Geogr. Fis. Dinam. Quat.
30 (2007), 229-232, 6 figg., 1 tab.

JÁNOS RAKONCZAI (*)

GLOBAL CHANGE AND LANDSCAPE CHANGE IN HUNGARY

ABSTRACT: RAKONCZAI J., *Global change and landscape change in Hungary*. (IT ISSN 1724-4757, 2007).

Today, an increasing number of observations show that the effects of global climate change can be felt in Hungary. One important long term effect is the decrease of ground water. This paper uses test well data for a GIS model of ground water recession and the prediction of water deficits on the Danube-Tisza Interfluve in Hungary, where the detail of recession is closely related to topography. Consequent declines in biomass, examined using mutlispectral methods, after 25% of this area. In the «Puszta» near Szabadkígyós a nature conservation area, within 25-years, unvegetated alkaline flats became covered by grass, former alkaline benches were totally eliminated by erosion, while grass and saline vegetation appeared.

KEY WORDS: Climate change, Aridification, Groundwater change, Biomass, Soil, Danube-Tisza Interfluve (Central Hungary).

INTRODUCTION

During the past fifty years, globalisation has become an increasing aspect of the world economy. In recent decades, its impacts on natural processes are becoming more and more obvious. In 1972, the Stockholm Conference considered the issue of a warming atmosphere as an interesting hypothesis. Nowadays, the world regards the greenhouse effect, the thinning ozone layer, acid rain and the problems of the oceans as well-established environmental issues. Today, increasing amounts of empirical evidence suggest that the effects of global change, including climate change, can be detected at even the most remote sites of the Earth and that they result in similar and predictable transformations (Rakonczai, 2003). Internationally, the most obvious effect of global warming is aridification but many scientists also recognise a connection with increasing storminess and larger flood events. Few have yet considered how a modified climate decades may, through changes in the water cycle, also lead to major landscape transformation.

(*) *Department of Physical Geography and Geoinformatics, University of Szeged, H-6722 Szeged, Egyetem u. 2-6.*
e-mail: rjanos@earth.geo.u-szeged.hu

ENVIRONMENTAL CONSEQUENCES OF CHANGES IN WATER CYCLE

Changes in the natural hydrological cycle, through direct and indirect effects, may transform landscape characteristics (fig. 1). Short-term changes are evident in droughts and the resulting poor crop harvest as well as flooding. However, the most important long-term effect is the dropping groundwater table, although it may not be obvious at first sight. Groundwater recessions, however, influence various processes through many interactions. They can lower the groundwater table beyond the reach of vegetation, which results in a decrease in biomass and on cultivated lands force changes in crop production. It can also modify the vertical movements of water and salts in soils which produce new soil types. It may lead to the onset of aridification or, in the case of some arid and irrigated soils; lead to better drainage that decreases salt concentrations. In both cases, the change in the quality of the soil is accompanied by a transformation of the natural vegetation.

Changes in the natural water cycle indirectly affect the quality of water supply and have both direct and indirect impacts on economic activities. The real problem, however, is whether the countries affected are able (or inclined?) to adapt to these changes. Experiments carried out in sample areas support the above-mentioned but decisions in environmental policy just follow the events. Social adaptation to changes demands that are proactive, not merely reactive. The VAHAVA project of the Hungarian Academy of Sciences supports national climate policy and has co-ordinated research for many years (Láng & *alii*, 2006).

ARIDIFICATION IN HUNGARY

Analysis of more than one hundred years of data shows a marked falling trend of precipitation over the latest 20 years in Hungary. Comprehensive national evaluations show a >40-50 mm - annual fall in precipitation during a century (fig. 2). The latest two «wet» years (2004 and 2005) do not contradict this trend. Although, annual rainfall has rarely dropped below 200 mm (except in 2000)

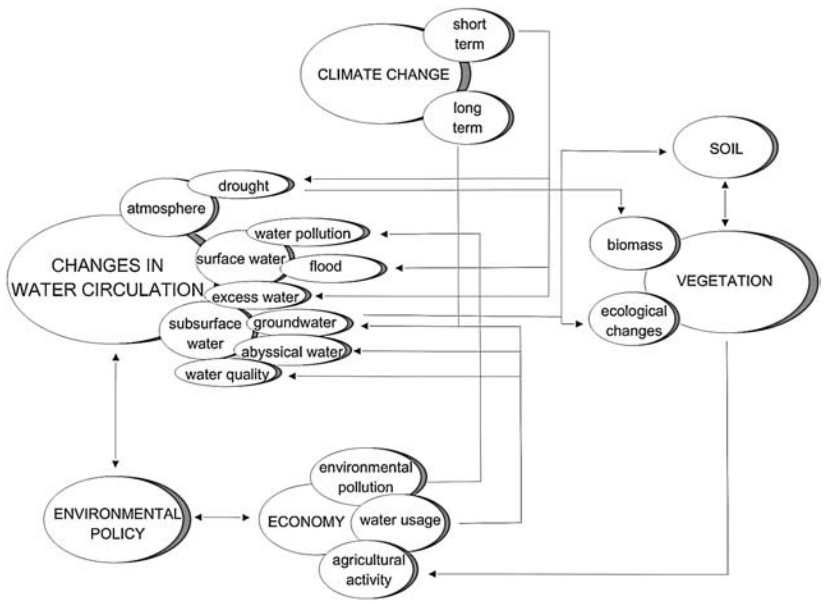

FIG. 1 - Environmental consequences of changes in the natural water cycle.

and then only in limited areas, there are growing problems from aridification. Water deficits are evident in certain parts of the Great Hungarian Plain, mainly on the Danube-Tisza Interfluve.

Aridification is a geographical process with direct consequences that can be hard to evaluate. There could be a poor harvest in a year with average rainfall as well if the distribution of precipitation throughout the year is unfavourable. Insufficient rainfall can be replaced by irrigation. For example in the year 2000, there were large areas covered with excess water in late winter and early spring, big floods in the course of the year but later a serious precipitation deficit with the national average of 400 mm unprecedented in the 20th century. For this reasons, we sought complex indicators in our research that do not pick out only one or another event but are capable of indicating tendencies.

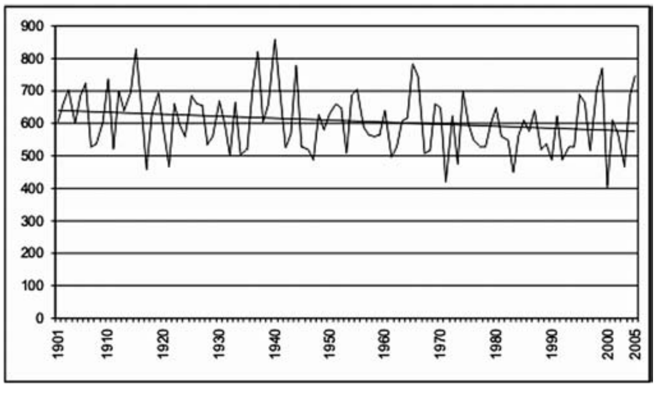

FIG. 2 - Annual precipitation in Hungary (mm) and its trend between 1901-2005 (data from the Hungarian Meteorological Service).

REGIONAL DECLINE OF GROUNDWATER TABLE

The regional decline of groundwater levels was detected first on the Danube-Tisza Interfluve. Subsequent research found that the decline in rainfall was only one of several reasons for a change driven by a complex process in which social factors are equally influential as physical elements. The most important factors that cause aridification are: lack of precipitation, increasing exploitation of confined groundwater resources, increased irrigation due to lack of precipitation, seepage/evaporation from waters and soils and land use changes.

From the 1930's, a series of test-wells were established in Hungary to record the level of groundwater, Now, more than a thousand wells with at least 50 years of data series are available for evaluation. On the Danube-Tisza Interfluve, there are about 500 observation wells in an area of 10.000 km^2 and more than half of them have data which can be used for long-term evaluation (fig. 3). Data from these wells have been analysed with GIS and at the their reliability checked by geostatistical methods. This allows definition of the regional and temporal process of groundwater decline (fig. 4) and the calculation of exact figures for water shortages.

The Danube-Tisza Interfluve rises between two large rivers as an elevated terrain (the highest parts being at 40-80 m relative height) and the subsurface water cycle of the area, namely groundwater is predominantly recharged from precipitation (there is no subsurface flow from higher areas to this region), and the impact of the rivers can be pointed out only in a limited zone. It has been found in the area mainly affected by the changes that dropping groundwater is closely related to the topography (fig. 5). It is also observed that groundwater recharge in particular sections is in even more dependent on meteorological conditions and thus a more humid period may help to re-establish former

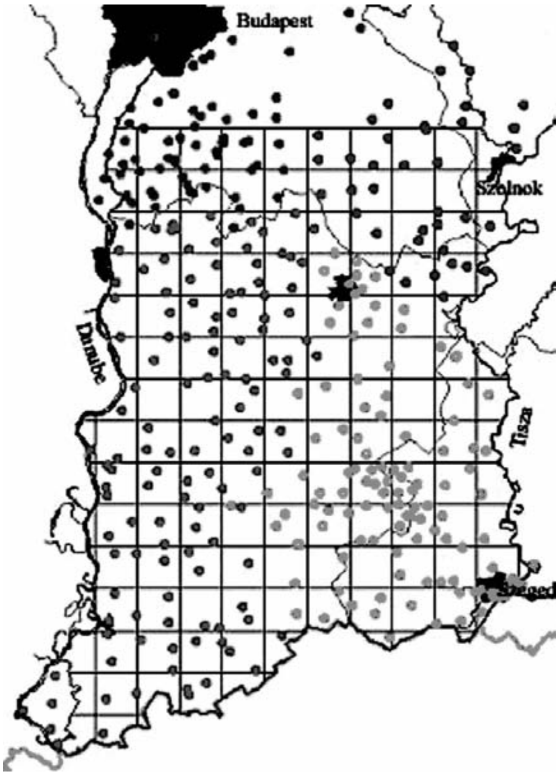

FIG. 3 - Location of groundwater observation wells on the Danube-Tisza Interfluve (grid size is 10x10 km).

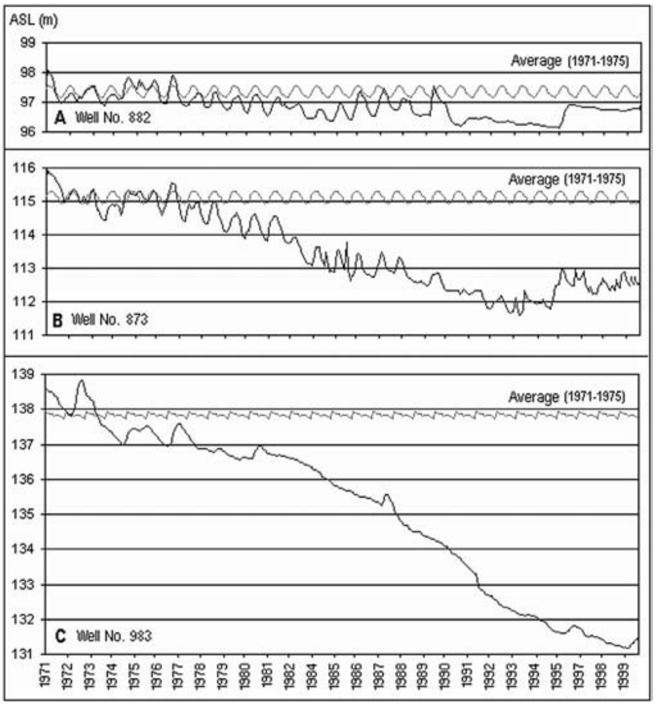

FIG. 4 - Drop in groundwater level in March 2003 (related to the average of 1971-1975).

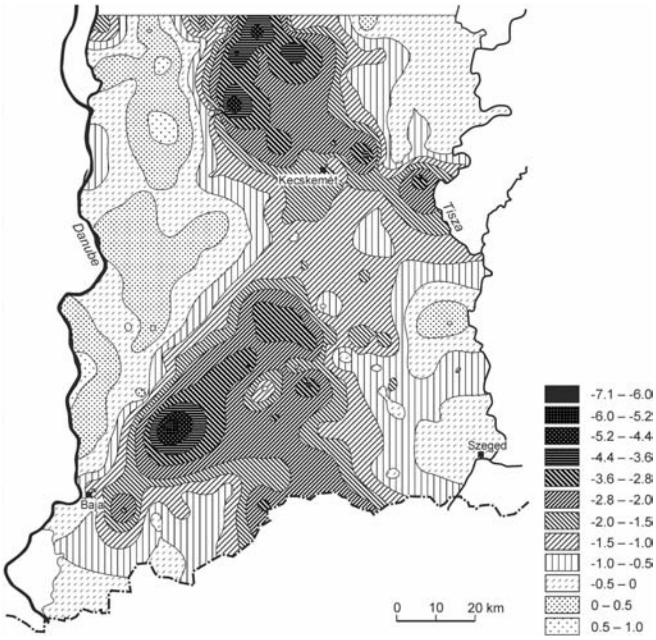

FIG. 5 - Change in groundwater level on the Danube-Tisza Interfluve in wells along three different latitudes (related to the average of 1971-1975).

conditions. All this, however, supports the idea that mainly the drier climate is responsible for the deficit. Fig. 5 shows that wetter periods have a minor influence on deeper groundwater. Several rainy years (like the late 1990's and the latest two years) can reduce the water shortage of the area (tab. 1) but there is an area of about 1.500 km^2 where the rate of depression is so great that conditions can hardly return to normal (Rakonczai, 2002).

TABLE 1 - Approximate ground water deficit in relation to the early 1970s on the Danube-Tisza Interfluve

Year	Water deficit (km^3)
1980	1,75
1985	2,32
1990	4,08
1995	4,80
2000	2,84
2003	4,81

REGIONAL MULTISPECTRAL BIOMASS MONITORING

Regional Multispectral Biomass Monitoring was used to observe natural water resources through the dynamism of vegetation between April and September from 1992 to 2004. Land use classes (CORINE) were monitored from LANDSAT and AVHRR and MODIS images of higher spatial and temporal resolution (Kovács, 2005). The heterogeneous land use pattern on the Danube-Tisza Interfluve prevented the detection of plant species or vegetation types, but four fundamental vegetation classes were identified.

The class of woodlands was made up of the entities of deciduous, coniferous and mixed forests. The class of non-arboreal plants includes seminatural meadows, grasslands and pastures. Woodlands tend to depend on precipitation and on subsurface waters, thus can be regarded as an indicator of long-term dry periods. However, non-arboreal plants react more acutely to short-term droughts, since for them water is mostly available from precipitation.

The most generally and frequently used method of predicting net biomass production via spectral analysis is the Normalized Vegetation Index (NDVI). Considering precipitation distribution, profiles were constructed for the individual classes on the basis of the average values for wetter periods between 1996 and 1999. Spatial and temporal analysis of alterations from these averages serves to reveal the dynamics of vegetation growth and allow the delineation of areas threatened by permanent biomass loss. Average profiles were made for the 2001-2004 period using MODIS images.

It was found that biomass is declining over at least a quarter of the Duna-Tisza Interfluve, and that the most sensitive contiguous areas lie in the middle and south-eastern part of the region. In particular, the mixed forest vegetation responds unfavourably to the ongoing changes. In addition, a decline in the production of herbaceous plants can be observed (fig. 6).

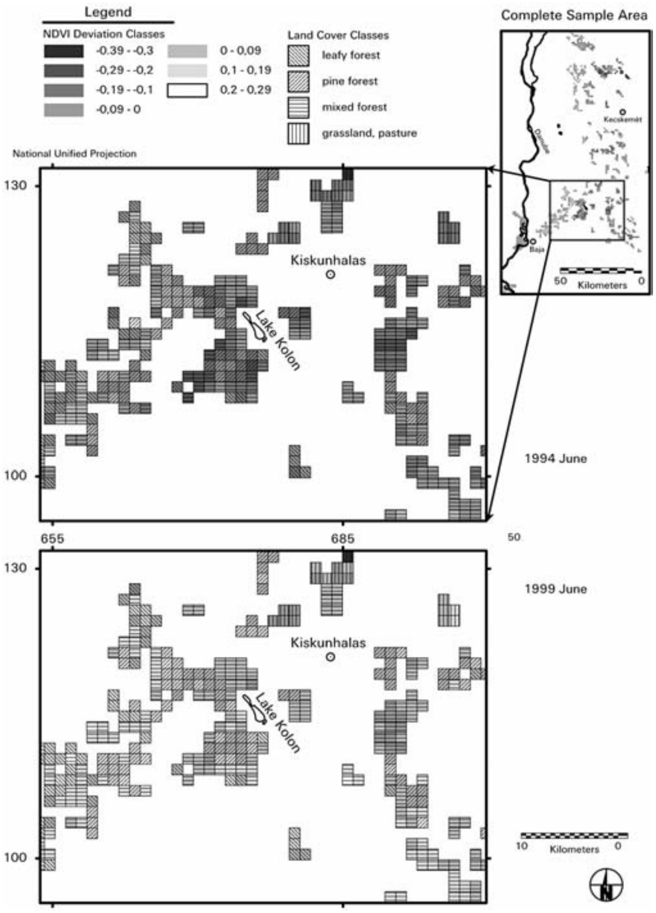

FIG. 6 - Spatial distribution of NDVI deviation values in the areas of the Danube-Tisza Interfluve most affected by aridification (Analysis was performed for ca 1.1×1.1 km cells where the land cover class occupied at least three cells).

THE IMPACT OF CLIMATE CHANGE ON LANDSCAPES

Climate change has effects that multiplying through groundwater-soil-vegetation connections and lead to significant landscape changes. The following example builds from detailed geomorphological and soil research in south-eastern Hungary, the «puszta» near Szabadkígyós, which was conducted in 1976-1978 as a part of a nature conservation project. A detailed micromorphological map was made of one of the alkaline benches typical of the area along with floristic surveys (Rakonczai, 1986). Twenty-five years later, this study proved suitable for detecting landscape change. New measurements were made in 2004, when not only bench erosion but the change of vegetation and soils were observed. Eroded alkaline flats, once free of vegetation, were covered by homogeneous grass. The former benches were totally eliminated by erosion while grass and saline vegetation spots emerged. Here, increasing groundwater deficit had caused spectacular landscape change.

CONCLUSION

In recent years, aridification has been observed in the Hungarian Great Plain, which is due to a steady decrease in rainfall with its resulting multiplying effects. Research has shown that, in the short run, precipitation shortage can be measured through the annual change in vegetation but long term deficits lead to regional groundwater deficits. These, in turn, can elicit dramatic landscape changes even within a lifetime! These processes affect protected areas (the test area is part of the Körös-Maros National Park today), and cultivated soils. The question is how national environmental policy can be framed to cope with such consequences.

REFERENCES

KOVÁCS F. (2005) - *The investigation of regional variations in biomass production for the area of the Danube-Tisza interfluve using satellite image analysis.* Acta Geographica Szegediensis, 38, 118-126.

LÁNG I., KISS CS. & BAGI A. (2006) - *A Nemzeti éghajlatváltozási stratégia koncepciójának alapjai (Fundamentals of the concept of National Climate Change Strategy).* Budapest, 38 pp.

RAKONCZAI J. (1986) - *A Szabadkígyósi Tájvédelmi Körzet talajviszonyai (Soils in the Szabadkígyós Protec ted Landscape).* Környezet- és Természetvédelmi évkönyv (Yearbook of Environemtn al Protection and Nature Conservation) 6, 19-42.

RAKONCZAI J. (2002) - *Some Conseguences of Environmental Change in Hungary: Subsurface Waters of the Great Hungarian Plain*. In: «Matter and Particle Transport in Surface and Subsurface Flow». ICWRER 2002, Dresden, Vol. II, 101-105.

RAKONCZAI J. (2003) - *Globális környezeti problémák (Global Environmental Problems).* Szeged, 192+16 pp.

(Ms. received 10 March 2007; accepted 30 November 2007)