ASSESSMENT OF LANDSCAPE VULNERABILITY IN THE CZECH-SLOVAK BORDER REGION USING NATIONAL APPROACHES

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Abstract

Currently, there are important methodological procedures (applications) for landscape vulnerability assessment on both sides of the border Czech-Slovak Republic border. In Slovakia it is the application "Horia obce" and in the Czech ESAI+. However, both approaches focus only on their territories, taking into account administrative borders and the availability of national datasets.

In our study (carried out in the framework of the Interreg project JIZKES), the two methodologies were first compared at the level of the concept of the evaluation. This was followed by an analysis of the data used and the possibility of equivalent data sets on the other side of the border. Both methods were then applied, first on the home side and then on the opposite side, at the extent of the selected adjacent counties, to produce seamless maps of the whole study area. The main differences were identified in the climate data used (value, resolution) and the detail of the habitat map. The resulting maps were published on the project's public map portal. Finally, the applicability of the methodologies was evaluated using the SWOT method to create a (new) unified landscape vulnerability methodology applicable in both countries.

Key words: GIS, landscape analyses, vulnerability

Introduction

The effects of climate change are evident worldwide and have various impacts—environmental, social, and economic. The fundamental principle of mitigating these impacts is understanding the causes, identifying vulnerable areas, and proposing appropriate adaptation and mitigation measures. These steps must respect the character of the landscape being assessed. Landscape research is very often limited by administrative state borders, which certainly do not correspond to the boundaries of ecosystem units. However, natural processes and other driving forces of landscape change operate in a broader context and must be analysed within logical, functional, and natural boundaries. This is doubly true for research on climate and its manifestations.

Landscape processes, not only along the Czech-Slovak border, do not recognise administrative boundaries but are shaped and operate based on natural conditions and the locally specific nature of land use. Analyses and adaptation measures implemented within the boundaries of administrative units are thus insufficient and do not deliver the expected benefits to the landscape or human society, partly due to the mutual interaction of various measures implemented in neighboring areas.

Currently, there are key analyses and applications for assessing landscape vulnerability on both sides of the border—on the Slovak side, this is the “Horia obce” application, and on the Czech side, the ESAI+ assessment of environmental sensitivity and landscape productivity loss. However, both approaches address only their respective territories, taking into account administrative boundaries, the availability of national data, and expert knowledge.

Materials and methods

Based on our own knowledge, extensive literature review, and direct discussions, we identified relevant methodological approaches used in the Czech Republic and Slovakia. These were analysed in terms of their objectives, concepts, and methodologies, followed by a comparison of their key components. The data and information sources used were then analysed. The focus of the analysis was on identifying their role in the analysis, assessing their availability across the entire territory of interest, and determining the existence of identical datasets or their equivalents in the other country. Finally, both methodologies were applied first in the home country and then in the neighbouring territory, and seamless maps of the entire cross-border area were created. The data and results were compared and evaluated.

Results

ESAI method

The methodology defines vulnerability assessment at the level of individual landscape segments. A key feature of the procedure is the large number of spatial overlay operations performed on individual layers, which result in extensive segmentation of landscape units (Pechanec et al., 2021). This is advantageous for the subsequent aggregation of vulnerability values for any administrative or natural unit. Still, it increases the volume of generated data and the demands on how individual values are presented.

- Clearly quantified outputs in four thematic groups and a single overall landscape vulnerability index,
- Designed for the habitat level, detailed landscape analysis,
- Ability to display results at various scales—municipalities, districts, regions,
- Enables assessment of the fulfilment of ecosystem functions and services,
- Direct mechanism for designing and targeting mitigation and adaptation measures (Prokopová at al., 2026),
- Comprehensive approach to degradation (multiple causes),
- Ability to compare results with other countries (Italy, Greece, Romania).

ESAI total index values for susceptibility to degradation: i) extremely high in more than half of the selected area in the Czech Republic—predominantly agricultural land, ii) extremely high in roughly one-third of the selected area in Slovakia – with a higher proportion of forested areas, iii) in the border cadastral areas of municipalities, the ESAI values show lower vulnerability to degradation in the Czech Republic – this is due to more detailed climate data and data on the occurrence of natural habitats in the Czech Republic compared to data in Slovakia.

Values for the thematic groups “Intensity of Human Activity” and “Climate Status” are similar in both territories: i) both thematic groups reach extremely high to moderate values in the Czech Republic—most notably in the South Moravian Region and, to a lesser extent, in the Moravian-Silesian Region; ii) in Slovakia, most notably in the Nitra Region, and to some extent in the Trenčín and Žilina Regions. Values for the Vegetation Condition thematic group show low susceptibility to degradation in mountainous areas: in the Czech Republic, the Moravian-Silesian Beskids; in Slovakia, the Strážovské vrchy and Malá Fatra. The thematic group “Soil Condition” yields nearly opposite values; areas with deeper, less skeletal soil and minimal slope exhibit low susceptibility to degradation.

„Vedúci! Horia obce” method

The aim of the “Leaders! The Towns Are Burning!” method (VHO) is to identify the levels of vulnerability of towns to the impacts of climate change, specifically in three main areas: heat waves, drought, and extreme precipitation (Nánásiová et al., 2023). The basic principle of the VHO method can be described as the calculation of an index, which is derived as the sum of the contributions of input indicators multiplied by automatically assigned weights using the statistical method known as Data Envelopment Analysis (DEA). For important indicators, experts set a lower threshold for their contribution to the resulting index, which must be met. Conversely, for less relevant indicators, an upper limit is set for their contribution to the index. Based on the index values, municipalities are divided into 10 groups (quantiles) representing the level of vulnerability, where a higher value indicates a higher risk.

The methodology is characterised by the fact that it processes all input data into a single value for the entire administrative territory using the weighted average method. This approach is thus suitable for comparing municipalities or higher administrative units, but it is not suitable for the detailed spatial localisation of the vulnerable segment. An advantage is that, for most of the climate indicators used, national climate data are not used, but rather data from the European project Copernicus -CAMS, which seamlessly cover the entire territory of both countries and fully meet our basic premise of fully compatible data without any internal barriers, uniformly describing the state of the entire area of interest, albeit at the cost of lower spatial resolution.

The following points can be seen as particularly positive aspects of the VHO method:

*0 The landscape vulnerability assessment also includes the impact on people (the procedure better addresses social aspects and adaptive capacity),

*1 Authorised climate data (CAMS) extending beyond national borders are used, incorporating climate scenarios (assessment of future threats),

*2 Clearly defined causes of vulnerability and relationships between layers; it separately assesses three real threats (heat waves, drought, extreme precipitation),

*3 Direct interpretation of results for municipalities and the option to aggregate data across various administrative units,
*4 Faster data updates - standardised data, accessible (for the Slovak Republic) and partially updated,
*5 The procedure does not rely on “subjective” expert classification of individual factors - impact is assessed statistically,
*6 The result is available in graded categories - making it easier to interpret,
*7 • There is the option to add weights—depending on the perceived or documented importance of certain areas.

The following can be seen as the main drawbacks of the Slovak approach:

1. The indices are expressed only at the level of the entire municipality (the lowest administrative unit) - it is not possible to calculate indices for other types of areas (e.g., landscape units, by land use type),
2. There is no single comprehensive index or metric; only three separate indices for different types of threats.
3. The results cannot be used for spatially localised adaptation measures (for different types of landscapes); only a general assessment of a municipality’s vulnerability and possible measures is possible,
4. Insufficient input data for natural factors (soil, water, vegetation, habitats), which are important in terms of landscape vulnerability.
5. Specific calculation issues regarding certain input layers (e.g., in the Czech Republic, two layers are unavailable: per capita income/municipality, Roma settlements; the methodology for calculating climate data is also partially different).
6. With the data used, certain linear elements - significant for representing green and blue infrastructure in the landscape - are lost (ignored).

A comparison of the differences between lowlands, foothills, and mountainous areas shows that lowlands are particularly critically endangered. A comparison of territories along the state border indicates that the territory of the Czech Republic exhibits higher vulnerability. However, this difference is primarily caused by the differing spatial resolution of certain input data and other factors that affect the overall consistency of the data and their comparability.

Discussion

During the analysis, it became clear that cross-border cooperation is essential for its successful implementation. Together, the participants discussed and expanded their knowledge regarding the availability of individual datasets, licensing rules, and contact points for obtaining data, as well as the significance of individual attributes and a shared understanding of key terms.

When adapting the Slovak approach to national conditions, it was necessary to utilise advanced knowledge of the landscape’s parameters (model inputs) and information on available data relevant to these purposes. On the Czech side, this issue was primarily addressed by researchers from CzechGlobe, who have long specialised in these topics within the quantification of the benefits of individual landscape ecosystem functions, using specific indicators modified with regard to the format and quality of national data.

The data were compared iteratively, first based on an analysis of the metadata of the spatial data used, followed by a direct analysis of data samples (again requiring cross-border coordination, where each partner was able to quickly and efficiently provide the required data samples). The output is a tabular identification of matching and differing datasets/expert knowledge, their interrelationships, and their convertibility.

Conclusion

The results are available both as static maps, which can be downloaded for free from the project website, and, in particular, on the project’s map portal, where users can interactively explore the resulting data layers. Based on these findings, a new, unified methodology for assessing landscape vulnerability was developed and applied during the course of the project.

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Souhrn
Příspěvek představuje výsledky z metodického srovnání národních přístupů k hodnocení zranitelnosti krajiny v České a Slovenské republice. Identifikuje silné a slabé části jednotlivých metodických přístupů, stejně jako dostupnost, a měřítko použitých dat. Základní rozdíly lze spatřit v základní analyzované jednotce (biotop x administrativní jednotka obce) a v prostorovém detailu použitých klimatických dat.
Mezi klíčové vlastnosti ESAI patří: i) jasně kvantifikované výstupy ve čtyřech tematických skupinách a jeden celkový index zranitelnosti krajiny, ii) komplexní přístup k degradaci krajiny, iii) určeno pro analýzu na úrovni biotopů a podrobnou analýzu krajiny, iv) umožňuje posoudit plnění ekosystémových funkcí a služeb, v) součástí je metodika pro navrhování a zacílení opatření ke zmírnění dopadů a adaptaci. Mezi klíčové vlastnosti VHO patří: i) hodnocení zranitelnosti krajiny zahrnuje také dopady na obyvatelstvo (postup lépe zohledňuje sociální aspekty a adaptační schopnosti), ii) Využívají se ověřená klimatická data (CAMS) přesahující státní hranice, která zahrnují klimatické scénáře, iii) jasně definované příčiny zranitelnosti a vztahy mezi vrstvami; samostatně hodnotí tři reálné hrozby (vlny veder, sucho, extrémní srážky), iv) přímá interpretace výsledků pro obce a možnost agregace dat napříč různými správními celky, v) postup se neopírá o „subjektivní“ odbornou klasifikaci jednotlivých faktorů – dopad je posuzován statisticky, vi) existuje možnost přidat váhy – v závislosti na vnímaném nebo zdokumentovaném významu určitých oblastí.

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