as well as an analysis of the application of modeling to soil erosion, however, most of the models were devoted to water erosion.

This study describes the structuring of a general algorithm for determining areas that may be affected by wind erosion through a functional model. The article presents the factors that affect the resistance of the soil to the occurrence of wind erosion: the direction of the prevailing winds, the type of soil, the presence of protective plantings, such as forest strips, as well as the slope of the studied territory. These factors are divided into two groups: those that protect the soil from destructive force (one line of the model) and those that contribute to erosion (another line of the model). A geo-information model for building a geo-image of erosion-hazardous lands was developed and implemented in the ArcGIS software using the ModelBuilder tool. Based on the results of modeling, erosion-dangerous areas of arable land, which may be subject to wind erosion under the action of wind on soil not covered by plants, were identified in the studied territory. The model can be used to automate the determination of erosion-dangerous areas on agricultural lands.

The results of the work can be used in the formation of spatial decisions regarding the rational use and protection of land.

Keywords. *geoinformation modeling, model, wind erosion, geoimagery.*

Introduction. The use of agricultural land is an important component of human economic activity. The most important component of agricultural lands is the fertile soil layer. During intensive production, soils are affected both by economic activity and by natural factors such as wind and water, which can lead to degradation. In recent years, the phenomenon of dust storms has been observed on the territory of Ukraine, and daily deflation on lands without vegetation is manifested already at wind speeds of 3-4 m/s. The consequences of wind erosion are very diverse: from loss of humus to damage to young crops. In view of this, there is a need to study the possibility of development and the potential of wind erosion, as well as to develop measures to protect arable land from deflation. In order to protect soils from destruction, it is necessary to develop a geo-informational model for determining erosion-dangerous areas.

Analysis of recent research and publications. The work of both foreign and ukrainian scientists [1-3] is dedicated to decision-making support automation systems. The article [1] covers the use of GIS to determine changes in the types of roof covering. The study [2] presents an approach to the formation of spatial decisions regarding land use and defines a set of data necessary for planning land management measures for the formation of spatial decisions regarding land use. In work [3], applied programs for modeling soil erosion of various industrialized countries were analyzed, however, most of the models were devoted to water erosion. The use of geoinformation modeling for issues of natural resources and engineering and technical measures was and is the subject of study by scientists [4-6]. The study [4] describes the modeling and structuring of data for the purpose of developing a cadastre of natural medicinal resources. In article [5] geo-informational modeling of engineering and technical measures of civil protection is considered. The work [6] presents the use of geoinformation technologies for modeling and forecasting flooding of territories.

The purpose and objectives of the study. The purpose of the work is to develop a geoinformation model for the automated determination of land plots that may be affected by wind erosion.

To achieve the goal, it is necessary to solve the task: determine the parameters of the model and implement the construction of a model for determining land plots that may be affected by wind erosion.

Research methodology. When determining the areas of soil that can be affected by wind erosion, the approach of geoinformation modeling is used, which implements the interaction of descriptive data with spatial data for the study of territories. The following tools of geoinformation analysis were selected for modeling: construction of buffer zones, analysis of proximity and overlay. The models were developed using the unified modeling language UML. The physical implementation is presented in the ArcGIS software.

The Bilotserkiv district of the Kyiv region was chosen as the object of modeling.

Presentation of the main research material. Soil erosion is a widespread degradation process on the territory of Ukraine. The negative consequences of erosion are not only economic losses, but also a threat to the existence of the fertile soil layer. Soil is the main means of production and an irreplaceable component of the biosphere, so it is important to determine the level of soil erosion, the intensity and dynamics of erosion processes for their forecasting and the development of anti-erosion measures.

When determining areas of soil that may be wear down to wind erosion, it is necessary to take into account a combination of a number of factors that affect the occurrence of the erosion process. These factors can be divided into two groups: those that protect the soil from destructive forces and those that contribute to erosion.

The modeling algorithm is represented by the UML activity diagram (Fig. 1). Its main components include: formulation of the problem, collection of cartographic materials, determination and extraction from further analysis of the wind shadow of forest belts, determination of indicators of the surface model, selection of lands that may be affected by wind erosion, and the final result - a thematic map.

At the stage of setting the problem, the research area is determined and climatic conditions are studied: prevailing wind directions and wind speed.

At the next stage, cartographic materials are collected. The initial data for building the model are agricultural groups of soils on arable land, forest strips in the study area (obtained by processing data from the Sentinel-2) and the topography of the area obtained from SRTM (for use in the developed model, the data is converted into a vector model). Since agroproduction soil groups are defined specifically on arable land, the model does not define arable land as a separate layer.

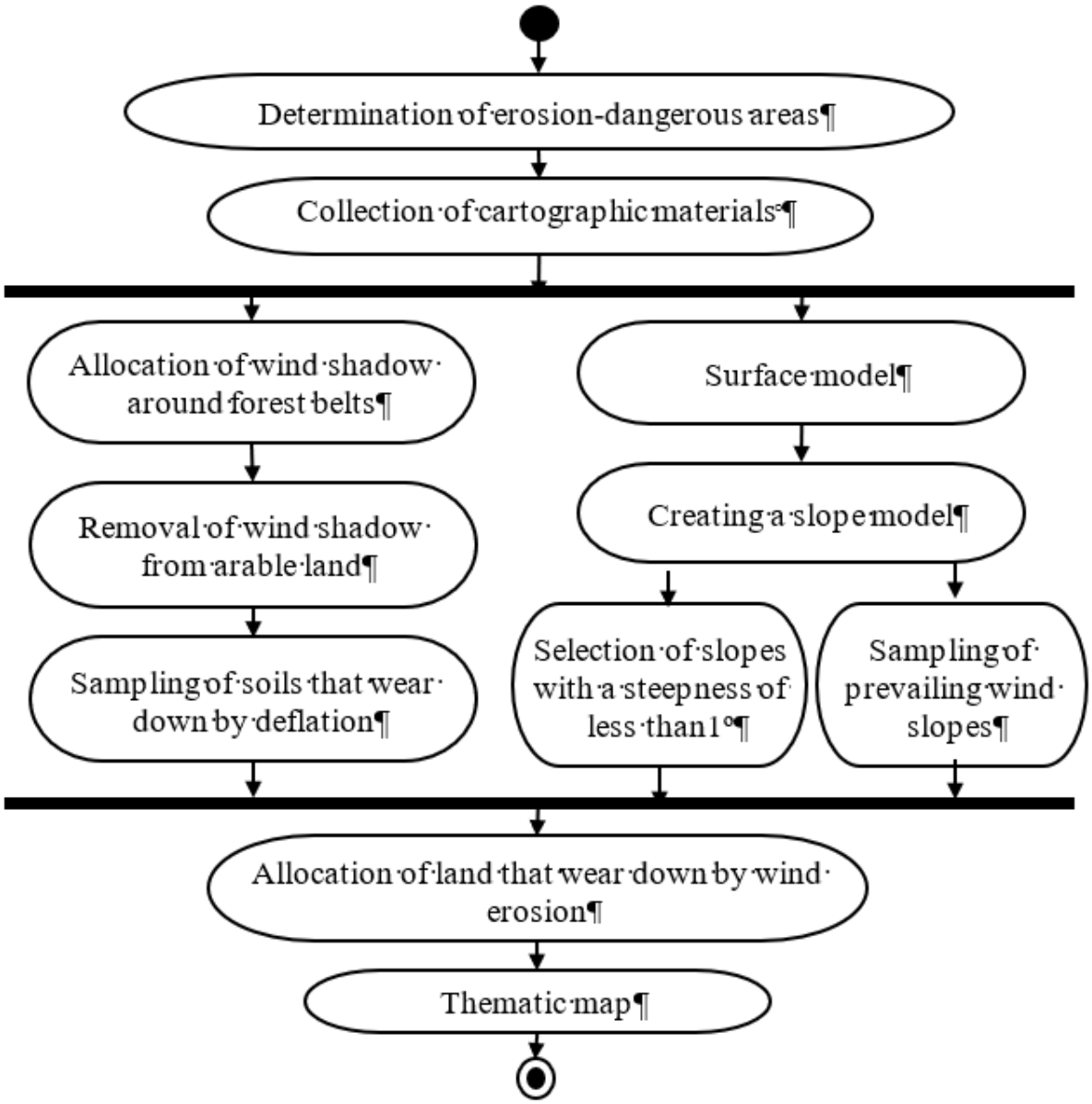

Fig. 1. Functional model for determining areas that may be affected by erosion

At the next stage of the model, a set of factors affecting the possibility of wind erosion development is determined. Thus, according to research data [7], deflation depends on the relief and the level of protection of fields by forest improvement

measures. To determine the area protected by forest belts, the wind shadow is calculated, which in the conditions of the Bilotserkiv district, where most of the forest strips have an openwork structure, will be equal to 25 times the height of the forest belts [8-9]. The influence of relief on soil blowing is taken into account in the model through two indicators: the selection of slopes to which the prevailing winds will have a wind impact and the determination of areas with slopes of more than 1º, because on such slopes the wind will already carry an impact force.

Finally, factors are combined and a geo-image of erosion-dangerous areas on arable land is constructed.

The developed functional model is implemented in ArcGIS Model Builder as an environment for building and implementing models. The following tools were used to solve the problem of geo-information modeling of wind erosion and the construction of a geo-image of erosion-hazardous lands: Select, Buffer, Erase, Intersect, Create TIN, TIN to Raster, Aspect, Raster to Polygon, Surface Slope, Reclassify (Fig. 2).

At the first stage, a TIN relief model is created, which is the basis for calculating surface slopes. Slopes are necessary to determine erosion-dangerous lands and choose a safe surface slope (up to 1º).

According to another line of the model, the wind shadow of forest belts is determined (for the forest-steppe zone it is 450 m [9])

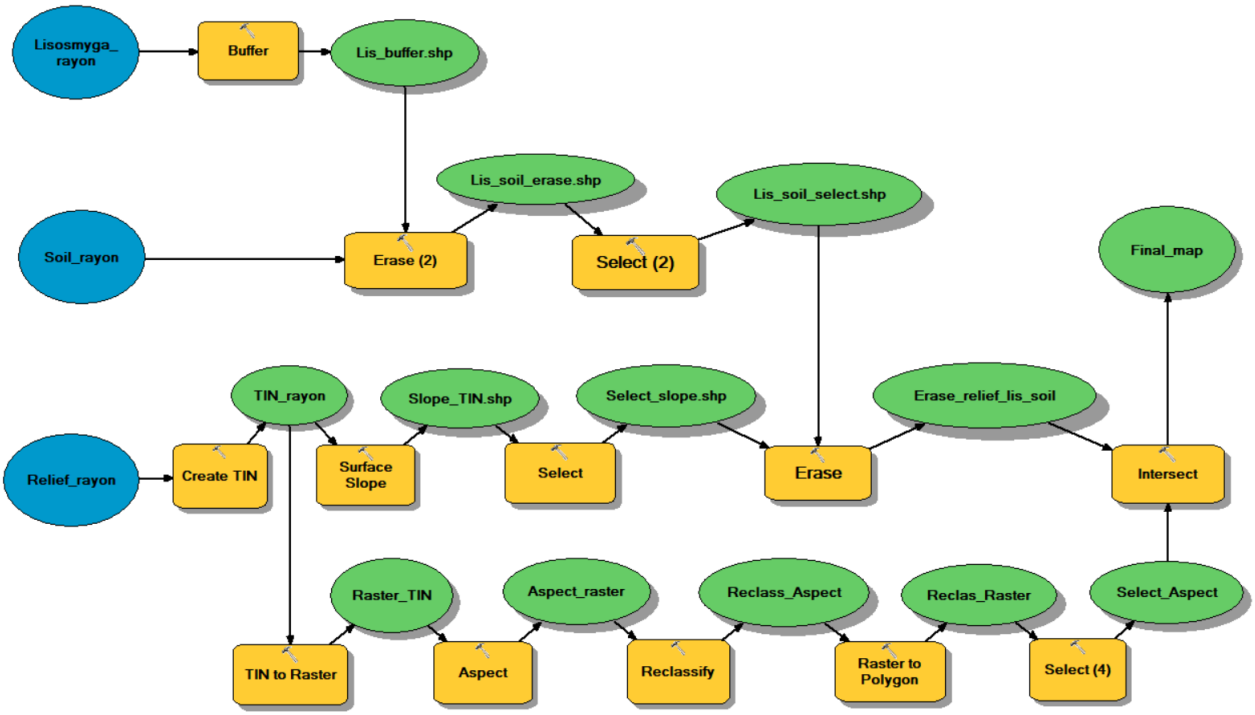

Fig. 2. A model for constructing a geoimage of erosion-prone lands

With the Erase tool, we remove protected areas from the layer of agroproduction groups of soils on arable lands and obtain geoimages of lands that are not protected by forest belts. Next, from the obtained geoimage, we remove marshy and swampy soils that are resistant to wind erosion [10]. At the next stage, slopes up to 1º are extracted from the geoimage of soils on arable land.

In order to take into account, the direction of the prevailing winds for the studied area, the aspects of the slopes are determined and the wind-impacted slopes are selected from the created geoimage.

At the final stage, the slopes that are vulnerable to the direction of the prevailing winds were combined with the geoimage of soils not protected by forest belts, and the geo-image of erosion-dangerous areas of arable land was obtained (Fig. 3).

Based on the results of modeling, erosion-dangerous areas of arable land, which can be wear down to wind erosion when the wind affects the soil not covered by plants, were identified in the studied territory.

Conclusions. Geoinformation modeling is indispensable for data analysis in the study of wind erosion. The developed model of geo-information modeling

provides an opportunity to analyze spatial data and build geo-images of erosion-dangerous areas on arable lands. The model takes into account a number of parameters that affect the probability of erosion: soils, slope of the terrain, direction of prevailing winds and presence of linear forest plantations.

The model can be used to automate the determination of erosion-dangerous areas on agricultural lands, and the obtained geoimage can be the basis for substantiating decision-making regarding the planning of land protection measures, recommendations for farming.

The prospect of further research is to develop an automated decision-making block for planning land protection measures.

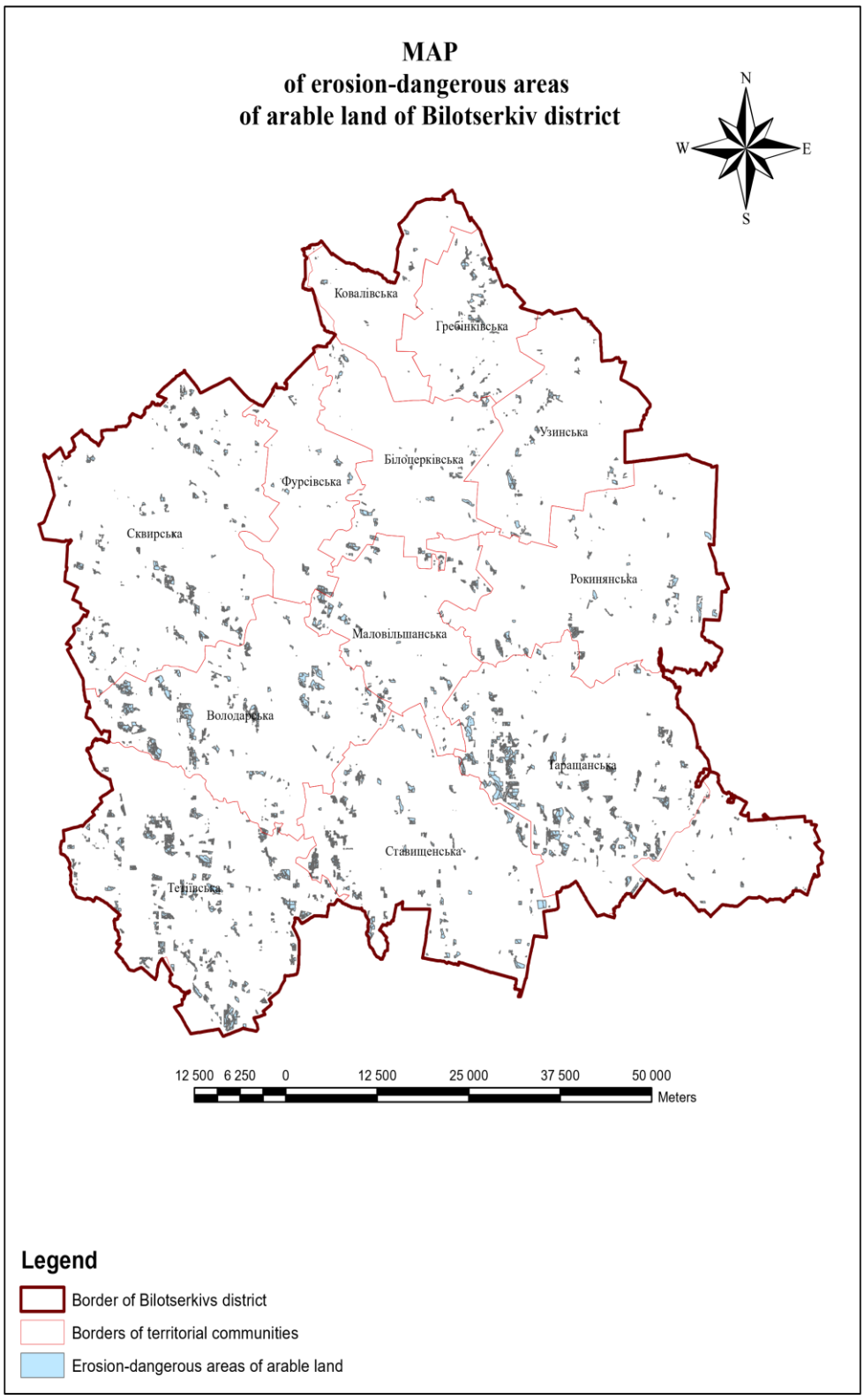

Fig. 3. Geoimage of erosion-dangerous areas of arable land of Bilotserkiv district

References

1. Karaya, RN; Onyango, CA; Ogendi, GM. (2021) A community-GIS supported dryland use and cover change assessment: the case of the Njemps flats in

Kenya. COGENT FOOD & AGRICULTURE, 7(1). DOI: https://doi.org/10.1080/23311932.2021.1872852

2. Moskalenko A. (2021) GIS support of forming spatial decisions on land use. Mechanization in agriculture & Conserving of the resources Vol. 67, Issue 3, P. 79-81

3. P. Borrelli et al (2021) Soil erosion modelling: A global review and statistical analysis. *Science of The Total Environment*. 2021. Vol. 780. P. 146494. DOI: https://doi.org/10.1016/j.scitotenv.2021.146494

4. Lyashchenko A., Zakharchenko YE. (2019) Kontseptual′ne modelyuvannya ta pryntsypy realizatsiyi bazy heoprostorovykh danykh kadastru pryrodnykh likuval′nykh resursiv [Conceptual modeling and implementation principles of the database of geospatial data of the cadastre of natural medicinal resources] Naukovi zapysky Ternopil′s′koho natsional′noho pedahohichnoho universytetu imeni Volodymyra Hnatyuka. Ser. Heohrafiya. Ternopil′: TNPU im. V. Hnatyuka, 2019. № 1 (Vyp. 46). P. 232-239.

5. Lyashchenko A., Starynets′ R. Metodychni zasady heoinformatsiynoho modelyuvannya inzhenerno-tekhnichnykh zakhodiv tsyvil′noho zakhystu [Methodological principles of geo-informational modeling of engineering and technical measures of civil protection] Mistobuduvannya ta terytorial′ne planuvannya. 2018. № 66. P. 408–417. DOI: http://nbuv.gov.ua/UJRN/MTP_2018_66_47

6. Zatserkovnyy V. (2019) Zastosuvannya heoinformatsiynykh tekhnolohiy v zadachakh modelyuvannya ta prohnozuvannya zatoplen′ terytoriy [The application of geoinformation technologies in the tasks of modeling and forecasting flooding of territories] Heoinformatyka. 2019. № 2. S. 74–83. DOI: http://nbuv.gov.ua/UJRN/geoinf_2019_2_9.

7. Tarariko, O. H., Il′yenko, T. V., Kuchma, T. L., & Bilokin′, O. A. (2021) Eroziya gruntiv yak chynnyk opustelyuvannya ahrolandshaftiv Ukrayiny [Soil erosion as a factor of desertification of agricultural landscapes of Ukraine].

Agroecological Journal, 2021, №3, S.6-16. DOI: https://doi.org/10.33730/2077-4893.3.2021.240316

8. Sovakov, O. V. (2014). Konstruktyvni osoblyvosti i melioratyvna efektyvnist′ polezakhysnykh lisovykh smuh [Design features and remedial effectiveness of field protection forest strips]. Naukovi dopovidi Natsional′noho universytetu bioresursiv i pryrodokorystuvannya Ukrayiny, (3).

9. Yukhnovs′kyy V., Dudarets′ S., Malyuha V. (2012) Ahrolisomelioratsiya: pidruchnyk [Agroforestry: a textbook]. Kyiv: KondorVydavnytstvo, 2012. 372 s

10. Ponomarenko YE., Katkov M., Kovalenko YU. (2020) Zastosuvannya ekotekhnolohiy dlya zakhystu vodnykh ob'yektiv vid sil′s′kohospodars′koho poverkhnevoho stoku [Application of eco-technologies to protect water bodies from agricultural surface runoff]. Wissenschaftliche ergebnisse und errungenschaften: 2020. DOI https://doi.org/10.36074/25.12.2020.v1.31

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ГЕОІНФОРМАЦІЙНЕ МОДЕЛЮВАННЯ ВІТРОВОЇ ЕРОЗІЇ

Розглянуто можливості застосування геоінформаційного моделювання для визначення ділянок, що можуть зазнати впливу вітрової ерозії. Проведено аналіз публікацій застосування моделювання для вирішення різноманітних задач, а також проаналізовано застосування моделювання для моделювання ерозії ґрунтів, однак більшість моделей присвячена водній ерозії.

Дане дослідження описує структурування загального алгоритму визначення ділянок, які можуть зазнати впливу вітрової ерозії через функціональну модель. В статті наведено фактори, що впливають на стійкість ґрунту до виникнення вітрової ерозії: напрям переважаючих вітрів, тип ґрунту, наявність захисних насаджень, таких як лісосмуги, а також ухил досліджуваної території. Ці чинники поділено на дві групи: ті що захищають ґрунт від руйнівної сили (одна гілка моделі) і ті що сприяють ерозії (інша гілка моделі). Розроблено та реалізовано геоінформаційну модель побудови геозображення ерозійно-небезпечних земель в програмному засобі ArcGIS з

використанням інструменту ModelBuilder. За результатом моделювання на досліджуваній території виділено ерозійно-небезпечні ділянки орних земель, що можуть зазнати вітрової ерозії при дії вітру на ґрунт не покритий рослинами. Модель може застосовуватись для автоматизації визначення ерозійно-небезпечних ділянок на сільськогосподарських землях.

Результати роботи можуть бути використані при формуванні просторових рішень щодо раціонального використання і охорони земель.

Ключові слова. *геоінформаційне моделювання, модель, вітрова ерозія, геозображення.*