Assessment of the development of erosion processes using the stereophotogrammetric method

V.A. Inysheva*, *A.S.* Gusev, *S.A.* Bronitskaya, *M.A.* Khomyakova, and *A.A.* Belichev

Ural State Agrarian University, Yekaterinburg, Russia

Abstract. Soil is the most important resource on earth, the need for its rational use is fixed in many regulatory and legal sources of the Russian Federation, it is necessary to control the use of land resources, prevent pollution and soil degradation; for these purposes there are measures carried out to monitor the state of the soil cover. All these actions allow for a more rational allocation of funds from the use of land resources, as well as ensure the safety and compliance with environmental standards for the protection of land resources and the environment [2]. This article considers the issue of using three-dimensional models to assess the development of erosion processes on lands suitable for agricultural use, which are a strategic resource. The study of the erosion hazard of lands is of great importance in the modern world, where there is an active change in the natural environment under the influence of human activity. Soil erosion is a serious problem that can lead to the loss of land fertile layer, lower yields, and increased risk of natural disasters. In this regard, the assessment of land erosion hazard is an urgent task that requires an integrated approach and the use of modern methods and technologies [1].

1 Introduction

To assess the land erosion hazard, it is necessary to have access to data on the state of soils, topography, and other characteristics of the area. The use of remote sensing methods makes it possible to obtain up-to-date information about territories with a high degree of detail, which makes this approach an effective tool for studying the erosion hazard of lands [6].
The article analyzes the materials obtained by remote sensing to identify the development of foci of erosion processes. The main objective of the study is to identify the links between the characteristics of the terrain, such as topography, soil type, depressions, etc., and the degree of vulnerability of these territories to erosion. Based on the results obtained, it is planned to develop recommendations on preventing and reducing the erosion hazard of land to preserve biodiversity and ensure sustainable agricultural development. The study of the erosion hazard of lands has both an applied and scientific research character. The development of effective methods for forecasting and preventing erosion will reduce the negative impact of this natural process on agriculture and the environment as a whole. Thus, this study is important for

* Corresponding author: inyshevav@mail.ru

practical application in the field of land use, as well as contributes to the expansion of scientific knowledge in the field of soil protection and erosion control

2 Materials and Methods

Studies on the assessment of erosion processes using three-dimensional terrain models were conducted on the territory of the educational and experimental farm of the Ural State Agrarian University. The educational and experimental farm is a platform for the practical training of students during their studies. It is geographically located in the Beloyarsk district of the Sverdlovsk region [8].

The layout of the farm working areas is shown in Figure 1.

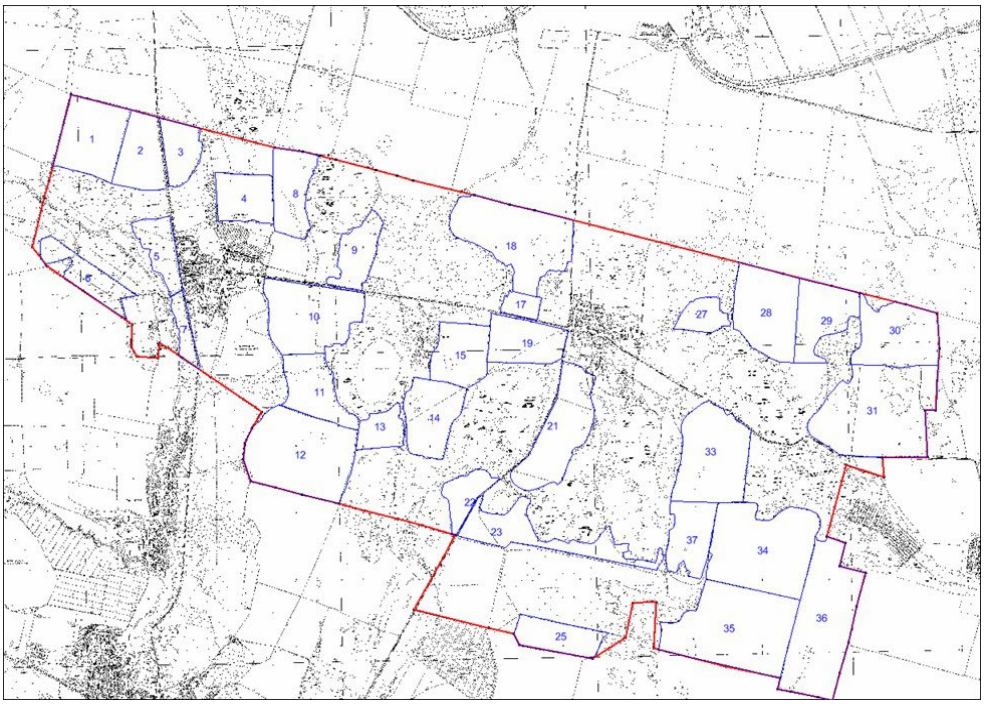

Fig. 1. The layout of the arable land plots of the educational and experimental farm.

The assessment of the shape of arable land working areas in the farm was carried out on the basis of calculating the compactness coefficient. The lower the compactness coefficient, the less complex the configuration of the land mass. The calculation of the compactness coefficient is shown in Figure 2.

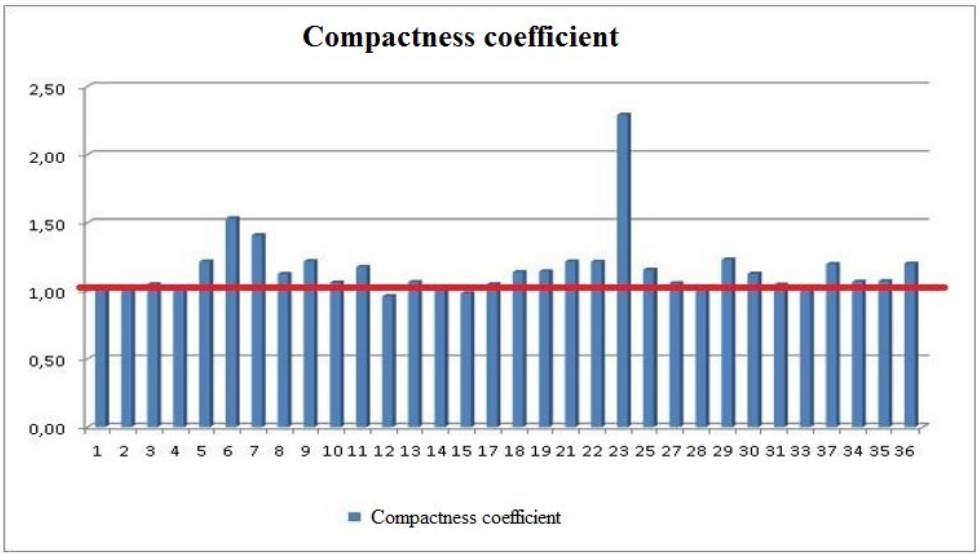

Fig. 2. Calculation of the compactness coefficient.

Calculations have shown that the compactness coefficient of most work sites is approaching one, with the exception of work sites – 5, 6, 7, 23, which have a large curvedness of the boundaries.

The total area of agricultural land is 227 hectares, arable land covers an area of 220 hectares (96.92%), including an irrigated area of 25 hectares (11.01%). Perennial plantations occupy 7 hectares (3.08%) [7].

An assessment of the structure of the sown areas was carried out, according to the results of which, it is possible to adjust the sown areas, make changes to increase productivity and preserve soil fertility, increase yield and efficiency of growing season use (Figure 3).

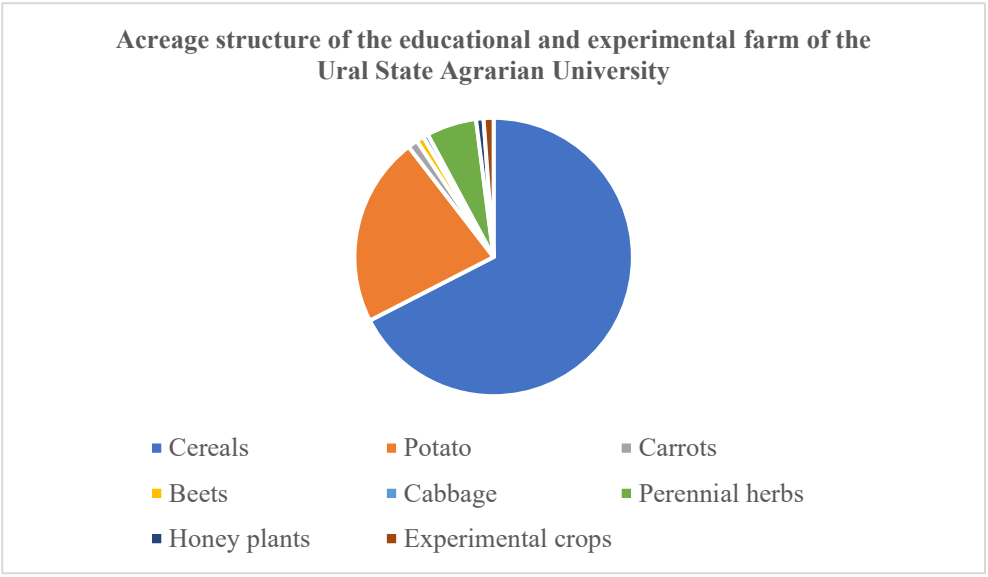

Fig. 3. The acreage structure of the educational and experimental farm of the Ural State Agrarian University.

A large area is occupied by grain crops (67%), they are represented by winter rye and spring grains (wheat, oats, barley). Potato occupies a significant share in the crops – 22%. The area of vegetable crops occupies 1.4%, perennial grasses – 5.81%, honey plants – 0.87%. The share of experimental crops accounts for 1.16% of arable land.

The results of the study of the field stage materials allowed to obtain valuable data on the land state. The analysis of images and maps of the farm made it possible to identify areas with an increased risk of erosion, which is an important step for the development of effective measures to prevent negative consequences for the soil cover [10].

The data obtained can serve as a basis for the development of a strategy for the rational use of the lands of an educational and experimental farm, which in turn will help in planning the allocation of planting areas. Thanks to the use of modern technologies, it was possible to conduct a detailed analysis of the territories. The results obtained will allow not only to assess the current state of the soil cover, but also to plan further measures to eliminate negative impacts on the farm working sites (Figure 4).

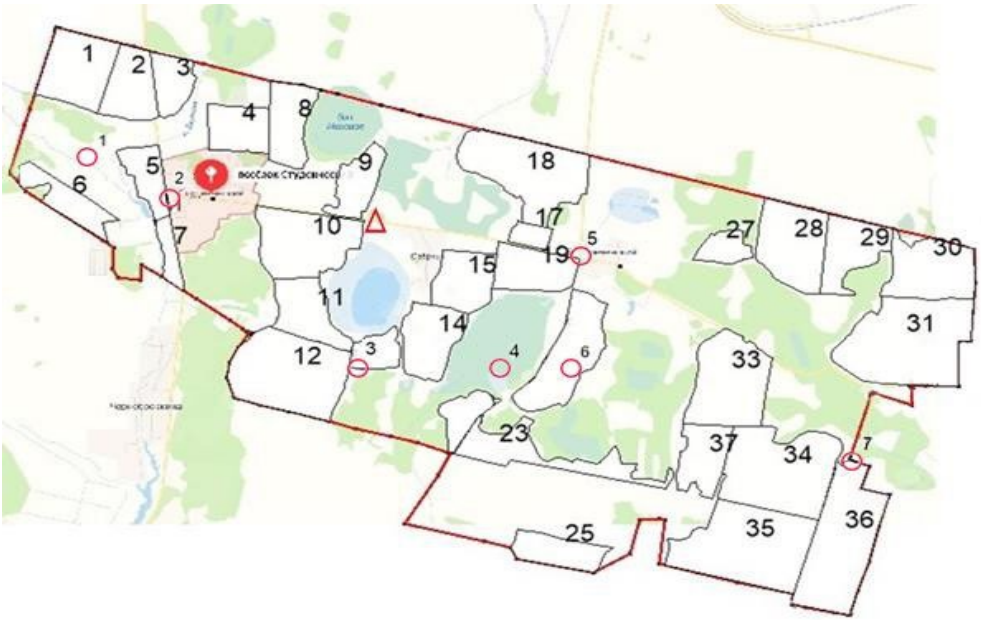

Fig. 4. Points of the geodetic network on the territory of the educational and experimental farm.

Table 1 shows the rectangular coordinates of seven points of the geodetic network located on the territory of the educational and experimental farm.

Table 1. Rectangular coordinates of geodetic network points.

No.	X coordinate	Y coordinate
1	6276240,949	1573116,275
2	6275657,760	1574241,017
3	6272999,302	1577022,132
4	6272966,274	1579005,553
5	6274793,052	1580072,560
6	6272996,084	1580005,939
7	6271644,680	1583968,459

The geodetic network points are evenly located throughout the territory of the

educational and experimental farm.

3 Results and Discussion

To work in the stereophotogrammetric method, a stereo terrain model is needed, the creation of which is possible if high-quality high-resolution images are available. Aerial photography was carried out by JSC Ural-Siberian Geo-Information Company on the territory of the educational and experimental farm of the university. Aerial photography was carried out using an area method, on a scale of 1:8500 – 1:10000, on an area of 66 square kilometers, a total of 8,712 images were obtained. To perform aerial photography, a link was made to the geodetic network points to create a survey justification.

In this work, aerial photography of the experimental farm was carried out by a set of Geoscan 201 UAVs. This drone is designed for shooting fairly extensive territories. Monitoring of work sites using this set of UAVs must be carried out every 2-3 years to obtain an up-to-date general electronic map of the farm. To track the development of adverse processes, as well as to track the state of vegetation in the fields, crop rotation planning, electronic maps of a larger scale are needed, not of the entire farm as a whole, but for example of specific work sites. For these purposes, the Geoscan lite UAV kit is suitable, which in its work is not inferior in quality to the previous set, but is designed for shooting smaller territories, with this kit it is possible to take more spot surveys to obtain up-to-date information about the state of the fields 2-4 times a year [5,9].

The shooting route is shown in Figure 5.

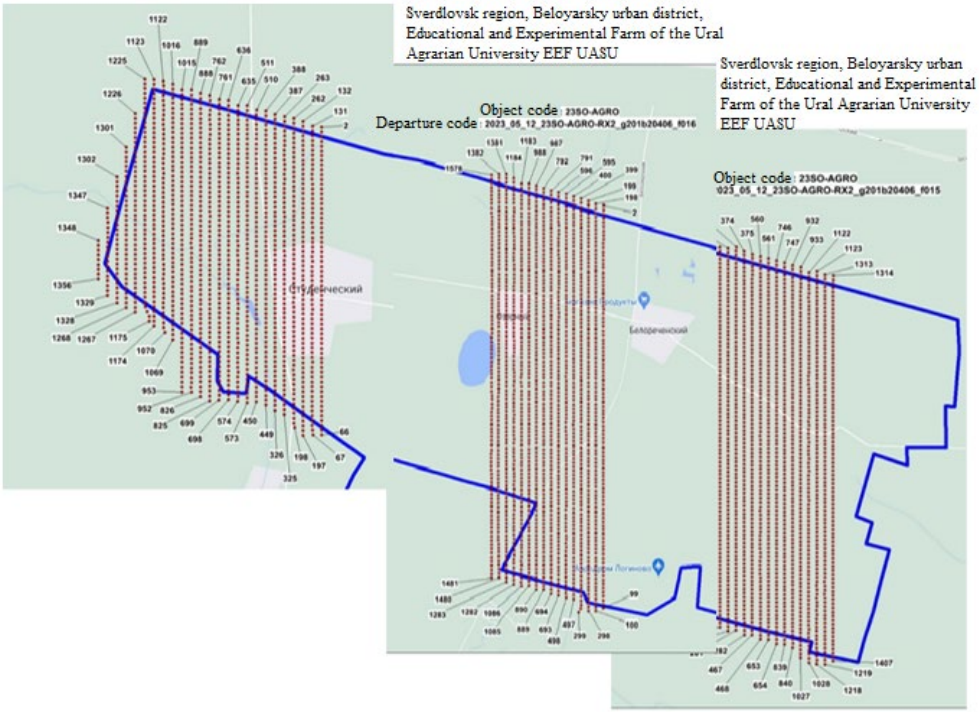

Fig. 5. The route of aerial photography of the educational and experimental farm.

The images obtained during aerial photography of the farm were processed in the PHOTOMOD software. As a result of this processing, a stereo model of an educational and experimental farm was obtained (Figure 6).

Fig. 6. Stereo model of an educational and experimental farm in the INSOT software.

On this stereo model, in stereoscopic mode, using a stereo monitor and special glasses, in the INSOT software, working areas of arable land were drawn in the vector layer, information on the site number, its perimeter, area and altitude characteristics were entered into semantic tables, characteristic relief points were applied for subsequent horizontal rendering.

The obtained data on relief marks make it possible to create a digital relief model [3]. According to the digital relief model, we can track elevation changes and identify foci of erosion hazard. The digital model in the QGIS software is shown in Figure 5.

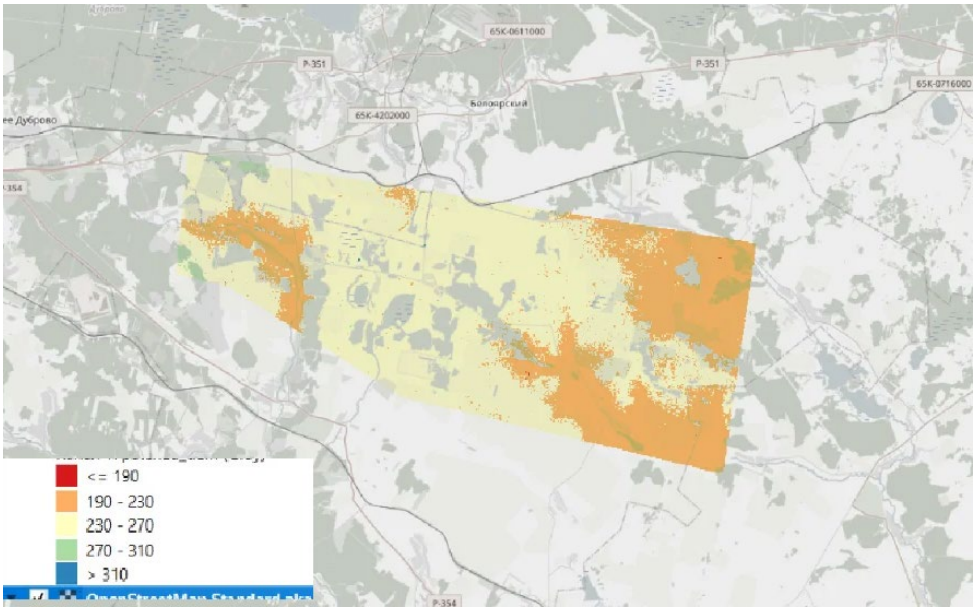

Fig. 7. Digital relief model of an educational and experimental farm in QGIS.

4 Conclusions

The results of the conducted research are digital counterparts of the educational and experimental farm. The analysis of satellite images and their comparison with soil maps of the territory made it possible to identify areas with an increased risk of erosion, which is an important stage for the development of effective measures to prevent negative effects on the soil cover.

The data obtained can serve as a basis for the development of measures to preserve the soils of experimental farm fields. Thanks to the use of modern remote sensing technologies, it was possible to conduct a detailed analysis of territories with different levels of erosion hazard. The results obtained made it possible not only to assess the current state of the soil cover, but also to plan further measures to eliminate negative impacts on the land. The assessment of the development of the dynamics of erosion processes using the stereophotogrammetric method shows its practical significance and effectiveness of use, which can be concluded that this technique is advisable to apply in further monitoring work on the farm.

The research methodology based on the territory survey using the stereophotogrammetric method has shown its effectiveness and relevance in fulfilling the tasks set in the final qualifying work.

The results of the work done will make it possible to create a set of measures to protect land from the development of erosion processes. The development and implementation of programs for the rational use of land is one of the main priorities within the agrarian policy framework. In connection with the transition of the agricultural sector to digital technologies, the performance of monitoring work to assess the condition of the lands of the educational and experimental farm of the Ural State Agrarian University using modern automated methods has shown its relevance in this work.

As part of further research in this area, it is also proposed to strengthen cooperation between educational organizations, scientific institutions, government authorities, and agricultural enterprises, and public organizations to develop and implement joint programs

to combat land degradation. It is important to create an effective system for monitoring and controlling the state of the land, as well as provide access to relevant information and resources.

References

1. A.H. Sheugen, T.N. Bondareva, A.A. Tenkov, *Agrochemical soil survey and cartography* (Krasnodar: KubSAU, 2017) 44.
2. F.G. Gafurov, *Soils of the Sverdlovsk region* (Yekaterinburg: Ural Univ-ty Publishing House, 2008) 396.
3. A.S. Gusev, E.A. Skvortsov, Bulletin of the Michurinsk State Agrarian University**, 4(63)** (2020).
4. GOST R 58854-2020 Photogrammetry. Requirements for the creation of oriented aerial photographs for the construction of stereo models of built-up areas
5. A.A. Alyabyev, E.A. Kobzeva, A.V. Grachev, Geoprofi, **5,** 23-26 (2017).
6. A.S. Gusev, V.A. Varnina, S.A. Bronitskaya, A.A. Belichev, G.V. Vyatkina, Moscow Economic Journal, **8(7),** (2023) DOI 10.55186/2413046X_2023_8_7_314. EDN EGELSF.
7. N.V. Vashukevich, A.S. Gusev, V.A. Varnina, V.A. Chulkov, A.N. Fedorov, Agroecological monitoring of soils in the educational and experimental farm of the Ural State Agrarian University
8. Zarechny City District [Electronic source] The official website of the government of the Sverdlovsk region. Access mode: https://midural.ru/100034/100089/mu_leaders/document2352 /
9. A.S. Gusev, N.V. Vashukevich, I.A. Staritsyna, A.A. Belichev, A.D. Smirnova, International Agricultural Journal, **66(3)** (2023).
10. N. Vashukevich, E3S Web Conf., (ETSAIC2023), **395,** 04004 (2023). DOI: 10.1051/e3sconf/202339504004