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How to interpret geodiversity as a spatial variable?

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Abstract:

Earth science consists of a number of distinct disciplines characterised by unique features and elements – yet there is a close relationship between them. The variety of geological, geomorphological, hydrographical, soil, mineral and fossil properties over a particular area is called geodiversity. The background of this concept reveals a link between scientists and society: the richness in geo-attributions may generate research and tourism interests too (Gray, 2018). Assessing this kind of diversity of inanimate nature has great importance for both nature conservation and (geo)tourism – especially for the UNESCO Global Geoparks. Geodiversity evaluation ('quantification') implies a thorough synthesis of analogue and digital base data. Thematic datasets are analysed using various models. Nowadays, these workflows are usually aided by GIS methods that make them easier to compile as they require less field- and office work (Zwoliński, 2018).

For most methods, the result of geodiversity assessment is an index value, which can be considered as a complex thematic spatial variable combining different characteristics of the earth science disciplines. Geological, pedological maps (vector polygons), DEMs (for quantifying relief and watercourse indices), and mostly open-source mineralogical and palaeontological datasets were analysed to produce the final geodiversity index (Pál & Albert, 2021). These resulting values are usually defined for spatial units, mostly grid cells covering a certain study area. The resolution of this grid depends on three factors: 1) the extent of the sample area, 2) the scale of available base data, and 3) the complexity of the desired result. Based on these factors, geodiversity evaluation is recommended to be distinguished into three scale groups:

- A **local** evaluation applies large-scale thematic data (up to 1:100,000) and a large resolution grid (up to 1000*1000 m cell size). The larger the base data scale, the smaller should be the grid cell size to produce balanced results. This assessment type is good for highlighting locally important features and characteristics, therefore not suitable for result comparison with other areas – e.g. Hjort & Luoto (2010) used 500*500 m cells and base data of 1:20,000 and 1:31,000 scales.
- A **subregional** evaluation applies middle-scale thematic data (between 1:100,000 and 1:500,000) and a grid resolution up to 15-20 km. These assessments provide a good solution for revealing interrelations between geoscientific subindices and various evaluated areas as features with local importance are mainly omitted. Results can be used to initiate further exploration research on possible geoconservation and geotourism utilisation of highlighted 'geodiverse' areas – e.g. Pál & Albert (2021) used 2*2 km cells and base data of 1:100,000 scale.
- A **regional** evaluation is characterised by small-scale thematic data (smaller than 1:500,000) and a grid resolution larger than 20 km. This kind of evaluation is suitable for the examination of large areas. Diverse parts are highlighted in this case too, but the small scale of base data distorts the results as important geoscientific features (e.g. distinct rock types or significant morphological characteristics) may be omitted. Maps edited from these results can be used for representative purposes – e.g. Pereira et al. (2013) applied 25*25 km cells and base data ranging from 1:500,000 to 1:650,000 scales.

The proper thematic cartographic visualisation method of the geodiversity index depends on the scale and purpose of the assessment. We can define two distinct mapping methods (Fig. 1):

- **Choropleth maps:** this kind of visualisation is based on spatial units (the grid cells) and variable quantitative data (the geodiversity index). This method is suitable for local and subregional evaluations because further research works based on the results use the data defined in each grid cell. These are presented as individual attributes assigned to cells. The cells, and hence the geodiversity variable, have a clear reference location.
- **Isoline maps:** this visualisation method is used for values continuously varying in space. Although geodiversity index is not this type of data, it can be densified by using interpolation methods and interpreted in a similar way

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to continuous data. This kind of visualisation is primarily suitable for regional-scale maps, as these are intended to provide an overview. Inevitably, the use of this method reduces the accuracy of the visualisation by modifying the original spatial reference of the evaluated geoscientific elements.

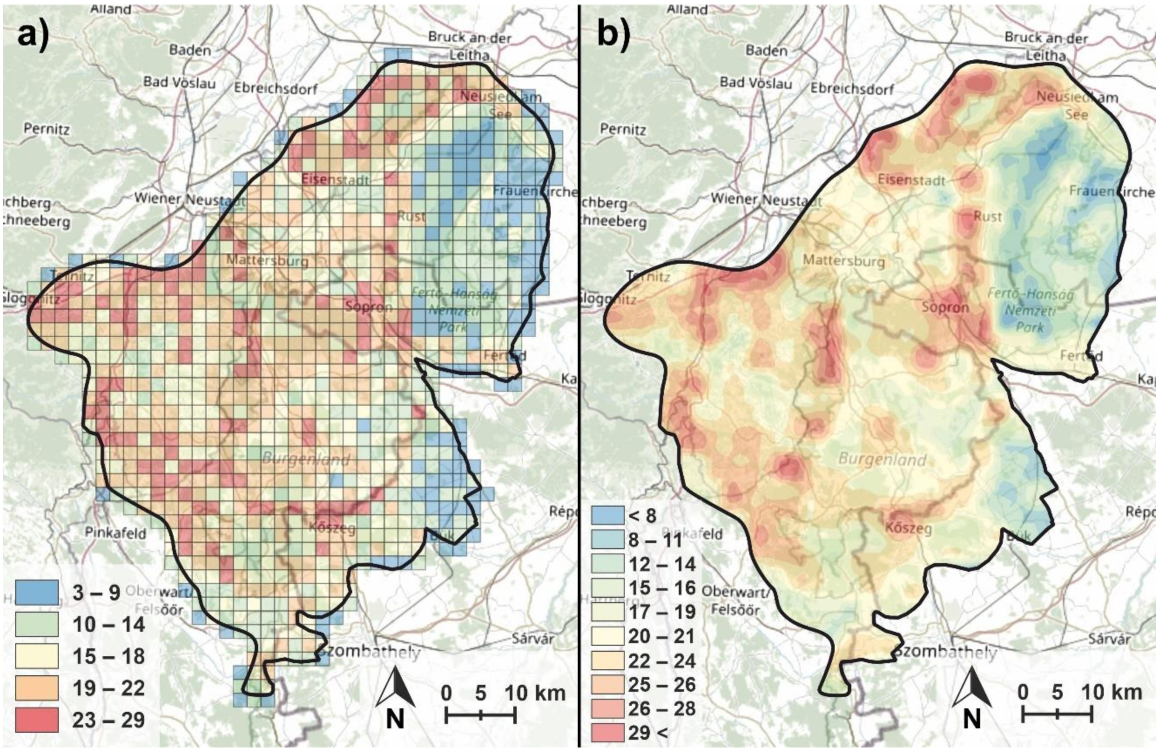

Figure 1. Geodiversity of the surroundings of Sopron (Ödenburg) visualised on a) a choropleth and b) an isoline map

The results of the geodiversity assessment should form the basis for all geoconservation and geotourism work. In particular, this includes the identification and management plans for geosites to be protected. The maps produced should communicate the geodiversity variables to a wider range of readers. The use of different scales and visualisation methods depends mainly on the purpose of the map: scientific accuracy or better interpretability. Although the choropleth map is more accurate, the many cells and sharp boundaries add content to the map, making it more challenging for both the mapmaker and the reader. The isoline map is a better solution in this respect, but the accuracy of the content displayed is reduced.

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