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Understanding Mediterranean Landscapes

Human vs Nature

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Identification of Sensitivity to Land Degradation and Desertification with Respect to Landscape Services

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Abstract

Land degradation and desertification processes threaten various parts of the Earth including Mediterranean Europe and Hungary (1.). They trigger very serious problems in the third world reducing the possibilities of agricultural use of the land and creating difficulties in food supply. Climate change increases land degradation and desertification risk (2.). Environmental sensitivity has been in the focus of environmental and landscape research during the past two decades (3.). The objective of this paper is to present methods to characterize various areas from the aspect of sensitivity to land degradation and desertification and to apply this method for two selected landscape units of Hungary. Soil erosion sensitivity was examined in the natural macro-region of the Transdanubian Hills and desertification sensitivity in the meso-region of the Danube-Tisza Interfluve. The sensitivity of the above mentioned landscape units to degradation is determined by applying sensitivity indices. The method is well applicable for the characterization of land degradation processes, to identify the areas with different sensitivity values and decreasing quality of landscape services in order to support decision making with respect to conservation measures and land use change.

Key Words: land degradation, soil erosion, desertification, environmental sensitivity

INTRODUCTION

Land degradation and desertification processes threaten various parts of Hungary. Soil erosion by water and wind, extreme soil reaction, compaction, structure destruction and surface sealing are the most significant land degradation processes in the country. Water erosion endangers 25 %, wind erosion 16 % of the country area. Agricultural activities on hillslopes and soil parent material (loose sediment, mainly loess) favour soil erosion. Wind erosion is promoted by sand and peat soils, on unvegetated surfaces in spring and summer.

Desertification as a special and very important group of land degradation processes in arid, semi-arid and dry sub-humid areas is already present in the central part of Hungary, i.e. on the Danube-Tisza Interfluve.

Different factors are the driving forces of the various degradation processes. Because of this diversity a country-wide analysis of the degradation processes will be prepared for each natural micro-region of the country. The objectives of this paper are to present a methodology to characterize two meso-regions of Hungary from the aspect of sensitivity to land degradation and desertification, to apply this method for these regions and to present the results on a series of environmental sensitivity maps.

STUDY SITES

The Transdanubian Hills are a natural macro-region situated in the SW of Hungary (Figure 1). With an area of 12 000 km2 this landscape unit is mainly a hilly country, one third of it is lowland and 5 % are mountains of medium height (up to almost 700 m). The overwhelming part of it is covered by loess and sand, generally with loose sediments prone to soil erosion. The soils developed on these loose sediments and the agricultural use leaves the surface uncovered after harvest so that huge areas are sensitive to soil erosion (4.). A considerable part of the forest was cut a few centuries ago to gain new territories for agricultural use. The percentage of forests in 2010 was only 25% and 60 % is used for agriculture (the percentage of arable land is 53 %).

The meso-region of Danube-Tisza Interfluve (Figure 1) includes the administrative area of 104 municipalities with a total area of almost 10 000 km2. It is an alluvial plain covered by sand, loess and loess-like sediments. The low-lying areas are filled with swamp clay, calcareous silt, peat and meadow limestone. The sand dunes areas emerge from the sand covered plain. (5.). The Danube-Tisza Interfluve has a very poor surface water network. The number of sunshine hours is high, mean annual precipitation is low (500-600 mm), droughts occur frequently (6.). The driving force of aridification processes is the fluctuating groundwater table.

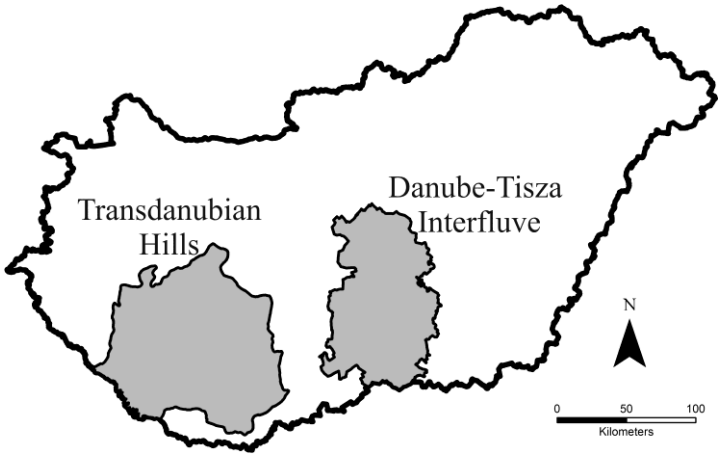

Figure 1. The study sites

METHODS

The sensitivity of the natural micro-regions to degradation is determined by applying sensitivity indices. Diverse indices will be created for each process. The factors will be weighted. Based on empirical data it will be determined how sensitivity changes with changes of the values of each factor. Sensitivity classes will be determined for each factor as described above. The concept of the index is based on the MEDALUS index (7.). The value of an environmental sensitivity index will be obtained by the geometric mean of the weighted factors. A map series will be prepared for each factor, i.e. soil properties maps etc. Finally the sensitivity index values will be shown on maps.

RESULTS

1. Sensitivity to Soil Erosion.

The maps used for the assessment will be evaluated first.

- Sensitivity of soil types. Two thirds of the area are moderately sensitive belonging to the category 3 on the 1-5 scale. The most sensitive soils are the luvisols, cambisols and rendzinas in the western part and the calcic chernosems in the NE. Roughly 30 %

belong to category 2 (calcic and luvic chernosems). The least sensitive are the histosols along the lake and the most sensitive are the arenosols also along the lake.

- Soil texture sensitivity. 80 % of the area is sandy loam and belongs to category 4. The most sensitive areas (sand) are in the western part. Soils of the mountains in the SE with clay loam texture and with a high skeleton content are less sensitive (category 2). The peat covered areas near the Lake belong to category 1.
- Sensitivity of soil parent material. The map is rather homogenous, 90 % belongs to category 5, covered by loess, glacial deposits and alluvial sediments. Less sensitive are the mountains and hills in the SE.
- Sensitivity of soil gradient classes. Gentle slopes are characteristic. Category 1 with 60 % and category 2 with 20 % point to low sensitivity of Transdanubian slopes. Again, the mountains and hills in the SE and S are more sensitive.
- Land use sensitivity. Arable fields, vineyards and orchards were classified as most sensitive (category 5). Together with degraded areas (category 4) they make out 60 % of the area. Most of the sensitive areas are in the northern and southern parts of Transdanubia, on gentle hillslopes. The percentage of category 1 (not sensitive) is also remarkable (33%).
- The soil erosion sensitivity map (**Figure 2**) was prepared with the application of the above sensitivity maps. Valley side slopes are the most sensitive to soil erosion (category 5). In the western part arable land where the soil parent material is sand are also very sensitive. 44 %, i.e. the overwhelming part of the area is also sensitive (category 4). Here loess is the soil parent material and in spite of gently slopes, the land use type (arable land and vineyards) gives the explanation for relatively high sensitivity. Medium sensitivity (category 3) is on meadow and pasture and forested areas have low sensitivity (category 2). Wetlands along Lake Balaton and some forested parts to be found in the mountains of the SE are the least sensitive, also because the soil parent material is mostly the regolith of a hard rock.

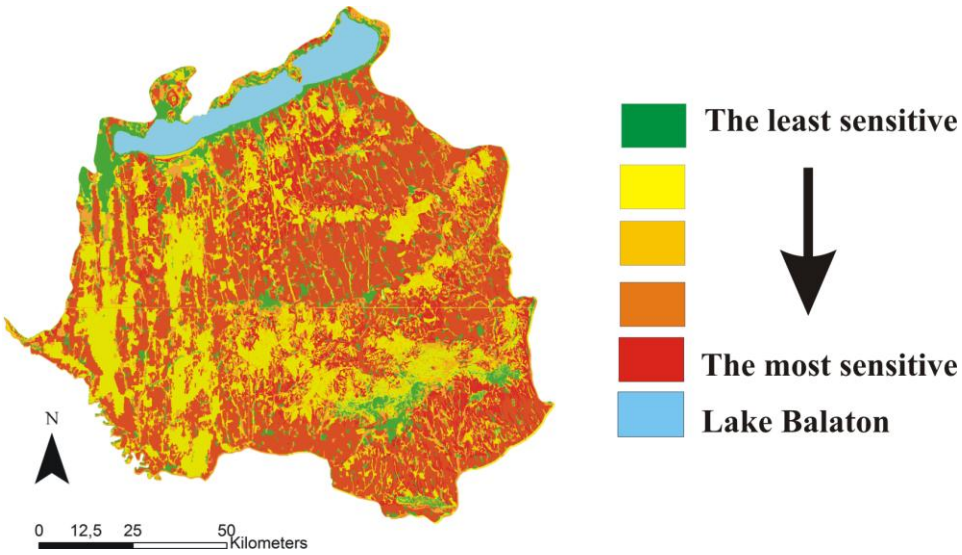

Figure 2. Soil erosion sensitivity map of the Transdanubian Hills

2. Sensitivity to desertification

- Soil sensitivity. The predominant part of the area is covered by sand which is highly sensitive. There is very little sandy loam and loam and hardly any clay. Soil texture and soil water management properties are generally promoting desertification. The organic matter content is lower in the western part of the area. Saline soils appear mainly in the low-lying spots of the SE. On the whole, soil properties favour desertification on the sand ridges to be found in the central part and they are more favourable in the loess covered areas, along the rivers and especially close to the Danube.
- Climate sensitivity. The northern part of the area is the most sensitive from the aspect of the climate, the highest drought index values are in the NW, gradually decreasing to the SW where the annual mean precipitation is also the smallest.
- Vegetation sensitivity. The percentage of the forest cover is the highest in the areas with unfavourable soil conditions, since forests were planted to stabilize the sand dunes. The forest uses too much groundwater contributing to groundwater subsidence. The highest forest fire risk is in the southern part, the lowest in the northern part and close to the River Tisza. From the aspect of the vegetation the south-western part of the area is the most sensitive, because of the high percentage of forest and high fire risk.
- Land use intensity. The water use per area is the highest in the major cities (Kecskemét, Kiskőrös) and in the municipalities with the smallest administrative area. It is also relatively high around Kecskemét and near Budapest (the northern part of the study area). If the large settlements are not taken into consideration, the spatial distribution of this factor is the opposite of the soil quality index because afforestation took place on the areas with the worst soil conditions, characterized with low water use (it is not worth cultivating and irrigating there), while the cultivation of better soils requires more water.

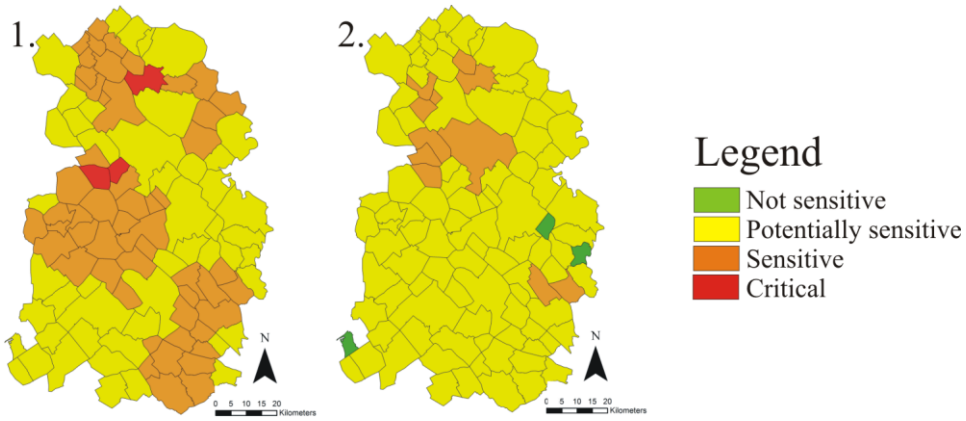

Figure 3. Environmentally sensitive areas in the Danube-Tisza Interfluve

- Desertification sensitivity. Environmental sensitivity indices were calculated as the geometric mean of the four indicators (the sensitivity maps are shown in **Figure 6/1**). The north-western and south-eastern parts of the study area are the most sensitive to aridity. In the NW this can be explained by the drier climate and by the high density of forests, in the SE by the poor soil quality and by the high risk of forest fires and the

climate is also drier than the average. The sensitivity map presented in **Figure 6/2** was prepared so that only the sensitivity of soil, climate and vegetation are taken into account and land use intensity is neglected. In this case sensitivity is not so high near Kecskemét (the largest city in the area).

3. Land degradation and ecosystem services

Land degradation reduces the quality of land in multiple ways. Improper land use leads to long-term losses of ecosystem function and productivity. Soil erosion and desertification processes decrease the rate and quality of ecosystem services. Table 1 shows the ecosystem services influenced negatively by soil erosion indicating the different land cover types which provide them.

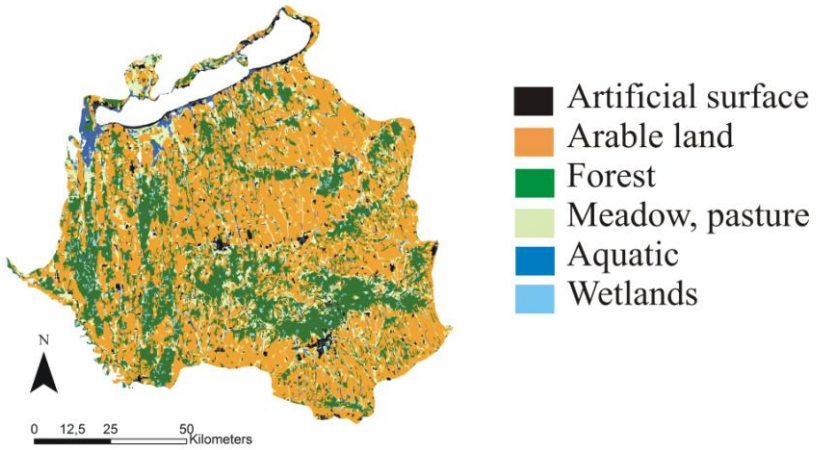

Figure 4. Land cover of the Transdanubian Hills

Table 1. Ecosystem services influenced by soil erosion, provided by various land cover types (Ar: Arable, F: Forest, M: Meadow, Aq: Aquatic, W: Wetland, S: Settlement)

Ecosystem service categories	Ecosystem services	Land cover types
Supporting	Soil formation	Ar, F, M
	Nutrient cycling	Ar, F, M, Aq, W
	Primary production (biomass)	Ar, F, M, Aq, W
Regulating	Water quality	F, M, Aq, W
	Erosion control	Ar, F, M, W
Provisioning	Production of food	Ar, F, M, Aq, W
	Fiber	Ar, F, M
	Fresh water	Aq, W
	Fuel (energy sources)	Ar, F
	Genetic resources	Ar, F, M, Aq, W
	Ornamental resources	F, M, Aq, W
Cultural	Recreation and ecotourism	Ar, F, M, Aq, W, S
	Aesthetic values	Ar, F, M, Aq, W, S

CONCLUSIONS

The main objective of the present paper was to test the applicability of two methods to be applied for the characterisation and mapping of landscape sensitivity. In both cases the applied methods proved to be suitable to characterize sensitivity to land degradation. The resulting maps were validated, they are in accordance with the present situation in the study areas.

Within the framework of a future project the whole area of Hungary will be investigated from the aspect of sensitivity to land degradation and desertification. On one hand a medium-scale (1:50 000) survey of landscape degradation processes acting in each micro-region of the country will be provided to identify the areas where these processes are already acting. On the other hand the sensitivity of the micro-regions to sensitivity will be investigated by applying the methods presented above. A sensitivity analysis of the micro-regions will be carried out in order to identify the various degrees of sensitivity in the country under the present climatic conditions and under the conditions of the expected climate change. The aim is to follow the development of land degradation processes and that of the degraded areas to answer the question what will happen to the degraded areas in the future.

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