

Geospatial Insights into Agricultural Land Use Dynamics in Slovakia (2004–2024): Challenges and Opportunities

Tomáš Goga^{a,*}, Šimon Opravil^a, Daniel Szatmári^a, Dobromil Galváněk^b

^a Institute of Geography, Slovak Academy of Sciences, Slovakia, tomas.goga@savba.sk, simon.opravil@savba.sk, daniel.szatmari@savba.sk

^b Institute of Botany, Plant Science and Biodiversity Centre, Slovak Academy of Sciences, Slovakia, dobromil.galvanek@savba.sk

* Corresponding author

Keywords: Land Parcel Identification System, LPIS, arable land, grasslands, data analysis, cartographic visualisations

Abstract:

The Land Parcel Identification System (LPIS) in Slovakia was brought into operation in 2004. The first LPIS database was created using aerial orthophotomosaics in 2002 and 2003, and since then, it has emerged as Slovakia's most reliable and consistent database for monitoring agricultural land use. This study utilises LPIS data to evaluate the significant changes in the spatial distribution and utilisation of arable land and grasslands between 2004 and 2024, focusing on their environmental implications. Over this period, Slovakia experienced a substantial net loss of agricultural land (Figure 1), totalling 2376.97 km² (-11.32 %). Furthermore, arable land and grasslands (Figure 2), the two most significant land cover/land use (LC/LU) classes within LPIS, have undergone dynamic changes. By 2024, arable land accounted for 70.22% of the total LPIS area 2024, a decrease of 40,084 hectares from 2004. Within grasslands (28.71% of total LPIS area in 2024), a decrease of 6,356 hectares from 2004 was recorded. These LC/LU classes are essential for agricultural productivity and critical to maintaining biodiversity.

Grasslands contribute to ecosystem stability and resilience, while arable lands represent the foundation of traditional agricultural practices. However, despite their relative spatial stability, extensification and encroachment have been observed, particularly in species-rich grassland communities. These trends pose challenges to biodiversity conservation and the preservation of agricultural landscapes. The loss of traditional land-use practices and suburbanization-driven transformations further exacerbate these issues, emphasising the need for sustainable management strategies that balance competing land-use demands.

The temporal development of LPIS data reveals the evolving legal and methodological framework underpinning its implementation from 2004 to 2024. Legislative amendments, such as integrating EU directives and land registration policy changes, have reflected and influenced broader socio-economic transformations in Slovak agriculture. Notably, these changes have improved data accuracy and adaptability to new challenges. However, inconsistencies in implementation and periodic methodological updates could have disrupted long-term data comparability, underscoring the importance of a stable regulatory framework for effective land monitoring and policy-making.

This study highlights the potential of LPIS as a robust tool for monitoring and analysing land use dynamics over time. To capture spatial heterogeneity, we conducted a grid-based geospatial analysis by overlaying a 1 × 1 km grid across Slovakia and aggregating LPIS land use data within each cell. This approach allowed us to detect localised trends, such as hotspots of agricultural land abandonment, suburbanisation, and shifts between arable land and grasslands. Cartographic visualisations provided further clarity on spatial patterns and regional disparities. These findings have direct implications for spatial planning, agri-environmental policy, and biodiversity protection. For example, identifying regions with persistent grassland degradation can inform targeted conservation or restoration measures. Integrating LPIS with remote sensing and socio-economic data in future work will enhance predictive capabilities and support evidence-based decision-making for sustainable land management.

Acknowledgements

This work was supported by the Slovak Academy of Sciences under Postdokgrant APD0119, “Comprehensive Analysis of Abandoned Agricultural Land in Slovakia”, funded by the Early-Stage Grant schema (09I03-03-V05: Recovery and resilience plan). The generative AI (GPT-4o) was used only to improve the readability of the presented work.

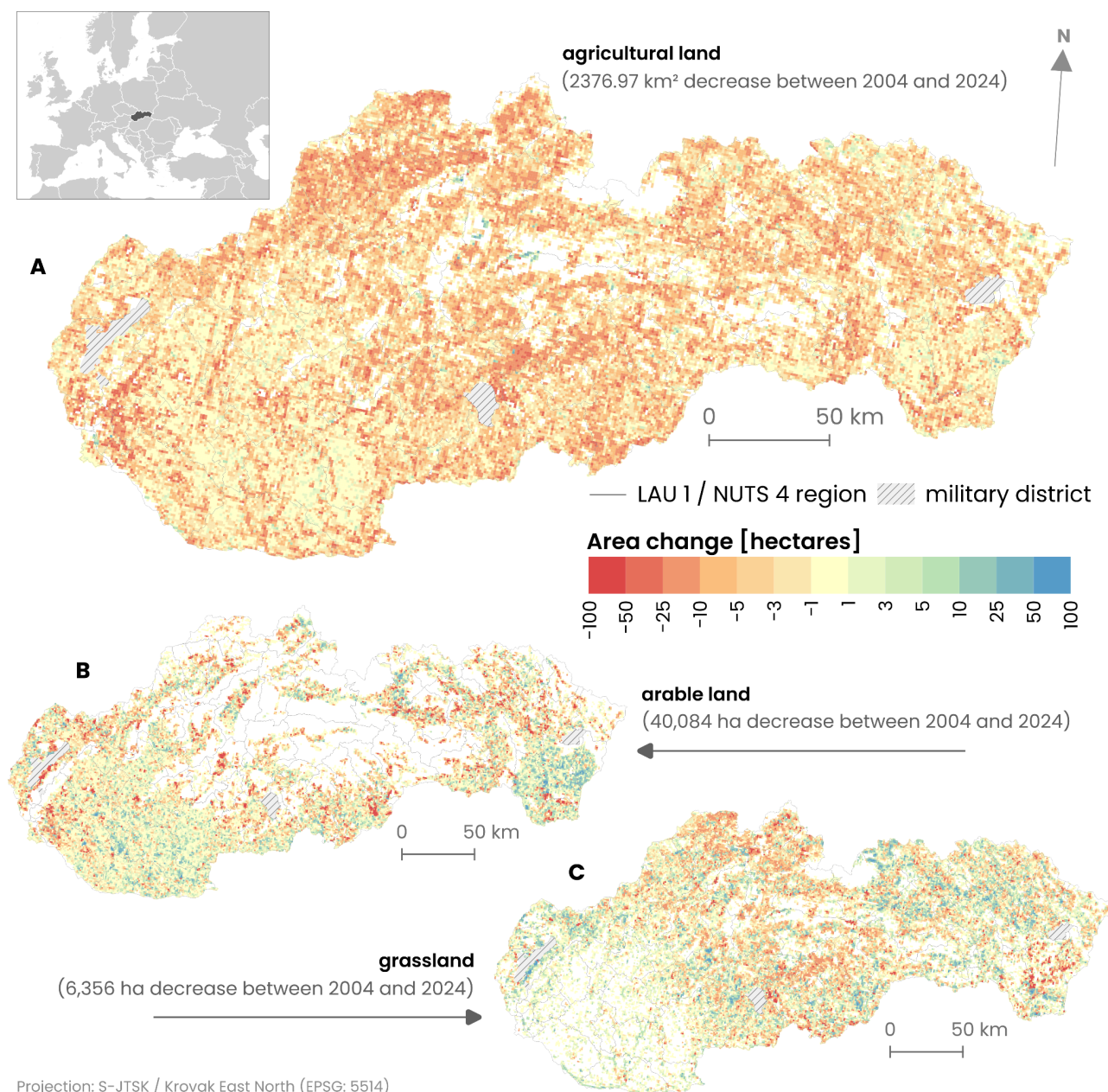


Figure 1. Changes in Agricultural Land Use based on the Land Parcel Identification System (LPIS) in Slovakia (2004–2024). **A:** Area Change for Aggregated LPIS Classes Between 2004 and 2024 in 1 x 1 km Grid; **B:** Area Change for Arable Land Class Between 2004 and 2024 in 1 x 1 km Grid; **C:** Area Change for Grassland Class Between 2004 and 2024 in 1 x 1 km Grid.

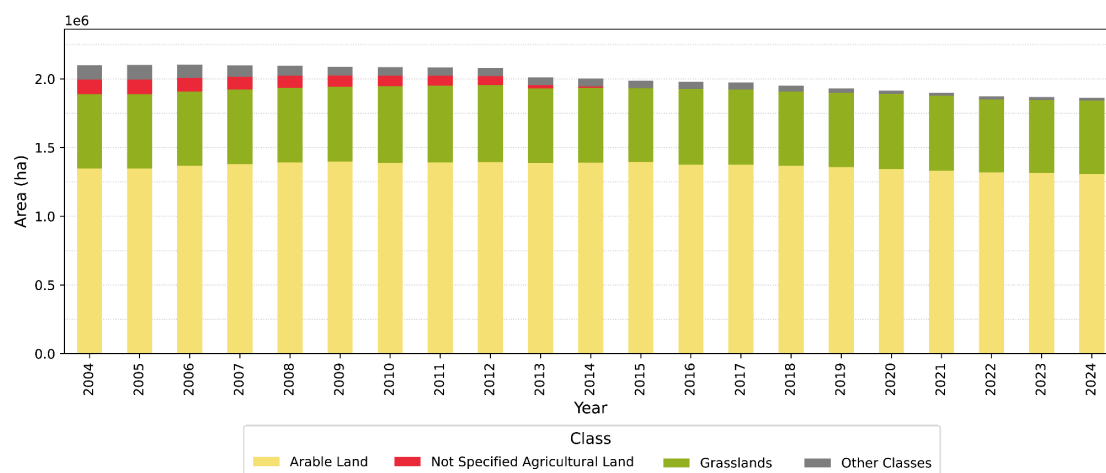


Figure 2. Trends in the Land Parcel Identification System (LPIS) Classes Over Time (in Hectares).