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Critical environmental areas in Hungary (a GIS based approach)

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Summary

In Europe and also in Hungary the ecological condition of the environment is extreme rapidly changing. In this paper we try to create a GIS based method to identify the critical environmental areas and to compare these results with the ecological stability/ sensitivity of the given area.

In the project we connect the natural limiting factors and the socio-economic factors of agriculture, industry that cause the greatest environmental impacts. The following natural limiting factors were taken into consideration: karst areas, steep slopes, extreme climate (drought, frost), areas affected by landslides, inland waters, extreme chemical and physical properties of soils, danger of wind erosion. These factors restricted land use and can be exploited only at much higher risks and costs. There are some places where more than one factor limit utilisation. The human activity (intensive agricultural, industrial, transportation use) affects these surfaces having distinctive limiting factors. In this case the sensitivity of the environment increases and its stability decreases, the more environmental risks can be found in the given region.

The limiting natural factors and the parameters of human activity were digitized and stored in a GIS. We use ARC-INFO to overlay the maps and ERDAS/IDRISI for classification by remote sensed data. Overlaying the maps we can identify areas with different natural and economical limitations. We divide critical areas into three categories. Land utilisation in the first class claims prudent management.

Introduction

In Hungary - similar to other European sites - the geoecological condition of environment decreases by the increasing economical impacts. The society is unsusceptible to environment and the level of "environmental consciousness" is also low. The intention and aims can be more or less circumscribed and it is typical that the observance of the existing decrees is not general. Environmental impact statement is rarely part of the planning. In Hungary due to the former economical and social conditions environmental protection was based on the protection of nonusable resources instead of the health and ecological approach. From 0.7 to 1% of GDP was applied to environmental investments between 1980 and 1990 (Report 1992). At the same time according to the most humble estimation the environmental damage reached 3.5 - 4.5 % of GDP. These financial resources were insufficient for the stabilization of the conditions, apart from few exceptions (e.g. Balaton Project).

The short-term severe disasters urge as to do something, because more than 170 havarias were harmful to the lithosphere and 20 of them were particularly. But the long-term effects give us also much trouble, because they cause slow decay. At present both the politics and decision makers are disinterested in evaluating the environmental effects, but we are not able to say, on what kind of level do we have to intervene in the process. Analysis made after the decay (caused by continuous damage) as well as after the environmental damage, are very accurate but all of them contain the following general but correct phrase: " It could have been avoided."

The aim of our study was not to assess the condition of environment in the classical meaning (the assessment of the environmental factors or effects), the harmful materials, perhaps the complete system. We wanted to localize those surfaces in Hungary, where the land became sensible (in environmental sense) due to the intensive social and economic effects. Our aim was not direct human ecological but we analyzed the system of effects in practical point of view (e.g. tolerance of the environmental elements, stability, sustainable renewal etc.).

Definitions of the critical environmental areas

Many explanations of CEA are known (see Stoddard, R.H. 1977). We considered the land as a CEA, where the development of the natural environment is determined or its stability decreases due to the injured real geoecological conditions or the economical effects. It does not mean critical situation, but in our opinion on these sensible areas we have to make continuous and detailed measurements of the condition of the environment. If we adhere to the assuring of the compatible and sustainable development and the prevention of damage than we have to know that the intervtion can be successful only in small regions.

Analyzing environmental havarias occurred in small regions requires specialised methodology.

Method

We used GIS to circumscribe the CEA in the above mentioned concept in Hungary. Two major overlay systems got into the GIS. First group contains 11 limiting (abiogenic) natural factors (National Atlas of Hungary, 1989; Szabolcs, I. et al. 1978):

- landslide
- inland water

- karst area
- sensibility for pollution
- area endangered by wind erosion
- soil erosion
- alkali soils
- acid soils
- marshy, swampy area
- drought-affected land
- land endangered by early spring frosts.

In our opinion the limiting natural factors considerably control the utility, the sensibility, the condition of the biogenic factors, the stability, the possibilities of the development of the given surfaces. It does not mean that the above-mentioned geoecological factors could be the most important structural components, but determine the character of the unit.

In principle all the natural components have an influence on the condition and structure of environment. A factor becomes a limiting factor if it has the above influence. On the other hand it becomes significant and perhaps a limiting factor if it turns into determinant in the use of natural resources and conditions or in the living conditions. Depending on the economic and social conditions the judgement of a limiting factor can be different in the stage of the condition and the change of the environment. The above-mentioned limiting factors make land use hazardous and expensive.

The other large overlay group contains the environmental stresses. We characterized the intensity of human activity by 4 factors density of population over the average (over 100 persons per km^2) as the intensive urban factor, the use of chemical fertilizers (over the average +300 kg per ha) as the intensive agrarian factor the mining and economic activity (over 1 billion Ft) as the industrial technogenic factor as well as the recreation stress (over 10.000 days per km^2). We have added to these factors the areas of National Parks and nature conservation areas (Fig. 1).

The aim of this study is the areal comparison of the limiting natural factors and the factors having the most critical and greatest environmental effects.
We digitized the limiting natural factors and above listed parameters of the human activity under AutoCad, and the data were transformed into Idrisi and later into Erdas. We used GIS modules of these softwares to the analysis. We have chosen Erdas and Idrisi softwares because we tried to correct the localization of the critical and sensible lands by remote sensing data (LANDSAT TM), and the calculation of stability of the landscape units based on remote sensing data.

Results

The logical base of the investigation was to determine those areas where the limiting factors and the social effects are cumulated. We overlaid the limiting natural factors, then compared them with the ecostability of the land. In our opinion if one or more

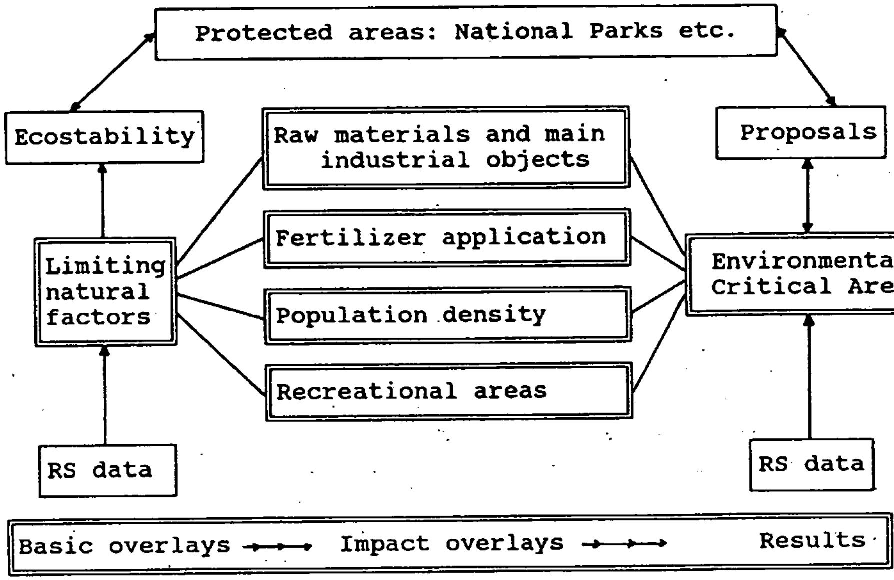

Figure 1 The scheme of the investigation

social/economic activities have influence on the land characterized by more limiting factors (land of small stability) then on these lands the sensibility of the environment increases and at same time the tolerance of the environmental elements and the stability of the natural environment decreases. We had to calculate with great environmental hazard and then with higher costs. On Fig. 2 we present the overlaid map of the limiting natural factors. In many instances the limiting factors can cover each other. We divided whole are into 3 categories according to the following system:

class No.1 ---- 1 - 2 limiting factors
class No.2 ---- 3 - 4 limiting factors
class No.3 ---- 5 - 8 limiting factors.

One of the most critical problem is to weight the limiting factors. Naturally these factors have different weights and they are very variable in time. For instance if we analyze the problem from human ecological point of view then they can have different values. It can be a very interesting task to examine the effects of the limiting factors on land use. Because of the forced and subjective simplification we disregard weighting (we know that the subjectivity of the examination is apparently decreased by this reduction). We mechanically supposed that if there are more limiting factors then the sensibility of areas increases. The most significant limiting effects occur in Great Hungarian Plain and in the Transdanubian Mountains.

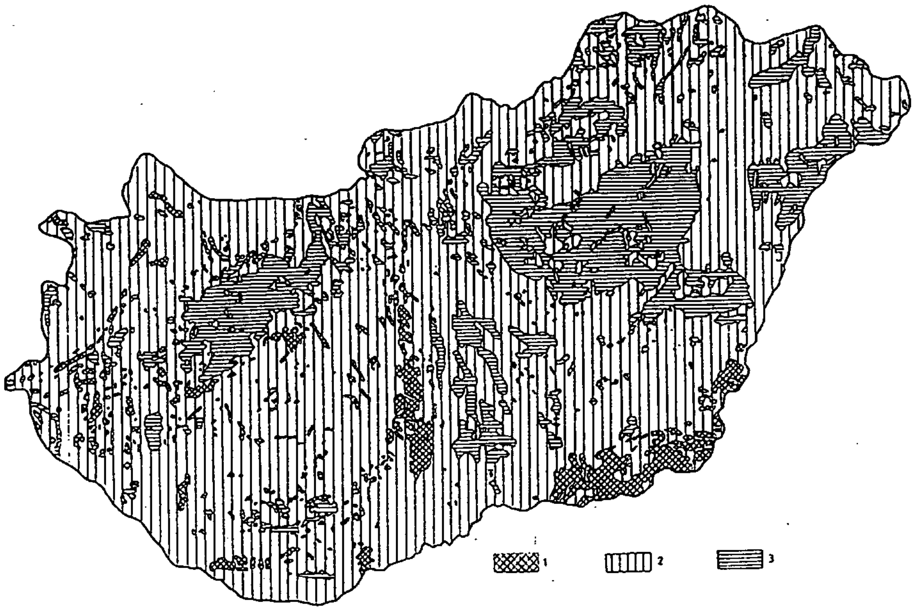

Figure 2 Superimposed map of the limiting natural factors.
1 - 1-2 limiting factors; 2 - 3-4 limiting factors; 3 - 5-8 limiting factors

On the basis of the LANDSAT TM images of Hungary we made the map of land use and by the method of Environmental Atlas of Czechoslovakia we calculated ecostability. According to this simple process we divided the area of "green surfaces" (forest, meadow, grassland, swamp, garden, wineyard) by the summarized area of available land and urban areas. This ratio can be used to express the value of ecostability. On the map presented on Fig. 3 we show these values on level of landscape units (microregions) in Hungary. Low values of ecostability are the results of many unfavourable natural effects in the central part of Great Hungarian Plain and in Transdanubian Mountains. These low values of ecostability combined with many limiting factors can from areas appear under very sensitive conditions.

Using a GIS we could compare the industrial, agrarian, urban and recreation effects with the natural limits as well as with ecostability.

Major energy resources and raw materials, mines as well as industrial factories - as potential industrial stresses - can be compared with the summarized limiting factors and it can be laid down as a fact that the southern part of the Transdanubian Midmountains and the central part of the Great Hungarian Plain are in the most critical condition. In these sites there are many limiting factors and sum of them is in class No.1 (or in 1-2). This fact shows the problem what is in connection with the environmental havarias endangering the lithosphere. We can list environmental havarias appeared in the following places: Héviz,

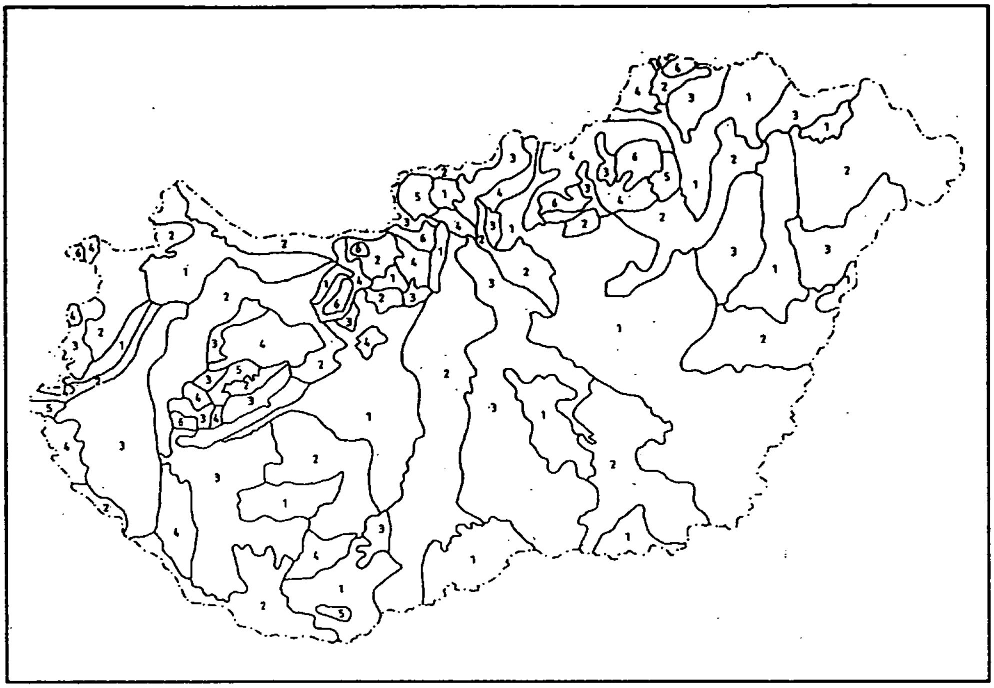

Figure 3 Ecostability of landscape units in Hungary.
1 - 0-0.25, 2 - 0.25-0.5, 3 - 0.5-1.0, 4 - 1.0-3.0, 5 - 3.0-5.0, 6 - under 5.0

Ajka, Veszprém, Biatorbágy, Etyek and Monori erdő, Albertfalva (Bohn, P. 1992). There are fewer and smaller surfaces with not so significant problem in the Northern Hungarian Mountains (pediment of Mátra Mountains, Borsod), in Mecsek Mountains, in the southern part of the Transdanubian Mountains as well as in West Hungary. If we make the comparison with the map of ecostability the same facts can be established, in spite of that the Hungarian Mountains show a higher value of ecostability.

The agrogenic stresses (over 300 kg fertilizers per ha) concentrate from the line of Duna river to west (Mezőföld and western part of region), in Kisalföld and in south-western part of Hungary.

Naturally these surfaces "avoid" the land with more limiting factors, because those are not typical agricultural areas. The use of fertilizers and pesticides is more benefitial lands under conflict on central part of Great Hungarian Plain (Hajdúhát, Körös region, Szolnok loess region). It is very unfavourable that the biggest use of chemical fertilizers concentrates on the lands of smallest ecostability. Intensive decrease of the use of fertilizers due to the change in agricultural devolution of ownership is not disadvantageous from the point of view of environmental protection.

On Fig. 4 we compared strong urban stresses with overlaid limiting natural factors. Potential and real conflicts (as was mentioned in the description of effects of technogen

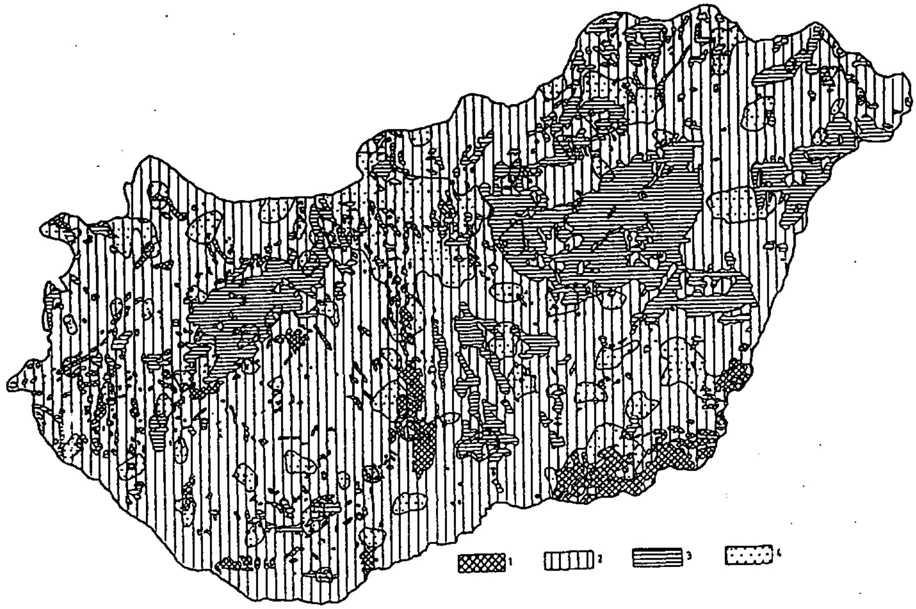

Figure 4 The limiting natural factors overlaid by urban impacts.
1 - 1-2 limiting factors; 2 - 3-4 limiting factors; 3 - 5-8 limiting factors;
4 - regions with population density over 100 person/km^2

stresses) appear on the southern border of Transdanubian Mountains (Várpalota, Veszprém, Ajka, Tatabánya), in borderlands of the agglomeration of capital (Budapest), in North Hungarian Mountains (e.g. Miskolc, Hatvan) as well as in the Great Hungarian Plain (Szolnok, Kiskunhalas).

On Fig. 5 we compared the limiting natural factors with the travel stress (over 10.000 persons per day). Similar to the above-mentioned facts, we are not able to find significant differences between the economic effects, although the following order of intensity of factors obtains: industrial - agrarian - urban (infrastructural) - recreational. The maps of economic effects were overlaid, then were compared to the same map of limiting factors. We could identify such areas where there are different numbers of limiting natural factors and economic-social effects. Depending on the overlay of the two investigated groups of factors we can divide the combinations of factors into categories.

We have chosen those categories, in which most of the limiting natural factors and the intensive economic effects appear together. It indicates about two dozens of areas that are presented on Fig. 6. If we did not investigate the simple "point" effects, then in our opinion these areas are the critical environmental areas (CEA) in Hungary. If we compare the

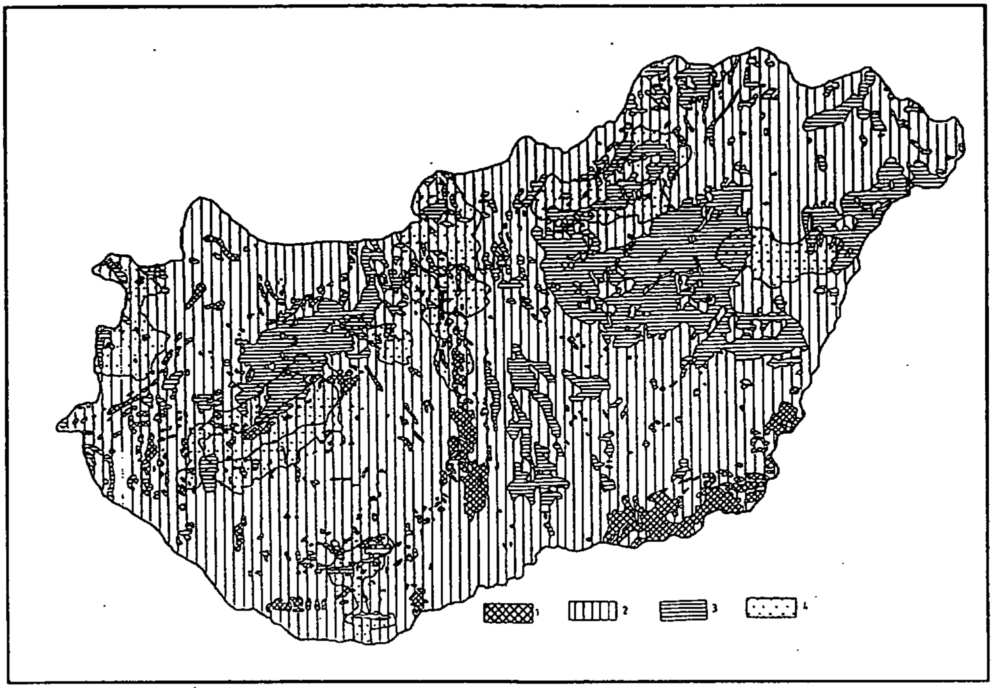

Figure 5 The limiting natural factors and the recreational impact.
1 - 1-2 limiting factors; 2 - 3-4 limiting factors; 3 - 5-8 limiting factors;
4 - recreational impact 10.000 days/km^2 (Balaton - 56.000, Budapest - 115.000 days/km^2)

results to the map of the nature conservation areas it can be assested that one of the CEA is in the Bükk Mountains National Park and another one in the Hortobágy National Park, while three CEA are in nature conservation areas in Transdanubian Mountains. It may prove that one of the conservation methods of critical environmental areas can be to place them under protection. When we compared the protected areas with the map of ecostability then the comparison shows that the protected areas perform conservation function and they are able to increase the ecostability. They cannot, however,re-establish the original natural condition (e.g. re-establishment with expansive direction, as a focus). This method can be used in European scale, as Chadwick et al. (1991) presented in connection with the stability against acid fall-out.

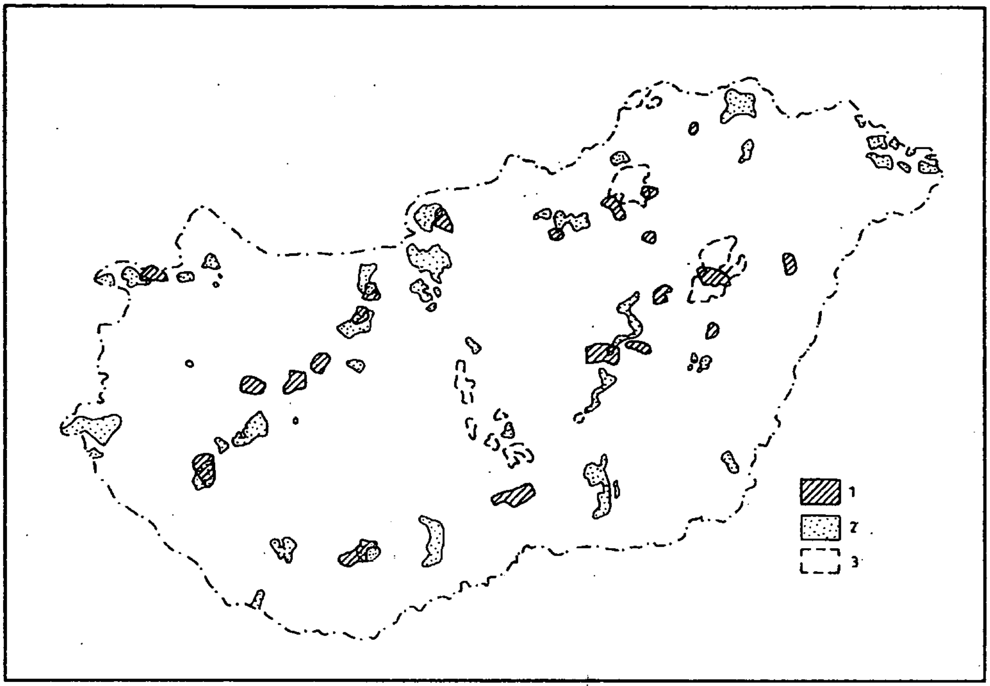

Figure 6 Critical environmental areas in Hungary
1 - critical environmental areas; 2 - landscape protection areas; 3 - natural parks.

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