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# EVALUATION OF LANDSCAPE CHANGES IN THE CASE OF AN ENVIRONMENTALLY AND CLIMATE SENSITIVE LANDSCAPE LOCATED IN THE DANUBE–TISZA INTERFLUVE, THE ILLANCS MICROREGION

*Theses of Dissertation*

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# 1. INTRODUCTION AND RESEARCH OBJECTIVES

The human impact of the last centuries and the consequences of climate change presumed in the last decades have caused significant changes in Hungary as well. These processes contributed to the maybe best-known hydrological problem of the country, the groundwater-sinking process in the Danube–Tisza Interfluve (Pálfai 1994, Rakonczai – Bódis 2001, VITUKI 2005, Völgyesi 2006). The causes of the changes were discussed by several conferences and studies and its significance was recognised by the politics. The degree and the importance of the water-shortage and the caused land degradation have already been disputed neither in national nor in international level. In the most affected areas, not only the worsening conditions of the natural areas appear but it is a social, economical question as well (Csatári 2004). The most significant changes can be observed in the case of areas with the highest elevation (Kuti et al. 2002, Rakonczai – Bódis 2002). The landscape changes of the Illancs microregion, as one of the most affected part of the Danube–Tisza Interfluve, were analysed by this research from the viewpoint of the natural and anthropogenic influencing factors in the last two hundred years. The development of the regional water-shortage problem and the role of the affecting factors were also evaluated in space and time. By using diverse methods of environmental sciences, the dissertation provides a complex analysis regarding to the social relations.

It focuses on the following questions:

(1) What changes can be observed in the landuse of the microregion and what are their causes and consequences? What landscape historical periods can be determined based on the landscape changes in the last two hundred years?

(2) How and in what degree is the landscape modified by human activities in the examined microregion? In which extent has the natural vegetation remained?

(3) What alterations can be observed in case of wet habitats due to the consequences of the rapid hydrological changes in the last forty years? Is it possible to identify the former wet habitats? Can the changes of soils also be observed?

(4) What are the dry habitats characterised with nowadays? What endangering factors can be determined (natural and/or human effects)?

(5) What is the relation between forests – as the main land use of the microregion nowadays – and precipitation, so how sensitive they are to the intensifying aridification? Can these facts prove the sensitiveness of the examined landscape?

(6) Do the inhabitants and farmers perceive the alterations in the environmental factors? Do they experience the negative effect of the aridification process in farming? In what do they believe the solution of the problem? Does the process have economical loss?

The landscape border of the microregion, needed for the evaluations on choric level, showed differences in the literature. That is why the demarcation of the microregion is also discussed in details in the dissertation. The different borders are confirmed by the detailed evaluation of landscape factors. The research reveals the ongoing processes in the landscape, shows the landscape changes of the last centuries, contributing to outline the potential and effective nature conservational (and environmental) goals.

## 2. APPLIED METHODS

### 2.1. Obscureness of the landscape border

The investigations on choric level needed a landscape border but the north-eastern part of the microregion showed differences in the literature (Marosi – Somogyi 1990a, 1990b, Bíró et al. 2007, Dövényi 2010). Therefore, the contradictory demarcations were compared with the geological maps of the Hungarian Geological Institute, the Kreybig soil survey, the groundwater-table maps and the vegetation-based landscape borders to make this obscureness clear. The detailed analysis revealed that the southern border should be refined as well. It was redefined by fieldworks, based on the quaternary sediments (sand-loess) and the landuse beside the former mentioned maps.

### 2.2. Land use changes in the last two hundred years

Land use changes and the (non-proper) land use itself are the most threatening factors of biodiversity in the Danube–Tisza Interfluve (Mucsi – Kovács 2005, Schrett 2005, Kovács 2006, Pándi 2006, Török et al. 2006, Dóka 2009, Somay et al. 2009). Based on the land use and the land cover data of the first, second, third military surveys, the topographical maps of the 1950–1960s and the 1980s as well as an ortophoto from 2005, a database was created to evaluate the landuse changes in the examined microregion. The data of the Corine Land Cover database (scale 1:50.000) were also applied. The geoinformatical evaluations were processed with the help of ArcMap 9.3. The degree of the alterations was investigated by landuse stability, making a patch-consistence matrix based on the overlay of the landuse maps between the examined different periods. Beside (and in strong connection with) the evaluation of land use changes, further anthropogenic effects were also described. By geomorphological evaluations, the characteristic sandforms of the microregion were analysed, the effects of the planation and the infrastructure on the landscape were demonstrated.

### 2.3. Evaluation of the water shortage observed in the microregion

Due to the human activities and the consequences of climate change, the Danube–Tisza Interfluve faces one of the most significant hydrological problems of Hungary, especially the places with the highest elevations (Pálfai 1994, Liebe 2000, Kuti et al. 2002, Rakonczai – Bódis 2002, VITUKI 2005, Völgyesi 2006, Szalai – Nagy 2009). The aridity of the years in the last century was evaluated by the data of the closest meteorological station

(Kiskunhalas), with the help of the Pálfai Aridity Index (PAI). The changes of the groundwater-table were described based on the groundwater-wells of the microregion. Evaluating the groundwater-conditions in 2007, the significance of the water shortage is emphasized. The geoinformatical evaluations were processed using ArcMAP 9.3.

### 2.4. Analysis of natural habitats

The habitats of sandlands belong to the most endangered ones of Center Europe. Due to the anthropogenic effects in the last centuries, their extent has significantly decreased in the Danube–Tisza Interfluve (Molnár 2003, Bíró 2006, Molnár et al. 2008). The hydrological changes have direct influence on its wet habitats as well (Dóka et al. 2006, Hoyk 2006, Varga 2009). Therefore, the condition and the alteration of natural habitats in the examined microregion are especially explained by the significant decrease of groundwater-table. The changes of dry habitats were investigated in the Hajósi Homokpuszta and the Kéleshalmi Homokbuckák Nature Reserve; the alterations of wet habitats were examined on two sample areas between dune zones (a pasture west from Borota and Lake Kélesi with the surrounding meadows). For the habitat-mapping the habitat-categories of the General National Habitat Classification System were applied (Bölöni et al. 2007). Based on the habitat-pattern of these sample areas, their conditions were outlined with special regard to the consequences of the water-shortage, revealing the ongoing processes in the landscape. In accordance with the above-mentioned, the threatening factors of the sample areas were also determined. The geoinformatical evaluations were processed using ArcMap 9.3.

### 2.5. Effect of aridification on wet habitats of the examined microregion: the vegetation–soil–groundwater connection system

The former revealed regional (Bíró et al. 2007) and local (Deák 2010) habitat patterns refer to the close connection between the water flow system and the habitats in the Danube–Tisza Interfluve, which contributes to the rapid alterations of the landscape due to groundwater-sinking. The connection between the vegetation, the soil and the groundwater was analysed in details in a blowout between dune zones near Borota settlement, by the alteration of soil attributes, the species composition of wet habitats and the groundwater-conditions. This sample area was described saline on the Kreybig Soil Science Maps (Nr. 5462/4, 1949), which was confirmed by fieldworks and laboratory analysis of soil attributes in the south part of the territory. This sampling was repeated in 2008 and soils of two other points were also taken. Total salt content, alkalinity, humus content, calcium-content and particle size distribution were measured based on the Hungarian standards. All soil samples were collected from topsoil to 2 m, in every 20 cm. Beside the habitat mapping (Bölöni et al. 2007), the list of the vegetation species were recorded. The species composition of the remained wet (fen and saline) habitats was evaluated separately.

### 2.6. Analysing landscape sensitiveness by geoinformatical methods

The investigation of the relation between vegetation and the climate elements plays more and more significant role in the climate change research (e.g. Ahl et al. 2006, Evrendilek – Gulbeyaz 2008, Huete et al. 2006, Kaurivi et al 2003, Waring et al. 2006). Climatic analysis of vegetation index data series has been made by Kern et al. (2007) and Kovács (2006) in Hungary, which research proved close connection between biomass production and climate elements. The significant water shortage and the deep groundwater-table presume increased sensitivity of vegetation in the examined area. Therefore, the vegetation dynamics of the main forest types in Illancs microregion (locust and pine) and the connection between biomass-production and precipitation were investigated by 10-year-long MODIS NDVI and EVI vegetation index data series. In the investigations, vegetation index series were analysed using softwares HegTool, Python 2.4, ArcGIS 9.3. The annual biomass-production was counted by the determination of the area under the curve of the annual vegetation index values, and its connection with the precipitation, as a variable climate element was evaluated. To confirm the 'climate sensitiveness' of the microregion, control areas having less significant groundwater-sinking (forests near Ásotthalom) and ones with near surface water resources (Gemenc) were also examined.

### 2.7. Investigation of aridification in the point of farming

Since water-shortage has already been having social and economical relations as well (Csatári 2004), personal interviews were made with inhabitants, foresters, farmers during the fieldworks. Furthermore, a questionnaire was composed which was filled in by the participants of an agro forum in Jánoshalma, where especially the active farmers were addressed. The main goal was to reveal the effect of aridification on farming by the following questions: (1) Do the farmers experience the consequences of climate change? (2) What is their opinion about the degree of the groundwater-sinking process (Can they estimate the actual groundwater-levels)? (3) Can they do the farming among such circumstances? (4) Do they experience the difficulties in farming and people migrating due to this process? (5) Do they try to adapt and how, if the former cultivation cannot be continued any more? (6) What do they think about the solution of the problem?

## 3. RESULTS

### 3.1. Obscureness of the microregion-border

*The obscureness of the former demarcations was caused by the slight knowledge about this microregion, the lack of the detailed research of the landscape factors, as well as the scale of the previous surveys.* According to my research, *the Illancs cannot be considered as a homogenous microregion but a microregion-group, which is confirmed by the differences of natural attributes and the diverse landuse for centuries* (Figure 1). The highest obscureness of the demarcation is shown by the sand-covered areas, mainly *the affiliation of dunes near Kéleshalom settlement is questionable*. To reveal the differences of the disputed parts, the protected areas were compared in respect of vegetation, geomorphology and landscape history *but significant differences could not be identified*. The different physiognomies of the areas can be explained by the former land use. *The south-*

*eastern border was redefined between Rém and Jánoshalma settlements without the indenture near Borota* (Figure 1). The blowouts between the dune zones showed difficulties in the demarcation, where the depressions former dominated by wet habitats marked the border.

Based on the available map-, database sources and my investigations, *the dunes around Késleshalom settlement are the part of Illancs, but further detailed sedimentological investigations are needed for the proper separation*. Consequently, I suggest the above mentioned facts to be considered (e. g. in case of a new microregion-cathaster).

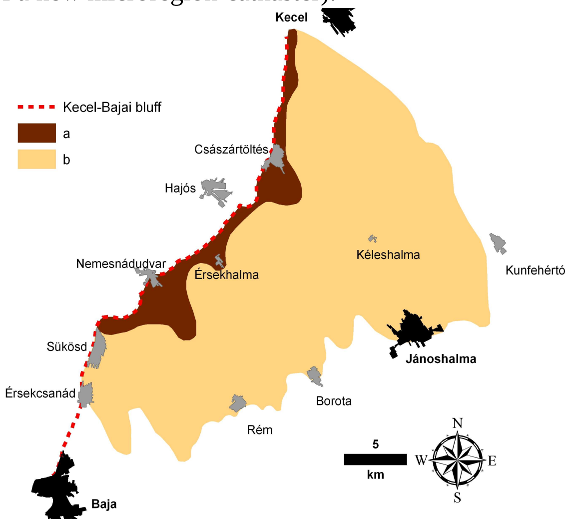


*Figure 1. Illancs as a microregion group, with the modified border*
*a. Nemesnándudvar-Császártöltési Loess Plateau*
*b. Illancsi Sandland*

## 3.2. Evaluation of landuse changes in the last two hundred years

*In the last two centuries, 90% of the territory of the microregion was found to become cultivated. The former (undisturbed) natural vegetation has remained only in 1.5% of the area; it is fragmented and highly endangered by the aridification and the spread of invasive species. The most significant human activity affecting the natural landscape was the forestation.* As a result of this process, 60% of the examined microregion (former determined by moving sanddunes, open sand steppes) is covered by planted forests. The highest degree of cultivation occurred in the middle of the 20th century, relating closely to the period of intensive agriculture and large monocultures.

By investigating the landuse changes in case of the narrower and the wider landscape-border, the tendencies in landuse changes *differed only slightly*, however, the cultivation proved to be much more significant in the south-western part in the middle of the 20th century resulting in the higher decrease of meadow/pasture/wasteland territories. *Based on my evaluation of landuse-changes, landscape historical periods were determined for the microregion (Figure 2).*

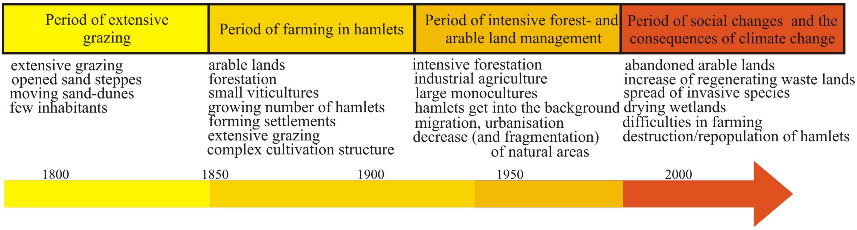


*Figure 2. Landscape historical periods on the Illancs microregion*

*The anthropogenic effect on the surface sandforms proved to be highly significant in the 20th century*. Due to cultivation and viticultures (and the related planations), *the characteristic sandforms has disappeared on many places*. *The further endangering factor of the remained sand steppes is the degradation due to the treading effect of vehicles.*

### 3.3. Evaluating of the water shortage in Illancs microregion

The first mapping of groundwater-depth *in the 1950s showed deeper groundwater-level in the Illancs,* which can be confirmed by the location and the relief of the microregion. Compared to the 1970s, *a continuous decreasing process can be observed in the last 30 years, which tendency was hardly interrupted by short humid periods.* In the last arid year (in 2007) the groundwater-table was *20 metres under the surface in the highest regions of Illancs microregion, which reflects the most significant changes* *in the Great Hungarian Plain. The territory could not regenerate due to the high amount of precipitation in 2010; the data still show 2-7 metres decrease compared to the 1970s.* All these confirm the fact that *short humid periods (not only the last year, but for example the end of the 1990s) can not contribute to the total refill of groundwater resource* in the whole Danube–Tisza Interfluve.

### 3.4. Investigation of natural habitats of Illancs

Anthropogenic and natural processes of the 19th and 20th century exerted significant influence on natural and semi-natural habitats in Illancs (Figure 3).

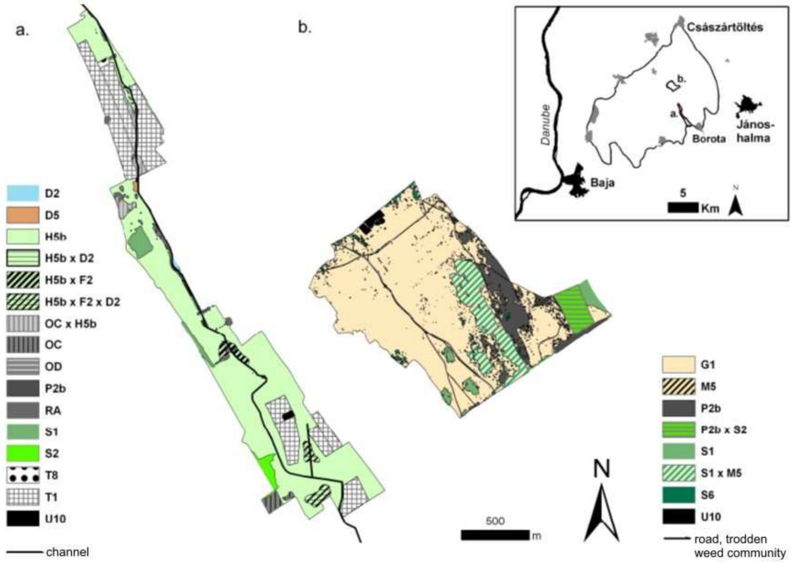


*Figure 3. Habitat maps of two examined sample areas*
*(Á-NÉR, Bölöni et al. 2007)*
*a. Meadow located west from Borota former determined by wet habitats*
*b. Hajósi Homokpuszta Nature Reserve*

*In dry habitats mainly landuse changes and their consequences caused significant alterations, and their fragmentation is an endangering factor in the 21st century*. In these remained meadows between planted forests, the *spread of dry shrubs and the infection with Asclepias syrica is significant*. The ratio of natural vegetation without disturbance is slight where the presence of invasive species is less significant. *In the examined wet habitats the shift of vegetation zones can be observed*: the former wet habitats were replaced with sand steppe grasslands and wet habitats receded into deeper location (e.g. channel), where the local water-flow systems could ensure them enough moisture. Nowadays, *the remains of wet and saline habitats can be identified just in the depressions* where mainly their steppificated varieties occur due to the deeper groundwater. On the other places they have transformed into sand steppe grasslands. *Landuse has nowadays significant landscape-forming effect as well*: for example due to grazing with sheep, the infection by invasive species of meadows is less significant.

The most considerable changes can be observed in case of wet habitats in the microregion. *The effect of the groundwater-sinking process is an important impulsive force in the alteration of habitats* (Figure 4).

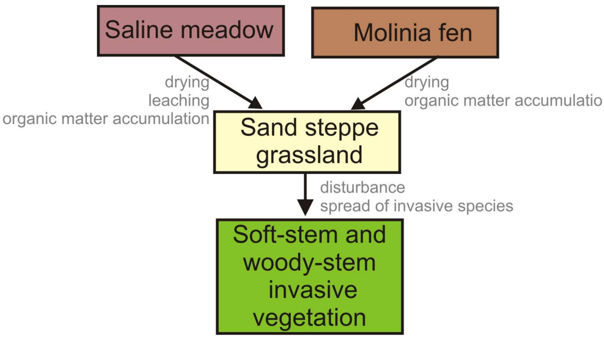


*Figure 4. Alteration of wet habitats due to groundwater-table sinking in Illancs microregion*

**3.5. Effect of aridification on wet habitats of the examined microregion: the vegetation-soil-groundwater connection system**

Due to the critical groundwater-sinking observed in the last decades, *other processes became dominant in the area that had been determining the landscape before the canalisation*. The soils of the deflation hollow, covered previously by wet meadows, have not been affected by groundwater any more. *As a result of this, leaching and steppification dominates instead of meadow characteristic and salinization.* The botanical investigations *proved the presence of the 'fen-head–saline-foot' local vegetation pattern in the Illancs microregion*, first described in the Dorozsma-Majsa Sandland. Compared my botanical investigations to soil science ones*, the north-eastern part of the examined deflation hollow has never been saline since neither the present soil parameters now nor the 'remained saline species' have referred to previous saline conditions contrary to the southern part of the sample area ('saline-foot' pattern).* Presumably due to the similar relief, the vegetation, the water-cover and the limited number of sampling, the different parts of the deflation hollow were described similarly.

### 3.6. Evaluation of landscape sensitiveness by geoinformatical methods

Based on vegetation index values of MODIS 16-day-composite images, *the close relation between forests (planted locust and pine) and the precipitation was determined. Biological activity of locust and pine forests in Illancs microregion proved to be affected by the precipitation in spring and early summer (from March to June),* so the trees can not utilize the winter precipitation. In the case of the control site on the edge of the Sandland, *the close relation between biomass-activity and precipitation can be defined as well, but here winter precipitation also proved to be relevant* owing to near-by groundwater. *The connection between precipitation and biomass on the other control site in the Danube-valley can not be detected*. In this case the regular floods and the continuous connection with the riverbed through the sandy, pebbly silt *ensure sufficient water for the trees. The precipitation shortage due to climate change and the close relation with this variable climate factor prove the 'climate-sensitiveness' of Illancs.*

### 3.7. Farmers and aridification in the examined microregion

According to our field interviews, *the farmers blame the channels, the oil research drillings in the 1980s and the heavy droughts for the formation of the water shortage*. The evaluation of the questionnaires proves that *people* *living and farming on sandy soils feel the consequences of climate change. They have difficulties in farming but they try to adapt to the changed conditions* (e.g. landuse changes, modern technologies). Majority of the questioned people hopes in water-supplement from the River Danube and the River Tisza, so *agriculture expects irrigation water. However, the realisation of water-supplement for this sector is doubtful regarding to the economical aspects. The farming is in bad need in new approach with guidelines of sustainability.*

*Aridification affects through a certain connection-system in the microregion* (Figure 5). The elements of the process were grouped according to the keywords of the VAHAVA program (Change – Effect – Reaction) investigating the consequences of climate change in Hungary.

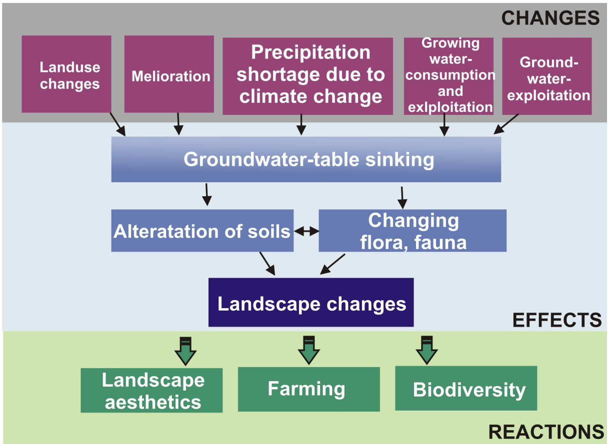


*Figure 5. The connection-system of the effects of the aridification*

*Human activities and precipitation shortage due to climate change played important role in the formation of a significant hydrological problem. Thus, the changes of flora, fauna and in certain cases soils together contribute to the landscape change. As a result of this process biodiversity decreases, farming difficulties appear and landscape alters due to landuse changes and the intensive spread of invasive species.*

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