22 Connection between Agriculture, Landscape Carrying Capacity and Climate Change in the Danube-Tisza Interfluve, Hungary

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Abstract

This study examines the landscape carrying capacity of the Danube-Tisza Interfluve (referred to as "Homokhátság"). Environmental, agricultural, and economic data at a 5x5 km resolution were examined to investigate agricultural landscape utilization. The analysis primarily entails evaluating the possible overutilization of the natural resources of Homokhátság by agricultural production. The findings highlight areas within the Homokhátság region where agricultural practices, such as arable farming, orchards, vineyards, and intensive livestock farming, exert heightened pressure on the landscape. The study concludes that considering climate change, a fundamental transformation of land use and agricultural practices is necessary in the region to stop landscape degradation. Sustainable agricultural production requires focusing on low-impact and low-resource agriculture and water management, particularly water retention within the landscape. Moreover, it suggests that certain areas within the Homokhátság region may need to be either abandoned or subjected to transformations to double or triple utilization, such as silvopasture or agro-photovoltaics.

Keywords

agriculture; climate change; Hungary; landscape carrying capacity; landscape suitability; land use

JEL Classification

Q15

1. INTRODUCTION, RESEARCH FRAMEWORK

In recent decades, global agricultural production has become more and more intensive, increasing the use of resources and strengthening exposure to the effects of climate change. Hungary's Danube-Tisza Interfluve (Homokhátság) region is also affected by these processes, with severe drought and soil erosion, making it extremely sensitive to climate change. Therefore, it is crucial to develop sustainable land practices to secure the region's environmental, economic, and social well-being. Our study focuses on assessing the agricultural production's sustainability in the Homokhátság, analyzing various indicators to identify landscape overuse and its factors and drivers. Finally, we aim to provide recommendations for long-term sustainability in the Homokhátság region and geographically similar areas.

The relationship between agriculture and landscape carrying capacity has long been studied. Sustainability, mainly through multifunctional agricultural models, has been a focus of the Common Agricultural Policy of the European Union since the 1990s (Podmaniczky et al., 2007). In Hungary, Ángyán (2003) proposed landscape management zones tailored to local characteristics to guide appropriate and sustainable land use changes, a concept we apply in our assessment of the Homokhátság's agricultural production.

Studies exploring the ecological connection between agriculture and landscape carrying capacity often focus on environmental vulnerability (Barczi et al., 2008; Ángyán et al., 2003), which initially garnered attention in arid and semi-arid regions. In these areas, the scarcity or absence of water resources significantly influences agricultural production, such as in the Homokhátság, officially designated as a semi-arid region by the United Nations Food and Agriculture Organization (FAO).
In addition to water, soil characteristics, and degradation processes, such as wind erosion, are critical factors affecting landscape sustainability. Various soil degradation processes affect about 30% of arable land globally, causing reduced or completely depleted fertility. Wind erosion is one of the most critical factors in soil degradation in the Danube-Tisza Interfluve, characterized by loose, sandy soils.

2. MATERIALS AND METHODS

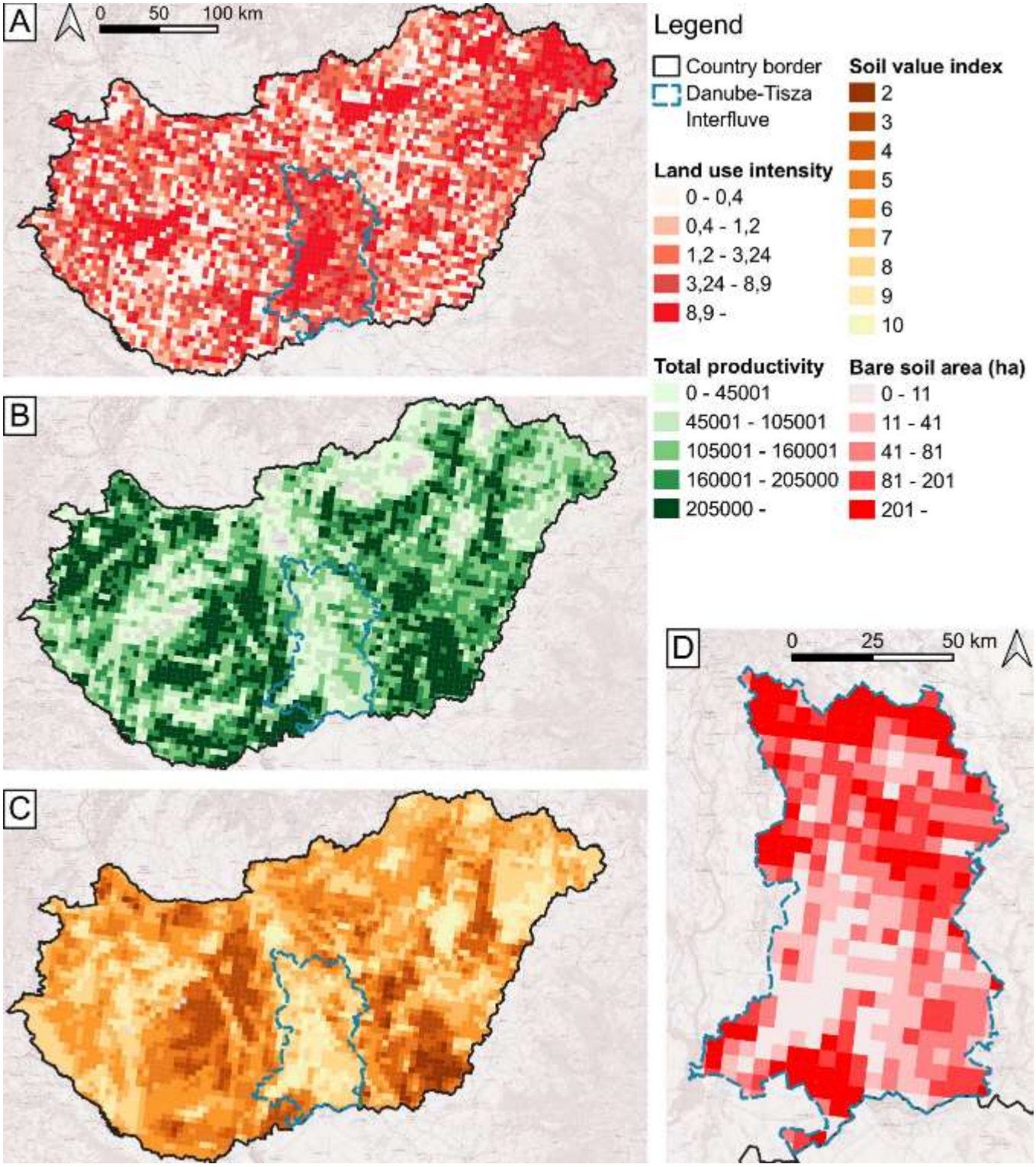
During the analysis, CORINE Land Cover – CLC (2018), Sentinel satellite data (2021-2023), agricultural census data from the Hungarian Central Statistical Office's (HCSO) TÍMEA database, agro-topographical data, and climate data were utilized. A uniform 5x5 km grid evaluation was employed, with data provided by HCSO TÍMEA. The analyses were conducted using the QGIS program.
The assessment of land use intensity followed the methodology outlined by Gardi et al. (2010), calculating the proportion of intensive production within agricultural areas (CLC category 2) through vineyards, orchards and berry plantations, rice fields CLC categories, and the ratio of animal population expressed in livestock units to their required area. The qualitative and quantitative intensity of large-scale arable cultivation was evaluated by the product of the total productivity over five years (2018-2022) – CLC 211: non-irrigated arable land – and the area of arable land. The soil value index, a composite indicator incorporating various soil properties, was determined as the average value within each grid cell. Our focus on the Homokhátság region aimed to uncover the spatial extent of bare soil areas. The indicator we have developed shows the extent of the occurrence of bare soil for at least six months in two of the years 2021-2022-2023. The results were derived from statistical analysis of NDVI data obtained from Sentinel satellite imagery during vegetation and dormant periods. The vulnerability arising from climatic change was evaluated through the normalized aggregation of changes in the number of heat days, >20 mm rainy days, and the Pálfai index based on multi-year averages (1971-2000; 2036-2045).

3. RESULTS

Based on the developed land use intensity sub-index (Figure 1/A), it is evident that the Homokhátság region ranks among the most intensively utilized areas across Hungary. Furthermore, the overall productivity index of the Homokhátság region's arable land is lower than the national average (Figure 1/B). These two factors indicate that land use in this region is not in line with the carrying capacity of the landscape. Farmers do not consider the weak agro potential of the landscape, resulting in overuse. This fact is further supported by the soil value index (Figure 1/C), illustrating that the region with the lowest fertility in the country is virtually the Homokhátság.
Improper cultivation practices further exacerbate the problems arising from overuse. A significant area of the Homokhátság region features arable lands that remain without vegetation for at least six months annually (Figure 1/D). Bare soil not only contributes to deflation but also intensifies undesirable effects in connection with climate change (for example, evaporation loss increases, which aggravates the lack of soil moisture and amplifies damage during periods of drought).

4. DISCUSSION AND CONCLUSIONS

Our analysis indicates that agricultural practices do not align with the landscape carrying capacity. This has led to overuse, resulting in insufficient resources and numerous problems in crop cultivation and animal husbandry, often accompanied by inefficiency, low-income generating capabilities, and unsustainability.



Data sources: NDVI; CORINE Land Cover; NÖSZTÉP; HCSO TÍMEA.

Figure 1. A: Land use intensity; B: Total productivity; C: Soil value; D: Bare soil area

The development of a land use system that aligns with natural conditions (water, soil, meteorological factors) is necessary to ensure the economic and social sustainability of the Homokhátság region. This necessitates the abandonment of numerous arable and vineyard areas, the creation of a mosaic landscape structure, and the implementation of soil cultivation practices to improve physical and chemical soil conditions. Without these measures, the region may face depopulation and severe economic depression in the future.

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