METHODS OF LANDSCAPE RESEARCH
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„RED BOOK" OF THE HUNGARIAN LANDSCAPES ATLAS OF THE THREATHS ON THE NATURAL FUNCTIONING OF THE 229 HUNGARIAN MICROREGIONS

key words: indexes for landscape functioning, landscape fragmentation, natural hazards, land use change, Hungary

INTRODUCTION

The extent of built up areas, infrastructural networks and intensely disturbed surfaces is spreading rapidly parallel with the growing population – and rising living standards – in our planet. However, there are efforts all over the world the same time to establish areas, where anthropogenic stresses on landscapes are limited. Areas of nature conservation and recreation, minimum tillage and sustainable forestry directly or indirectly help the achievement of that aim.

To harmonize natural endowments and social demands is hard **planning task**, where landscape geography has a significant opportunity to contribute. This kind of contribution is possible only if landscape geography is able to produce datasets and analyses that are useful tools for planners indeed. (Csorba et al., 2005; Jongman, 1995; The European environment 2005). Landscape geography must leave behind those theoretical debates of the last decades, which lead to important, but only indirectly useful results for instance in the case of landscape stability and landscape sensitivity. Authors believe that results which are to be presented in this paper are of greater practical importance in landscape planning.

THEME AND FRAME OF THE „RED BOOK”

The aim of the present study is to elaborate background materials, which can easily be used in practical landscape planning, rehabilitation management and protection. The specific theoretical frame of landscape geography– **the landscape – will not be given up**, however. It is a typical problem, undoubtedly, that landscape planners have to deal with fragments of the landscape only instead of the whole landscape, landscape geography must be devoted to that every well-established landscape planning work must consider landscapes as territorial entities.

Hierarchic order of Hungarian natural landscapes was elaborated 20 years ago (Marosi, Somogyi, 1990). Everybody has accepted the system that contains micro-regions, microregion groups mesoregions and macroregions. Although, there have always been critics about the determination of the borders of individual regions; only small readjustments of those borders have been suggested on the base of recent studies.

The main aim of the present research is to reveal the most characteristic indicators of landscape functioning first, then to determine their values for all the **229 microregions** of Hungary. On the base of the examinations categories of the degree of endangerment for each microregion for each indicator has been determined. Smallest microregions in Hungary have an area of 50-100 square kilometers, while largest ones are well over one thousand square kilometers in spatial extent. Small microregions can be found usually in mountainous and hilly regions, while large ones are characteristic for the Great Hungarian Plain mainly. A part of the 229 microregions is grouped into microregion groups, which are classified into 35 meso-regions. The six macroregions mean the highest taxonomic level of the landscape hierarchy in Hungary.

Beside regional frame other basic concern lies in **what indicators** should be taken into consideration in describing landscape functioning, the degree and type of the alteration of former natural endowments; in other words, what kind of data can be offered to ease landscape planning practice?

The question can be answered if factors that most strongly affect landscape functioning are exposed. Authors think that possible indicators can be determined according to the following criteria:

- The establishment of the original and present landscape type, that is, whether relief or hydrology, vegetation, soil, or climate the landscape was and has been the determinant factors in its functioning. On the other hand, what social activities rule the landscape today? The National Atlas of Hungary contains a landscape type map, what gives very brief explanations for this aspect, e.g.: "Landscape types dominantly used by silviculture".

- Present degree and spatial pattern of alteration of the landscape.
- Impacts of present land use on individual landscape forming factors (relief, soil, hydrology, climate, vegetation and fauna).
- Healthiness of the landscape; its ability to revive; stability of landscape functioning.
- Relationships between microregions; degree of dependence and independence from the aspect of landscape functioning, that is, from the aspect of material and energy fluxes.
- Aesthetic appearance, harmony of landscapes.

In the next two figures (fig. 1, 2) one can be see the possible set of indices.

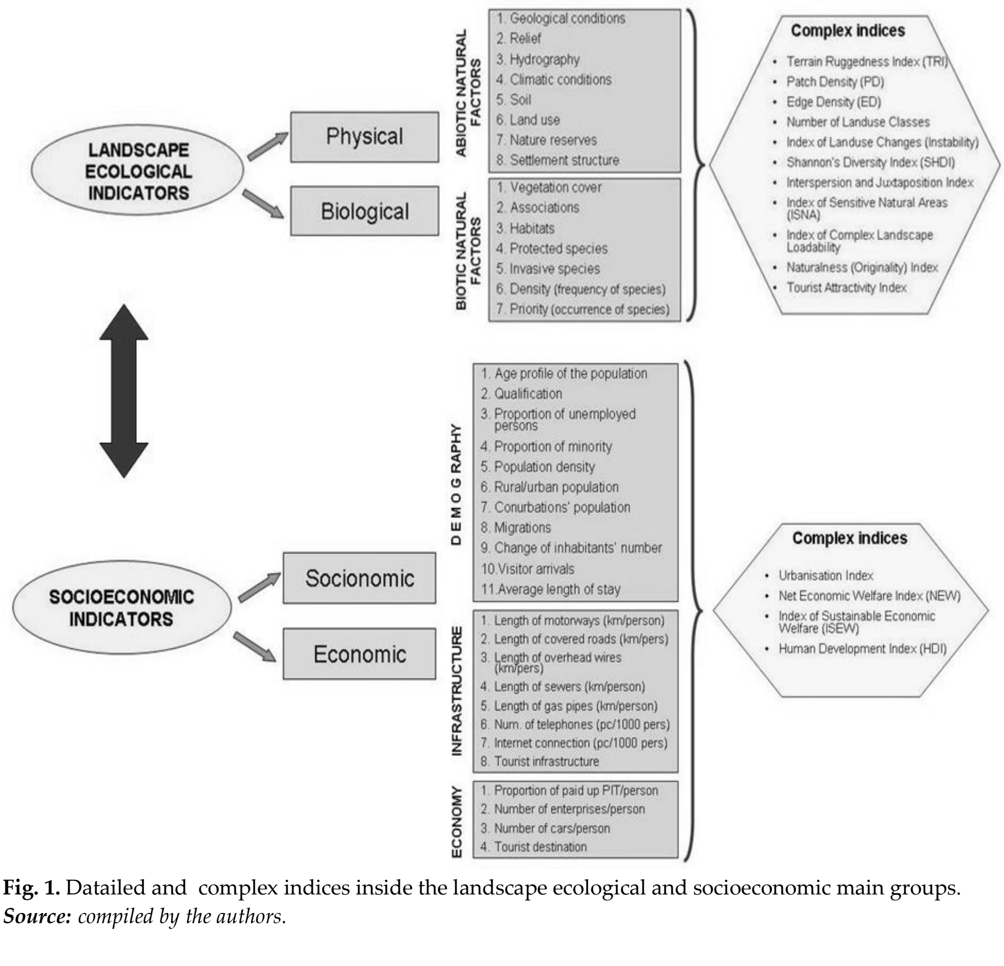

Fig. 1. Datailed and complex indices inside the landscape ecological and socioeconomic main groups.
Source: *compiled by the authors.*

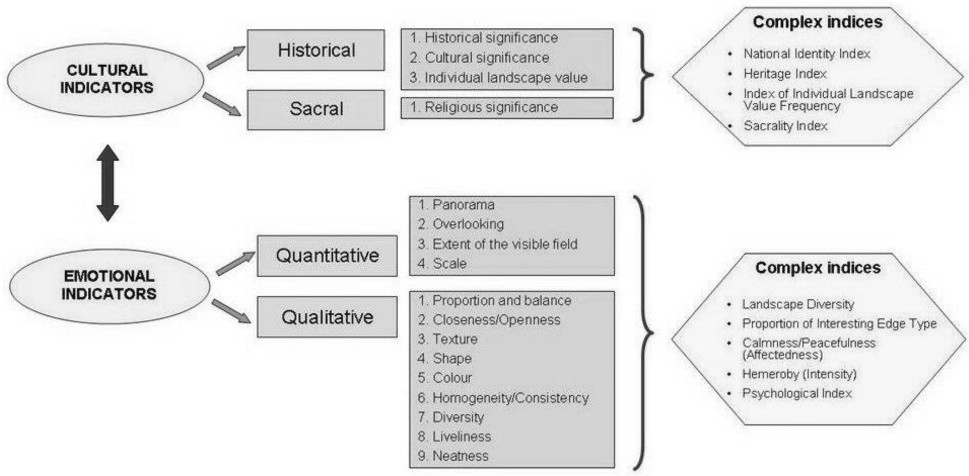

Fig. 2. Datailed and complex indices inside the cultural and emotional main groups. ***Source:*** *compiled by the authors.*

According to the before mentioned criteria, following topics are to be dealt with for each microregions:

- **Relief and geology**, (anthropo) geomorphologic endowments.
  Dams, agricultural terraces, opencast mines, ratio and spatial pattern of built up areas and cultivated lands in microregions. Their role in landscape appearance.
- The role **of air quality and bioclimate.**
  General air quality and air quality in the living environment, air pollution, buffer capacity, frequency of the accedings of the health threshold limits.
- **State of water bodies**
  Types of surface waters, artificial waterbeds, water management, the degree of the decrease of the ground water level; their ratio and weight within the microregion. Sensitivity of waters to the current land use practice. Water pollution and buffer capacity. The role of water bodies in the sturcture and visual appearance of the given microregion.
- Degree of the alteration of **vegetation and fauna** (merely the vegetation).
  Ratio of close to natural relics, protected and Natura 2000 areas within the microregions. Functioning of ecological networks. The ratio of invasive species,

healthiness of the vegetation. The role of vegetation in the visual appearance of the landscape.

- **Landscape fragmentation effect of the** build up and linear infrastructure**.** Spatial pattern of landscape fragmentation, the relationships between ecological networks and fragmentation. Visual appearance of landscape fragmentation.

- Intensity of **land use** on the base CORINE 2000 database.
  The spatial extent and pattern of decreasing intensity of landuse from landscape fragments with built up garden-orchards to extensive pastures, forest reserves, reeds. The degree of the use of chemicals and artificial fertilizers and soil pollution. Determination of the tendencies of land use (stability of land use).

- **Natural hazards.**
  Hazards of floods, inland waters, droughts, erosion, deflation, extreme precipitation, earthquakes and surface movements.

- **Landscape aesthetic** conditions.
  Fitting of linear technical elements, industrial and mining objects into the landscape. How landscape characteristics of the built environment are manifested.

- **Touristic loading capacity of landscapes.**
  Relationships between industrial, building, transportation infrastructure and areas of recreation. Spatial pattern objects of tourism; spatial and temporal limits of visiting.

During the elaboration of the system presented before naturally, it was impossible to pay the same attention to each segment. It seems, that in the case of certain indicators – air quality, for instance – it is reasonable to use not microregional but mesoregional frame.

In the final phase of the research **a series of maps, an atlas** will be compiled as well. In that atlas the significance of each selected indicators from the aspect of landscape functions is to be discussed first, then the method of compilation of the database will be presented. Maps will come out in a 1 to 1 500 000 scale with a 1-2 pages long commentary and additional figures, and photos, in order to help landscape planner, architect decision makers with differentiated information. The present situation will be presented in the planned atlas, what means a kind of static approach; however, attempts will be made to show the future trends of development either. The course and rate of landscape development together with the tendencies affect on the functioning and visual appearance of the landscapes are to be revealed.

Recommendations of the European Landscape Convention will be taken into consideration (*Committee…, 2003*) along with the most recent results of landscape evaluation (Head, 2000, Pedroli et al., 2007, Wascher, 2005).

These are the first steps of the research, but in the case of some indicators, there have already been tangible results. Maps on the landscape ecological fragmentation effects of build up, and linear infrastructure, natural threats and land use stability have been completed yet. In the next chapters, some details of these results will be presented.

MICROREGION FRAGMENTATION EFFECTS OF BUILT UP AND TRANSPORTATION INFRASTRUCTURE

According to the unanimous opinion of ecologists most serious threat for the ecosystem of the Earth is fragmentation of habitats nowadays (Colligne, 1996; Farina, 1998; Forman, 1995; Hargis et al., 1998; Ingegnoli, 2003; Jongman, Brunce, 2000; Klopatek, Gardner, 1999 etc.). According to M.J. Reijnen et al. (1995) the most important reasons for strong fragmentation of habitats are building up and development of linear infrastructure.

In the opinion of the authors of the present paper, an index of spatial fragmentation, which is more sufficient for the ecological landscape planning practice, would be a very useful tool at national, regional and settlement level, too.

For this reason using the 1:250 000 scale maps of the Cartographia Road Atlas of Hungary:

- the total settlement, road and railway line density of the country was measured,
- data gained that way was weighted on the base of landscape ecological aspects,
- finally, it was presented according to the official microregion system of the country.

The sections of **roads** outside the settlements were taken into account only, because a road that crosses a settlement does not strengthen the barrier function of a settlement to the migration of plants and animals significantly. On the other hand the scale did not make possible to take into account the complex barrier role, for instance, of a suburban area with a motorway, which is, however, not a frequent combination. Unsurfaced roads were taken into consideration only if they cross patches of forests or protected areas. Strong ecological barrier role of the openings in the forests is proved by several studies (Forman, 1995; Harris, 1984; Jaeger, 2002, Ružičková, 2003).

Settlements can be considered as permanent ecological barriers. An index to express the real ecological effect of the settlements the size of the settlement have to be reflected. A clear solution could be to multiply the maximal diameter of the settlements with their circumferences. It is an interpretable result from ecological aspects, since it gives the length of the ecological border (ecotone), which forms a barrier for the migration of the plant and animal species. Unfortunately there is no data available on the length of circumferences of the inner parts of the settlements in Hungary. There is data on the extent of the peripheries and inner parts of the settlements, on the other hand. For this reason the multiplication of the size of the inner parts of the settlements, larger than 1 km^2, was used as another index together with the diameter.

There are three maps based on the results of the measurements, which are presented here (fig. 2, 3).

The first map presents the degree of **fragmentation of microregions** of Hungary **by the settlement system** (fig. 3). Values are grouped into four categories on the base of before mentioned ecological, landscape-ecological considerations.

In the first category there are 89 microregions from the whole 229. Their total area is 39 300 km^2, which is 42% of the area of Hungary. There are two microregions in the mountains, where there are not any independent settlements at all, so the degree of fragmentation is practically zero. Microregions in the mountains and in the Great Hungarian Plain can be found in this category usually, while microregions in the foothills or hilly regions rarely fell into this category.

Only a bit more, 94 microregions fell into the second category, which is 42 640 km^2 on the total. Foothill microregions in Transdanubia region, north-eastern part of the Great Hungarian Plain and in North Hungarian Mts. can be found typically in this category (fig. 3).

Fragmentation indexes of the settlements were higher than 2.1 in the case of 47 microregions. Strongest habitat fragmentation values were found in microregions on the southern bank of lake Balaton, and in the valley of river Danube north from Budapest. Almost every major valley, which separates the parts of the North Hungarian Mts. fell into that category.

Spatial pattern of the landscape fragmentation index based on the fragmentation impact of **road and railway system** is presented in the second map (fig. 4). From the four intervals of the map compared to the first map, on the base of the number of microregions in the different categories, the first, lowest category is predominant, because from 229 microregions on the whole 120, that is more than half of them fell into that category.

On 64% (59 980 km^2) of total area of our country landscape fragmentation effect of traffic infrastructure seems to be weak. In opposition to the dataset of the settlements, here is not any microregions, where could not be found any analyzable fragmentation effect, that is, even if there are not settlements in every microregions, roads or railway lines still cross landscapes without settlements also.

Roads of forestry cause relatively strong landscape fragmentation in national parks in mountainous regions. It is remarkable, that some core areas in mountainous regions got the lowest index, while others show much higher fragmentation values. Higher results have come out where there are many roads in the forests, which cross protected areas, consequently get high index numbers.

Medium level of fragmentation can be found in 82 microregions (1.1–2.0). In the spatial pattern of the microregions in that category the radial traffic infrastructure of Hungary is slightly traceable. Stronger fragmentation of microregions along the 4 motorways set out from Budapest, and the radial railway lines is clearly visible. Fragmentation indexes of the microregions in North-Transdanubia are remarkably high (fig. 4).

In the case of microregions at the lake Balaton, and valleys between mountains, the contrasts to neighbouring microregions are much stronger than in the case of the fragmentation impact of the settlements.

There are high values for valleys between parts of the Northern Hungarian Mountains, while microregions in their environment got only fragmentation indexes under 1. Obviously, alluviums in the valleys endangered by floods are not occupied by settlements, but for roads, which cross deep, wet lands on the top of embankments those areas mean no obstacle at all. These differences are clearly visible comparing the two maps (fig. 3, 4).

The agglomeration belt around the Hungarian capital is not very striking in the maps of habitat fragmentation caused by traffic infrastructure. The spatial pattern of microregions in the first two categories, which show the strongest fragmentation (>2.1), is more uniform than in the case of landscape fragmentation caused by settlements.

Third map was completed using **weighted and summarized data for the fragmentation** effect of settlements and traffic infrastructure (fig. 5).

Fragmentation indexes, which express the degree of complex ecological dissection, show a **mosaic-like pattern**, and there are strong differences in the indexes of the neighbouring microregions. In some cases there are significant differences in the indexes of the microregions within one microregion group or a mesoregion even in the Great Hungarian Plain. Nevertheless, strong scattering of the indexes between microregions within a group can usually be found in the mountainous regions and a bit less frequently in the hilly regions.

Complex fragmentation index of the microregions in Hungary is between 1.1 and 2.0 in one third of all cases, and almost the same number falls into the next category between 2.1 and 3.0. 19 from the 23 microregions, where fragmentation is the weakest, can be found in the North Hungarian Mountains. Fragmentation indexes of the microregions in the two plains (Great and Little Plain) are usually under the averages of Hungary, but areas, where there are motorways and tiny villages, like in the north-east, indexes are close to the average.

Many passage valleys between parts of middle height mountain ranges or hills act as strong barriers for the migration of living creatures. Other types of landscapes overloaded with anthropogenic obstacles, are recreational landscapes on the banks of rivers and lakes (e.g. lakes Balaton or Velence). Recreation belt along river Tisza, on landscape level, has not such effect yet. Finally there are some densely built up small basins, where the degree of fragmentation of the landscape by settlements, roads and railway lines has reached a critical value.

As a summarization it can be stated that compared to the national averages, which are the followings:

- ecological barrier role of settlements (corrected km/km^2 values): 1.86
- ecological barrier role of roads and railway lines (corrected km/km^2 values): 1.39
- degree of landscape ecological fragmentation (corrected km/km^2 values): 3.25

Great Hungarian Plain shows weak, while the Transdanubian Hills) show strong landscape ecological fragmentation. Values over the average occur in the southern Transdanubian macroregion, while all other macroregions are around or under the average, what reflects well the different spatial pattern of the settlement network of the macroregions.

INDICATORS OF THE NATURAL HAZARDS

From the series of maps on natural threats on microregional level, the map of the hazards of drought is presented first. (Szabó et al., 2007) (fig. 6). Hungary is situated on the border of semi humid/semiarid climate regions. (Pálfai, 2001). The value of the aridity indexes reaches 1 in the Eastern part of Transdanubia, in other words the western and Northern 60% of the area of the country belongs to the semi humid region, while the Southeastern 40% is semi arid. There is a serious hazard of drought in all microregions in the arid region, and the whole area of the microregions is threatened by it. The hazard of drought is moderated within the Great Hungarian Plain in its Northeastern hilly parts only, since the annual amount of precipitation reaches 700mm there due to the vicinity of the Carpathian-mountains. Notably, the basins, valleys or even some mountains of the North Hungarian Mts. are threatened by drought either. The map is the most mosaic-like in the central parts of Transdanubia, and only the microregions in the Southwestern, Western parts of the country are devoid of the hazard of drought. The map gives a definite answer to the question, in which microregions is profitable to establish irrigation systems; and how high is the uncertainty of the rate of their utilization. Global warming, however, may modulate the map resented here remarkably in the next decades. Microregions that have been classified into transition categories with moderate or medium level of drought hazard may fall into categories of serious hazard of drought in the future.

A synthesizing map has been completed by summing the seven datasets of the indicator group of natural hazards and the weighting of the subsets (fig. 7).

Subjectivity of the weighting cause only minor errors, probably, due to the great number of samples. Similarly to the previous map microregions in the Great Hungarian Plain are the most endangered ones again, although this map shows a bit more differentiated picture, since microregions along rivers are the most endangered ones, while others away from rivers are less endangered. On the other hand, microregions in South-Transdanubia are not devoid of natural hazards either, due to earth quakes, surface movements and rainstorms. About half of the 50 microregions, where the level of natural hazards is low, are placed in the central and Western part of Transdanubia, while the other half of them can be found in the North Hungarian Mts.

PROSPECTIVE SHIFTS IN LAND USE STRUCTURE

Landscape planning is strongly affected by tendencies of macro economy on the present land use structure. EU agricultural policies have just started to affect strongly on Hungarian land use structure, therefore attempts have been made in order to forecast their impacts.Present Hungarian land use structure has been compared to priorities of the EU. Prospective shifts in land use structure have been determined for the 35 regions of Hungary (fig. 8). For the classification the following tendencies have been presumed (Ángyán, 1999; Csorba, Novák, 2003).

- The extent of intensely used plough lands will decrease; areas that are less fertile or have a disadvantageous position will be utilized as pastures or will be afforested.
- Meadows and pastures will grow in area on the whole, but in a way that mountainous and hilly regions drifting into economic depression will be afforested. Therefore the extent of grasslands will decrease there, while in

former plough lands suitable for intensive meadow utilization, the importance of grazing will grow.

- The strong incitement from EU will help growing the spatial extent of afforested areas; especially, in the former plough lands and grazing fields of mountainous and hilly regions.
- The extent of nature conservation areas will grow, mainly in the buffer zones of areas that have already been protected, in the environment of some new national parks and Natura 2000 areas. This process is to take place within a short period between 2006 and 2010, this way the ratio of protected areas will reach 20%, what is not expected to change significantly later.
- The extent of recreational areas will grow remarkably, mainly along waters and urban agglomerations.

Analyzing the before mentioned tendencies for each region, the following map has been compiled (fig. 7). It can clearly be seen that strong shifts in land use structure are expected in the Northeast part of the country. These are small backward villages with senescent population and struggling with economic depression; abandoned mining regions, or sites of former heavy industry. Significant shifts in land use structure are expected in the region along the River Danube South of Budapest as well, where the growth of recreational areas on the banks of the river and abandonment of low quality plough lands will trigger the changes. Least remarkable alterations can be expected in the agricultural regions with chernozem soils in the Great Hungarian Plain.

CONCLUSIONS

The aim of the planned series of maps and their commentaries is to support practical tasks of landscape planning. Those environmental changes and anthropogenic impacts are to be analyzed which disturb and alter the functioning of the 229 microregions of Hungary**.** Disturbing effects of landscape functioning are classified into indicator clusters. These indicators are to be used for the description of the state of the relief, air, water bodies, vegetation and fauna and to determine their alterations compared to the original conditions.

Attention is to be paid to the landscape fragmentation effects of build up and linear infrastructure, the changes of the land use structure; and factors, which affect on the aesthetic appearance of the landscape. Finally, results on the degree of natural risks from the aspect of soil erosion, floods, deflation, earthquakes etc., for the microregions of Hungary are presented.

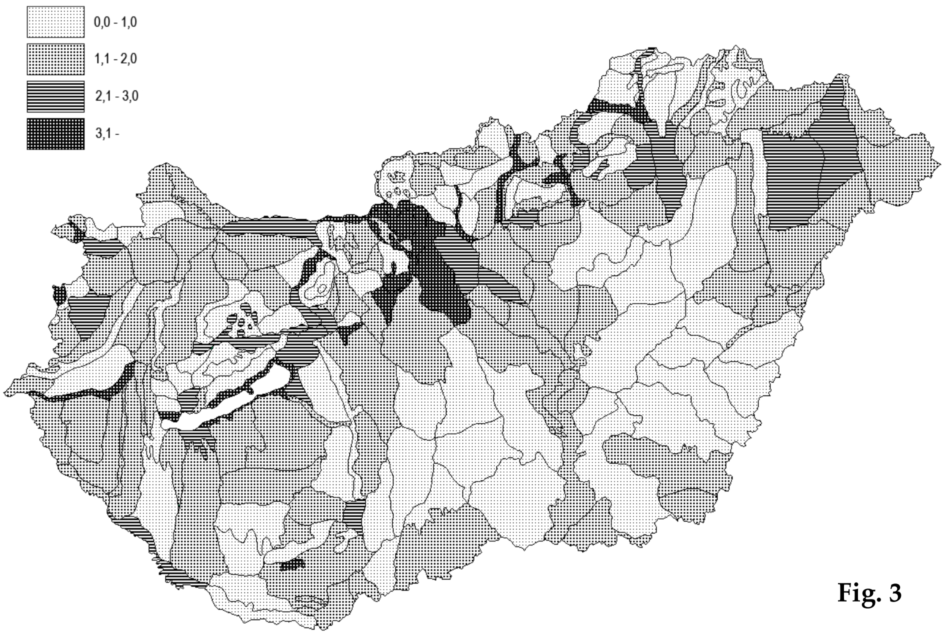

Fig. 3

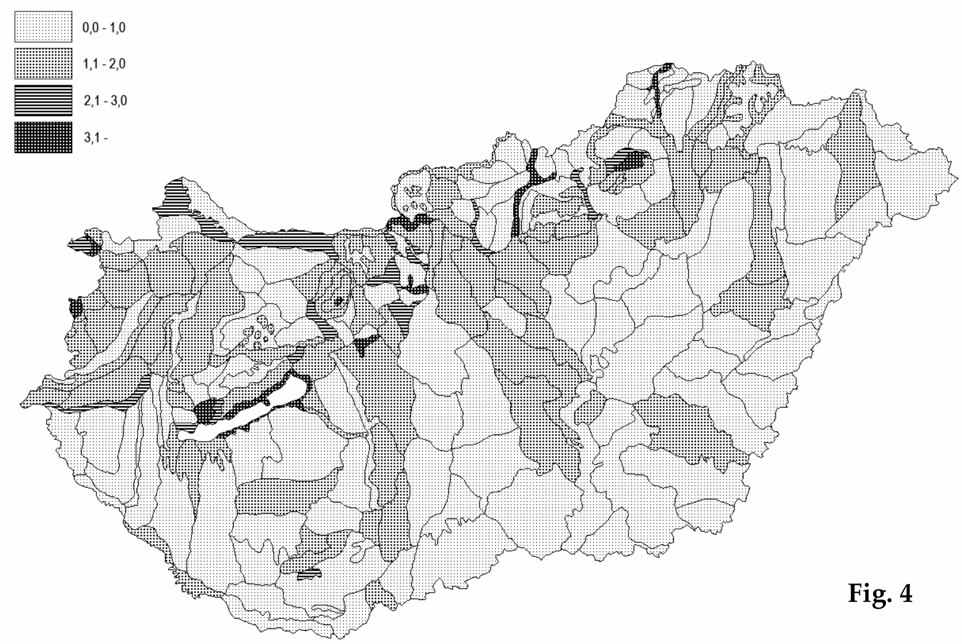

Fig. 4

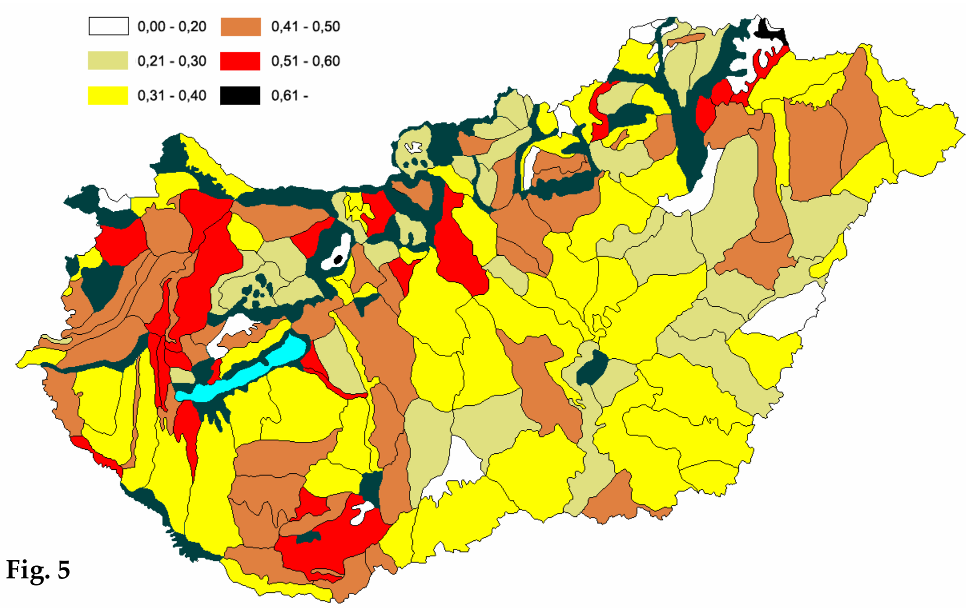

Fig. 5

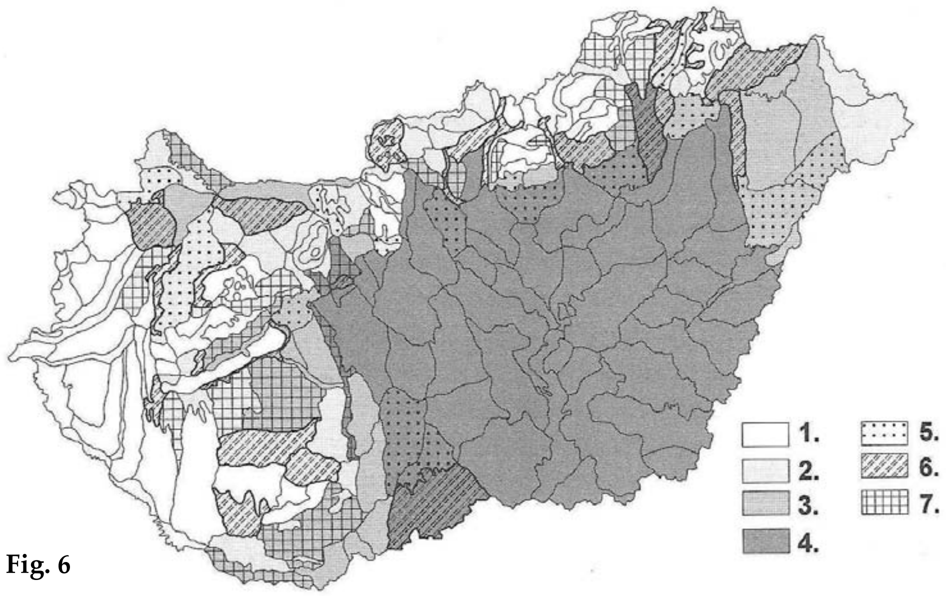

Fig. 6

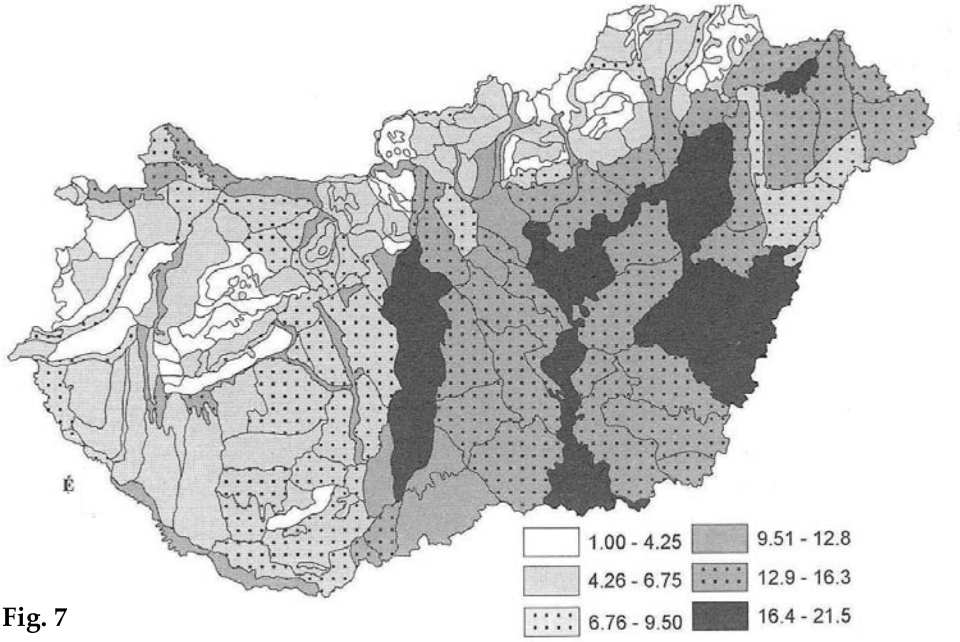

Fig. 7

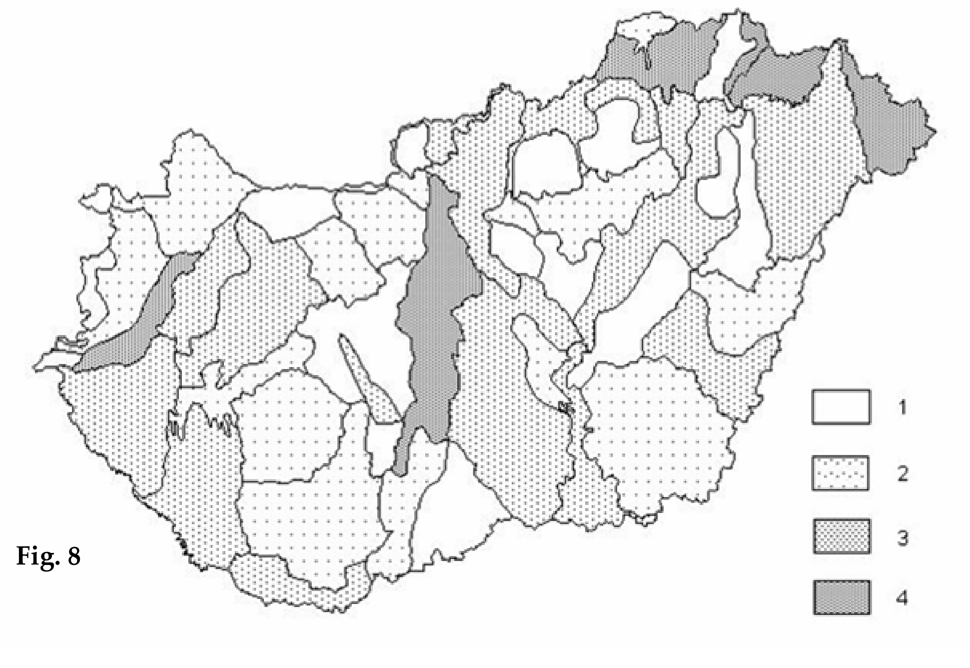

Fig. 8

Fig. 3. The degree of fragmentation of microregions of Hungary by the settlement system (modified data km/km^2). ***Source:*** *compiled by the authors.*
Fig. 4. The landscape fragmentation index based on the fragmentation impact of road and railway system is presented (modified data km/km^2). ***Source:*** *compiled by the authors.*
Fig. 5. Weighted and summarized data for the fragmentation effect of settlements and traffic infrastructure of Hungary (modified data km/km^2). ***Source:*** *compiled by the authors.*
Fig. 6. Drought hazard across landscape microregions of Hungary. 1- negligible, 2 - slight, 3 -moderate, 4 - serious Terrain of slight hazard within, 5 - ca 25%, 6 - ca 50%, 7 - ca 75% of the total area of the microregion. ***Source:*** *Szabó et al., 2007.*
Fig. 7. Natural hazards in Hungary by landscape microregions (obtained by a weighed summing up of balls) Possibility of the occurrence of natural disasters is 1 - uncommon, 2 - unfrequent, 3 - slightly moderate, 4 - moderate, 5 - significant, 6 – severe. ***Source:*** *Szabó et al., 2007.*
Fig. 8. Degree of expected changes of land use structure.
1 - negligible, 2 - moderate changes, 3 - medium level changes, 4 - significant changes.
Source: *compiled by the authors.*

Since recreation/tourist activities are expected to have a significant impact on landscape development in Hungary, special attention is to be paid to that field.

After finishing the examinations on the eight factors and the subsequent part-analyses, results of the individual indicator clusters will be compared and synergic or antagonistic effects will be estimated. According to our Geographic approach, a chapter is indispensable within the synthesis what deals with the interactions between the neighboring microregions with different endowments, ways and levels of alteration. How easy to cross the borders of the microregions, how environmental conditions of one microregion are reflected in its neighbor microregions?

Authors believe that effectiveness and long range success of well established landscape planning, protection, rehabilitation and management should be assisted by detailed examinations and widespread publicity of such complex systems of relationships.

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SUMMARY

For the good established landscape planning landscape protection and landscape management actions have to take into consideration the actual conditions of the landscape elements. Earlier we dealt with the stability of the landscapes (Kerényi, Csorba, 1996), recently started to investigate the most important factors, which are endangers the proper functioning of the landscapes. Results are calculated for **229 microregions** of the country, which are elements of the official landscape hierarchy of Hungary described in the Cadastral of Microregions of Hungary. The average size of the microregions are 100-500 km^2.

There are certain factors among which some have already elaborated, and others are being worked on yet. Degree of **ecological fragmentation** of the microregions by roads, railway lines and settlements was determined during the last year. In the case of large settlements the extent of inner parts, traffic intensities of the roads was taken into account, while in the case of railroads it was taken into consideration whether railway lines are single or double tracked. Results were purified using a weighting, where the location of the protected natural areas compared to the situation of the given settlement, roads or railroads was taken into consideration. In the calculations it was taken into account as well that the agglomeration processes of the large settlements may restrict the ecological gates and corridors of the migration of plant and animal species.

From the series of maps on natural threats on microregional level, the map of the hazards of drought is presented first. The map gives a definite answer to the question, in which microregions is profitable to establish irrigation systems; and how high is the uncertainty of the rate of their utilization. Global warming, however, may modulate the map resented here remarkably in the next decades. Microregions that have been classified into transition categories with moderate or medium level of drought hazard may fall into categories of serious hazard of drought in the future. A synthesizing map has been completed by summing the seven datasets of the indicator group of natural hazards and the weighting of the subsets. Landscape planning is strongly affected by tendencies of macro economy on the present land use structure. EU agricultural policies have just started to affect strongly on Hungarian land use structure, therefore attempts have been made in order to forecast their impacts. Present Hungarian land use structure has been compared to priorities of the EU. Prospective shifts in land use structure have been determined for the 35 regions of Hungary.

According to the 8-10 factors mentioned above, we shall have a detailed database to evaluate the microregions of Hungary in order to characterize the most threatened land-scapes, and the most dangerous impacts on the landscape functioning.