Evaluation of landscape changes using GIS methods with special regard to aridification

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1. Abstract

As a consequence of the increasing aridity experienced in Hungary in the past decades, any future decision in spatial planning should consider the threat of an arid environment. For identifying sensitive and endangered areas, suitable methods should be found and developed.

Through the investigation of vegetation, regional scale variations in the landscape along with the responses of forests to climatic changes can be easily detected. Our primary aim was the evaluation of the natural water supply on the Danube Tisza Interfluve between 1992 and 2005. According to the spatial and temporal analyses of vegetation indices based on AVHRR and MODIS images, a considerable decrease in the activity of vegetation can be observed throughout the entire vegetation period.

Our wetland study area is very changeable seasonal, therefore is why, answer the question above we have done a long-term study with maps, aerial photos and satellite images. The tendencies of disadvantageous years it is to be feared than in the next 40–80 years the wetland surfaces will completely disappear, and they will recover only seasonally in early summer.

2. The problem of landscape changes on the Danube-Tisza Interfluve

In the past few decades on the Great Hungarian Plain an aridification process is in development as the result of the changing role of the man and the global climate. Due to landscape changes this degradation process probably will speed up. The regional effects of a presumed climate change within the area of Hungary mainly affect the areas of the Great Hungarian Plains, especially the regions of the SE Great Hungarian Plains and the Danube-Tisza Interfluve (Kertész–Mika 1999, Rakonczai 2003) (Fig.1).

Figure 1 The location of the study area

The aridification touches c.a. 700.000 people. Several works draw our attention, besides the magnitude of potential dangers, to the necessity of increasing the spatial resolution of the environmental studies and the implementation of these at a regional scale, which would enable the accurate evaluation of the direct outcome of changes. Natural and anthropogenic factors have caused significant landscape changes in the previous centuries, but the climate change makes the changes possible quick in the future. There are several uncertainities and we do not know how many changes will be irreversible.

The connection within the landscape system are very complicated, that is why during our research we have sought "indicators" which can demonstrate the process related to changes. There are two opportunities to provide an answer for the extended scientific demands during evaluation: on the first hand to improve considerably the precision of analyses and on the other hand to extend length of investigation. The improvement of geoinformatic methods provides us a chance to widen our scientific interest in both directions: the development of remote sensing, land survey and other techniques increase precision, while the ability of systematising different data bases may ensure the temporal extension of the examination.

On regional scale the vegetation cover (Danube-Tisza Interfluve), on local scale the strictly protected wetlands (Northern Kiskunság Lakes) are good indicators to assess the degree of changes in the complex system.

3. The principles of the analysis and the applied geoinformatical methods

The aim of the long-term research is dual. Partly to determine from a methodological point of view how and in what extent can data originated from different periods and from different sources (old maps, topographic maps, aerophotos, satellite images and field work) be integrated into a unified information system (at the same time this may give an opportunity to significant temporal extension of authentic environmental evaluation).

3.1. Regional multispectral biomass monitoring

The primary goal was to observe natural water resources through the dynamism of vegetation between April and September from 1992 to 2005 (Kovács 2007).

- During the course of our work a monitoring type of analysis was carried out on the landscape utilization classes of LANDSAT images bearing a better spatial resolution with the help of higher temporal resolution AVHRR and MODIS images.
- Through the heterogeneous landscape utilization pattern, fundamentally only four major vegetation classes were examined. The class of woodlands (deciduous, coniferous and mixed forests). The class of non-arboreal plants (close-to-natural meadows, grasslands, pasturelands) According to geographic analyses the landscape ecological value of the region is expected to decrease in the future (Mezősi–Szatmári 1998).
- The most generally used method of predicting net biomass production is the determination of the Normalized Vegetation Index (NDVI) (Mucsi 2004).
- Considering the distributions of precipitation, so-called average profiles were constructed for the individual classes on the basis of the average values of the wetter periods. The alterations from these average profiles may be used to determinate the dynamics of vegetation growth.

3.2. Hidrogeographical analysis on Northern Kiskunság Lakes

The most notable effects of anthropogene and climatic processes are the decreasing water surfaces and the disappearing of the sodic lakes which were typical formerly. Our study area is very changeable seasonal, therefore is why, answer the question above I have done a long-term study (Fig.2).

- The analysis covering the period between the 18th and the 21st century shows the changes from the original natural conditions to the secondary converted culture-steppe landscape, via millitary and topographical mapping.
- During the detailed analysis I have used B&W and colour infrared photos and satellite images from 1950 to 2006. The selected images were taken at springtime representing the wetness conditions very well.
- Lakes, permanently water-covered areas, permanent marshes, seasonal marshes, brooks and canals were outlined at each date. Non-vegetated and potentially inundated areas could only be mapped by remote sensing.
- At image processing I have applied three fundamentaly unlike spectral indices and image classification ways to border the wet area.

Figure 2 Kelemen-szék is the biggest from the Northern Kiskunság Lakes

4. Results

4.1. The condition of a vegetation in the period of 1992–2005

In the average NDVI data series a negative trend have been observed primarily in the months of April, July and September between 1992 and 2003. The 10–15 % changes in deep-rooted arboreal surfaces within this short period is very dangerous especially in the case of mixed forests. The most quick decrease was shown in April and September. A stable decrease in the biomass territory of the non-arboreal plants was observed, while in the case of forests the decrease was 2–3 times greater in autumn than in spring or summer.

The most dangered area by aridification could be outlined, during the classified deviation of the average profile values. Fundamentally the amount of biomass produced is decreasing on one third of the vegetated area of the Danube Tisza Interfluve according to the spatial analysis of the 1992–2001 period. The reaction to the aridification process is unfavourable on one third of the mixed forests areas, on one fourth of the deciduous forests areas. 42 % of grass-meadow-pasture areas are also sensitive, especially on the highest regions of the plain territory. The amount of produced biomass is decreasing by 16 % on the vegetated areas of the Danube Tisza Interfluve as it was shown by the spatial analysis of the 2001–2004 period (Fig.3.). The response to the aridification process is unfavourable on one fifth of the mixed forest areas, on one seventh of the deciduous forest areas. 14 % of grass-meadow-pasture areas are also sensitive, which are also on the highest regions of the plain territory.

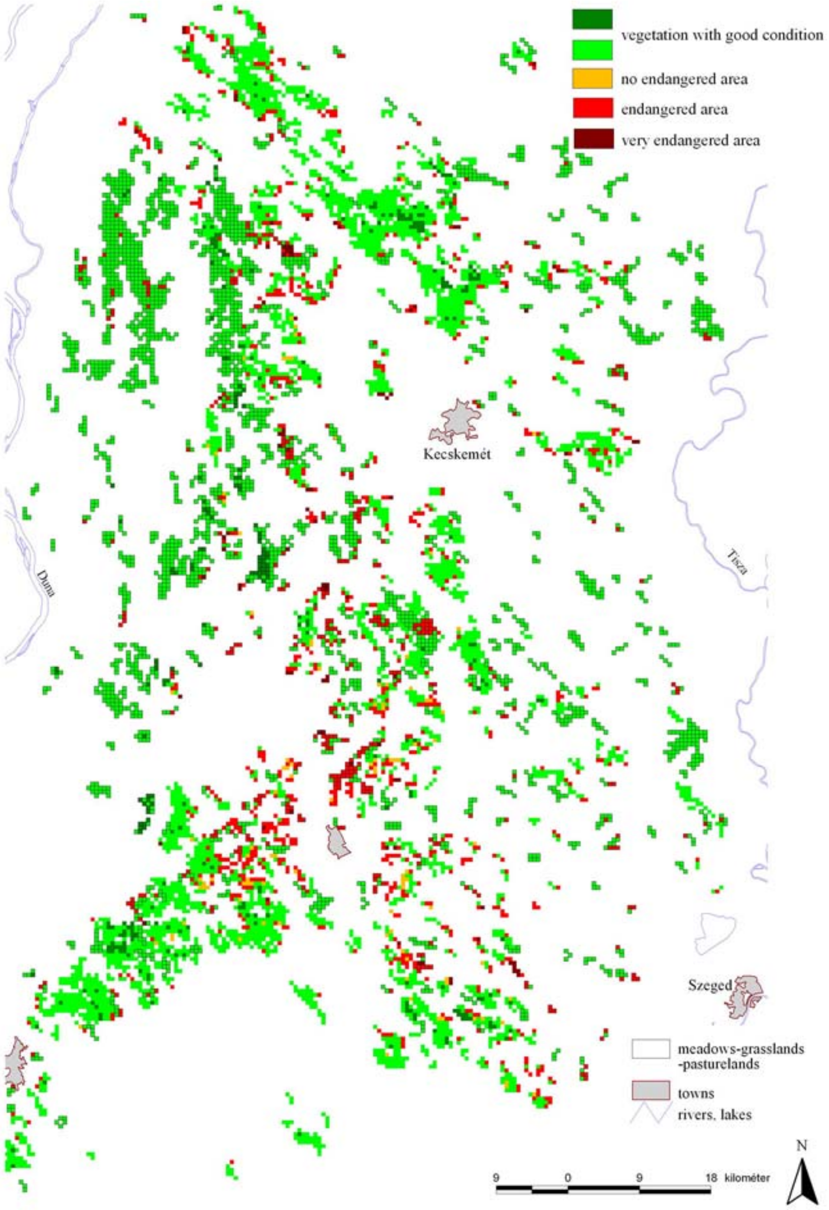

Figure 3 NDVI based regional distribution of the effects of aridification on the Danube-Tisza Interfluve

4.2. The changes of Northern Kiskunság Lakes

The decrease was 62 % during the whole studied period (1882–2002). The largest decrease (by 95 %) was detected at permanent and seasonal marshes. Two third of the water surfaces disappeard after 1882. Unfortunately, subsequently there was even a quicker change, because two third of the remained wetland areas dryed up by 1986. It can be seen on the data of 2000 and 2002, and at the end of the 1990s that as a result of some wet years, the extension of water surfaces have increased. Unfortunately it was not a long-lasting positive changes.

Important change is the invasion of harmful wetland plant associations at the expence of water surfaces, because they invade the lake bottoms with reduced salt content. In 1950 20 % of the lake surfaces were non-vegetated, but this reduced by 1,5 %/y between 1950 and 2002.

Based on trend analysis of remote sensing and map data considering, the tendencies of disadvantageous years it is to be feared than in the next 40–80 years the wetland surfaces (lakes, marshes) will completely disappear, and they will recover only seasonally in early summer. Almost 40 % of study area is endangered by aridification and 80 % the wetlands has already dried out or getting drier (Fig.4.).

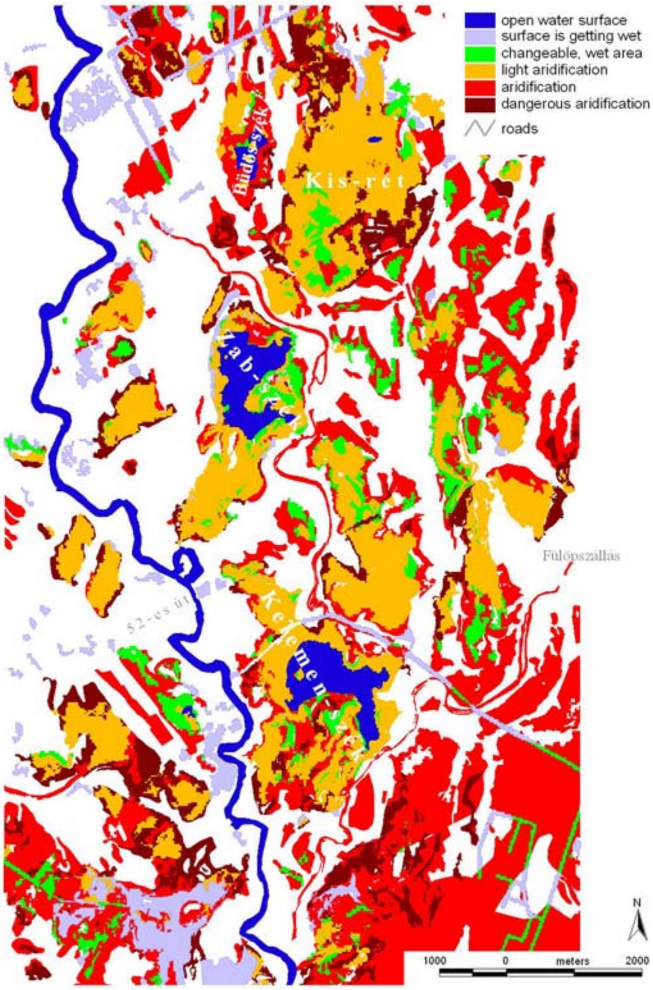

Figure 4 Effects of aridification on Northern Kiskunság Lakes

5. Summary

We have registrated degradation processes of some selected landscape factors. The positive effects of the period with more precipitation started in the late 1990's are not general. The documented changes of the vegetation, wetlands and soil are not always well-visible today, but we can see the hazard if we consider the short period of these changes and this trends which are the consequences of aridification.

6. References

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