

GeoTerrace-2026-065**GIS Analysis of Agricultural Land Use in Mountain Communities in Zakarpattia Region**

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SUMMARY

The rational use of agricultural land in Ukraine's mountain communities has become a challenge in the context of socio-economic transformations and climate change. In view of this, the territory of Zakarpattia Region, which is characterised by challenging natural conditions and significant anthropogenic pressure – and consequently by the heightened susceptibility of its agricultural landscapes to erosion processes and loss of productivity – is of particular relevance for studying the main trends and challenges in the use of agricultural land. The study integrates cadastral statistics (Form 6, as at 1 January 2016) with modern GIS technologies (ArcGIS 10.8.2) for the spatial analysis of land-use patterns. The methodology combines statistical indicators of land use categories (arable land, pastures, hayfields, perennial plantations) with geoinformation mapping tools. The results revealed significant differences in land-use patterns between communities in Zakarpattia Region, as well as a correlation between the proportion of arable land and pasture and the elevation profile of the territory. The proposed approach enables the assessment of long-term trends and the forecasting of risks of degradation caused by natural and anthropogenic factors. The findings provide a scientific basis for strategies to optimise land use, prevent erosion and ensure the sustainable development of agricultural systems in mountainous regions.

Keywords: Mountain agricultural land use; Cadastral statistics; Spatial mapping; Sustainable land management.

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Introduction

The Zakarpattia Region has a distinctive land use structure due to its mountainous terrain, where the proportion of agricultural land is lower than in the flat regions of Ukraine. The mountainous nature of the terrain across most of the region's territory (80 percent) also accounts for differences in the structure of agricultural land within the region itself. Thus, agricultural land covers a significant part of the flat area of the Transcarpathian Lowlands, namely the Berehove, Vynohradiv, Uzhhorod and Mukacheve districts (as of 2016), where the majority of the region's arable land is concentrated.

Due to the mountainous nature of the territory, some land is of limited suitability for intensive farming and requires protection against erosion and landslides. In the mountainous regions of Ukraine, including the Zakarpattia Region, the problem of agricultural land degradation is exacerbated by socio-economic changes and climatic factors. For example, the Rakhiv District of the Zakarpattia Region, situated within the Ukrainian Carpathians, is particularly vulnerable due to its challenging physical and geographical conditions and the rapidly increasing pressure from human activity. Ensuring the effective and balanced use of land resources is a prerequisite for maintaining food security, environmental stability and the sustainable development of mountain communities Stoyko (2005).

Method and Theory

The GIS analysis was carried out by digitally mapping land-use patterns based on cadastral data as at 1 January 2016. Thematic layers (agricultural land, arable land, hay meadows, etc.) were created using ArcMap 10.8.2. This made it possible to produce cartograms showing the distribution of land types and to track their spatial dynamics at the level of districts in Zakarpattia Region and communities in Rakhiv District. The results are presented in the form of cartograms illustrating the spatial structure of land use at the district and community levels. By combining cadastral data and GIS analysis, a comprehensive methodology for the spatial analysis of land use has been developed, enabling the identification of the most vulnerable areas and the formulation of scientifically sound strategies for land resource management.

Current research in the Carpathian region and neighbouring territories actively integrates GIS technologies and environmental methods to assess the condition of land and the environment. In particular, the study by Leta et al. (2025) on solid waste pollution in Zakarpattia highlights the role of GIS in monitoring anthropogenic pressures. In turn, the study by Luzhanska et al. (2025) considers revitalisation as a component of environmental monitoring of disturbed ecosystems, which is linked to the problems of agricultural landscape degradation. The study by Melnyk Shamrai, V., & Shamrai, V. (2025) presents an agro-ecological assessment of land degradation in the Zhytomyr region, demonstrating methodological similarities with the analysis conducted in the Carpathians. Finally, the article by Mamonov et al. (2025) highlights contemporary methods of land-use planning for the spatial development of communities, thereby providing a conceptual framework for integrating the results of GIS analysis into the practice of territorial management. Taken together, these works form an interdisciplinary context in which research into the use of agricultural land in mountain communities in the Zakarpattia Region takes on relevance and practical significance.

Results

An analysis of the cartograms showing the areas of agricultural land and arable land in the Zakarpattia Region as at 1 January 2016 allows us to identify spatial patterns in the use of land resources in the region. The first map (Fig. 1) reveals significant differences between lowland and mountainous areas: the largest areas of agricultural land are concentrated in the lowland districts (Uzhhorod, Mukachevo, Berehove, Vynohradiv), where natural conditions are favourable for intensive farming. Here, the areas of agricultural land exceed 1,500–2,000 hectares, indicating a high degree of land development. In contrast, in the mountainous districts (Rakhiv, Mizhhiria, Velyky Berezhny, Perechyn), forests

dominate, whilst the areas of agricultural land are minimal (less than 200 hectares), due to the challenging terrain and limited opportunities for farming.

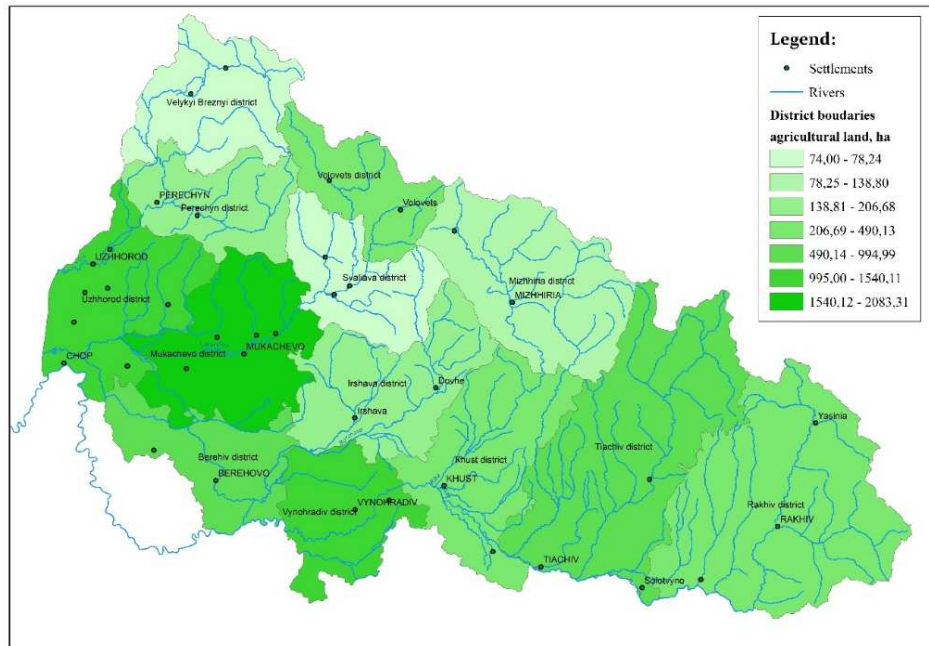


Figure 1. Map showing the area of agricultural land in Zakarpattia Region (1 January 2016), hectares

The second map, which shows the areas of arable land, reveals an even more pronounced variation. The largest tracts of arable land are concentrated in the valley regions of Zakarpattia, particularly in the Berehove and Vynohradiv districts, where the areas of arable land exceed 600–700 hectares. This is due to the flat terrain and the high suitability of the soils for growing cereals and industrial crops. In mountainous areas, the proportion of arable land is negligible (less than 10–20 hectares), confirming the predominance of woodland and natural forage land (pastures). This imbalance in land-use patterns reflects a general trend, namely the specialisation of lowland areas in intensive agriculture, whilst mountain communities preserve their forest and natural landscapes.

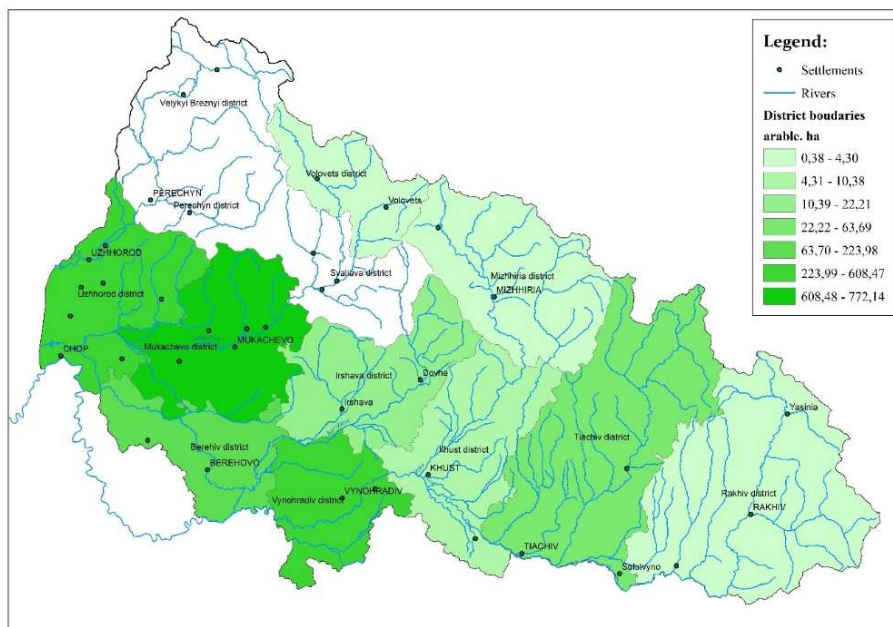


Figure 2. Map showing the area of arable land within the Zakarpattia Region (1 January 2016), hectares

There is a trend towards a reduction in the area of agricultural land, particularly hay meadows, pastures and permanent crops, which over recent decades has had a negative impact on the livestock sector, which has traditionally relied on the use of natural forage land. At the same time, the expansion of built-up and forested areas indicates changes in land-use patterns, reflecting socio-economic transformations. Land-use efficiency remains low, particularly in the case of small plots, which are often neglected and not subject to cultivation or technical maintenance. This reduces the productivity of agricultural systems and creates risks of degradation.

GIS mapping has revealed significant differences in land-use patterns, including between communities in the Rakhiv district, the territory of which has been selected for further, more detailed analysis. The terrain largely determines the ratio of arable land to pasture. A preliminary analysis indicates a reduction in hay meadow areas and an expansion of arable land in the low-lying parts of the district (the vicinity of Velykyi Bychkiv), which increases the risk of erosion.

A significant pattern is that the proportion of arable land in the district's land fund gradually increases downstream along the main rivers – the Black Tisa, the White Tisa, the Shopurka and the Apshitsa. This is explained by the widening of the river valleys, which create more favourable conditions for agriculture, a decrease in the average elevation of the territory, a reduction in the areas of hay meadows and pastures, and an increase in population density in the valley settlements.

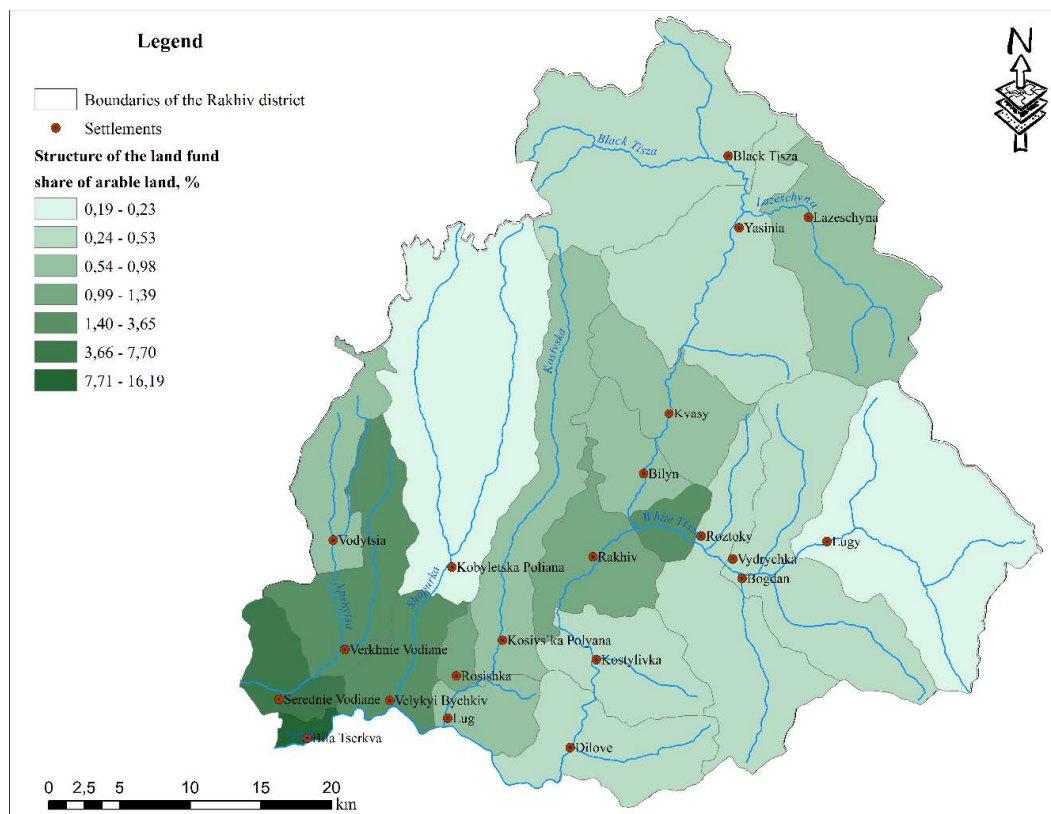


Figure 3. Map showing the proportion of arable land in the land use structure of the Rakhiv District, %

Conclusions

An integrated approach to spatial analysis of land use provides a comprehensive understanding of the dynamics of agricultural land areas in mountain communities. The results form the basis for sound land management strategies, erosion prevention, sustainable agricultural planning, post-war economic recovery in the region, and so on. The study may contribute to the environmental monitoring of land resources and, where necessary, the adoption of appropriate management decisions based on GIS analysis.

The marked spatial heterogeneity of land use in the Zakarpattia Oblast is due to the high level of land development and intensive agriculture in the lowland areas, whilst mountain communities are characterised by a predominance of forest areas and a low proportion of arable land. These differences determine the socio-economic specialisation of the territories and must be taken into account when formulating strategies for sustainable development, optimising land use and supporting the livestock sector. Scientifically sound land resource management is a key factor in ensuring the region's food security and environmental stability.

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