Assessment of geographical effects of climate change in Hungary with remote sensing methods

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Abstract. Over the past 30-35 years, in the Danube-Tisza Interfluve in Hungary aridification process can be observed. The degradation is expected to accelerate in the near future and at the landscape change the unfavorable trends are faster than regeneration. Assessment of vegetation dynamics was the main goal is to change the consequences of natural forest than in the water supply tested. Multispectral methods were used to examine the long-term water coverage, supplemented by those of map data case. For instance concerning the optimistic and pessimistic scenarios 5.6 and 33.5 % of the study area will be affected negatively by water management strategies and precipitation decrease, respectively. The aridification, drought problem; the expected rate of problems can be well evaluated in the landscape factors examined.

Keywords. climate change, aridification, MODIS, LANDSAT, vegetation, wetland

1. Introduction

Over the past 30-35 years, in the Danube-Tisza Interfluve in Hungary due to human activity and climate changes, a significant water shortage (aridification) process can be observed (Fig 1). The aridification processes are long-period, cover everything due to the complex structure, so in this case we can count landscape degradation [1].

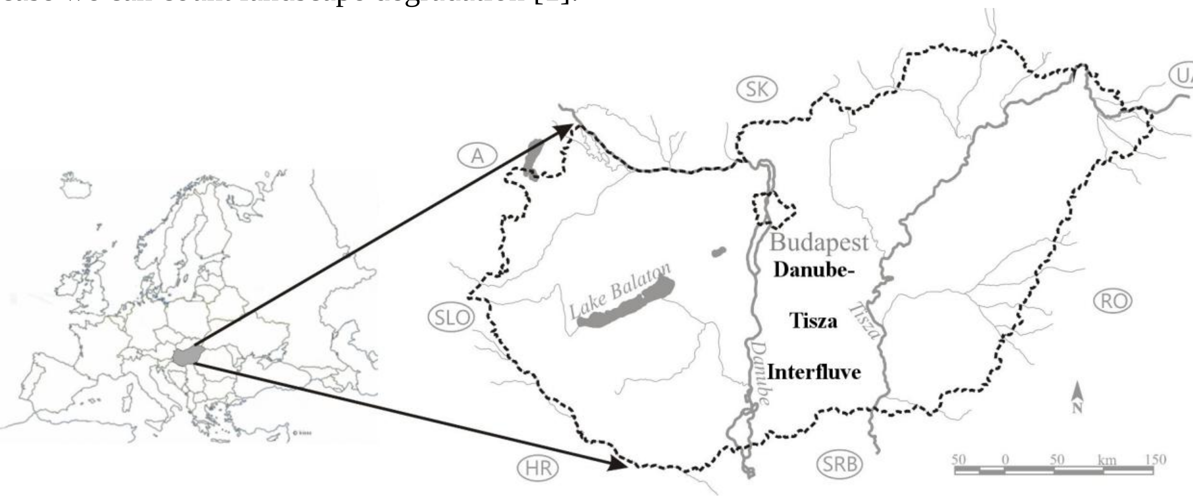

Figure 1. Hungary and the study area in Europe (Danube-Tisza Interfluve)

The degradation is expected to accelerate in the near future and at the landscape change the unfavorable trends are faster than regeneration [2]. The landscape development will be realistic, if takes account of changing circumstances. It is advisable to choose one or two dominant factors, which express the dynamics of the changing landscape processes. These are the vegetation and the water.

1.1. Research Background:

After the second half of the 1970’s until the mid-1990’s long dry periods, seven years less than the average rainfall fell in the last 12 years [3]. 1999th and the 2010th such as extreme rainfall years but in terms of geographical effects of a year-long process does not eliminate it. The water shortage in 1981-2010 more than 300 mm; and it was more than 500 mm from 1971-2000 (mean precipitation is 500-600 mm).

Climate change is recognized in temperature and precipitation in a time of change (Fig 2). Typical temperature rise is 1.3-1.5 Centigrade for the last 30 years.

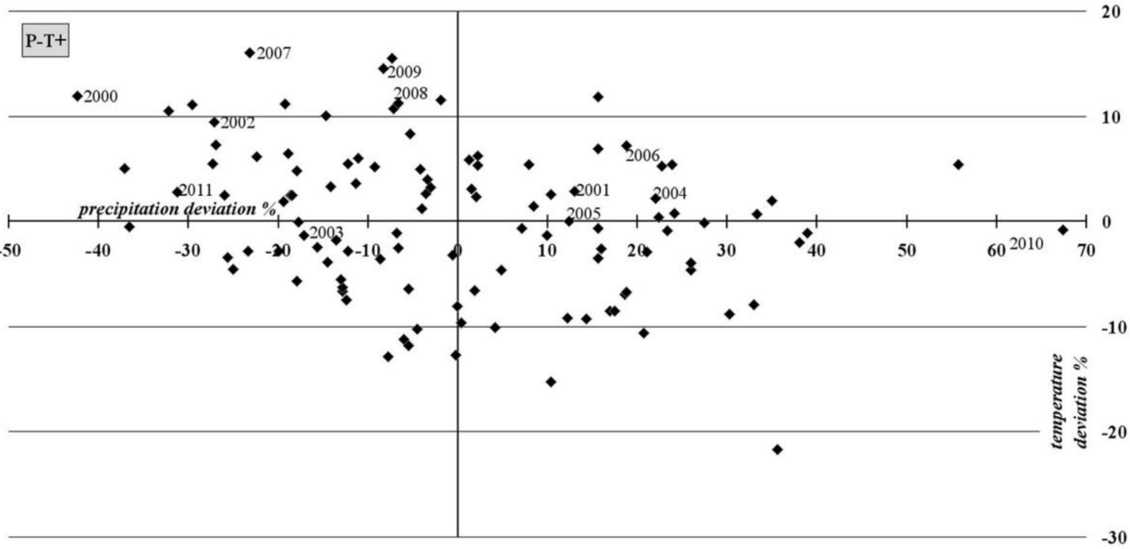

Figure 2. Temperature and precipitation deviation from the mean values (1911-2011) in Kecskemét, Hungary

The purpose of this investigation is very interesting status “temperatures above average, precipitation below average (P-T+)”; the co-occurrence of possibilities based on the last 30 years has increased to 35%. Over the past 80 years the half of the severe drought during the last 20 years (9 years) [4].

2. Methods

Assessment of vegetation dynamics was the main goal is to change the consequences of natural forest than in the water supply tested. The evaluation was performed for twelve years. The high time resolution data for the test are available since 2000 in the large study area. The freely downloadable images (MODIS 16 day composites: MVC) were downloaded from March to October half years from 2000 to 2011 (12 MVC per year) [5]. NDVI and EVI index values are used to evaluate the spatial-temporal dynamics of the vegetation of the Danube and Tisza deciduous, coniferous and mixed forests.

Multispectral methods – on LANDSAT images – were used to examine the long-term water coverage, supplemented by those of map data case. We found 230 years changes based on thirteen states in Upper Kiskunság Lakes sample area. In the changes analysis they are important in areas which are stable in terms of variability. The process can be dangerous if stable phenomena are at risk. The variability found twenty-two pieces of LANDSAT images.

3. Results

3.1. Description of the condition of the vegetation period between 2000-2011

The NDVI value range is wider than the EVI and have higher averages. EVI data show the difference between the species and also more significant deviation. EVI values are sensitive to changes in vegetation, external influences.

The deciduous forest spring show increasing values, but on based data autumn the extended growing season theory is no longer applicable. After wet years following dry years immediately reduces the biomass product. Development of drought increases, more and more, 2007, 2011. year, a similar situation may occur (Fig.3.).

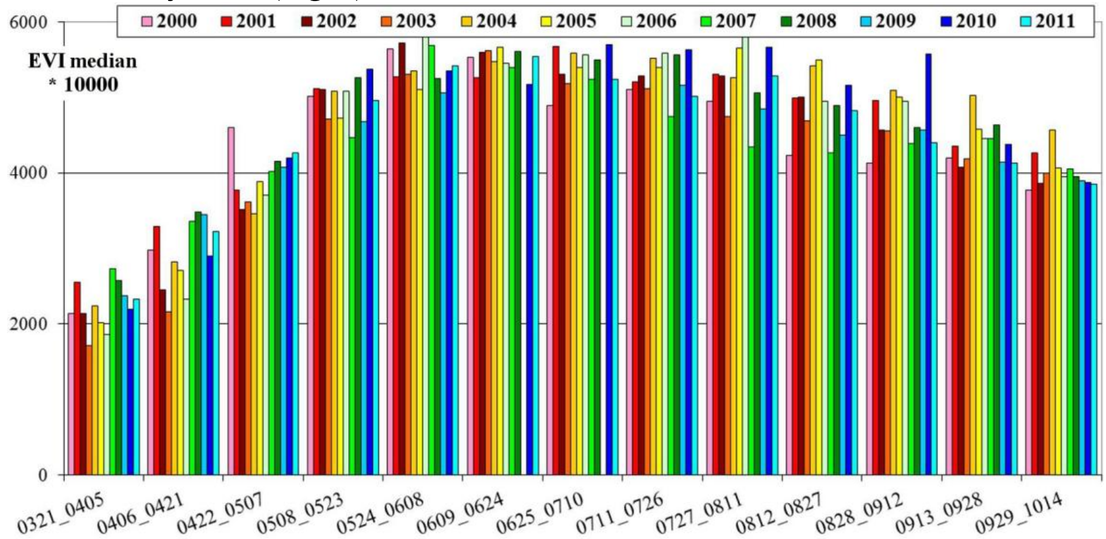

Figure 3. EVI median monthly values of deciduous forests (2000-2011)

The index value amounts to a sudden decrease in the dry years, well seen on vulnerability within a short period of time: 2000, 2003, 2007, 2011. Can be expressed in terms of climate change, the time series of monthly balance amounts, despite rainfall values (2004-2006, 2010) does not increase the biomass. In terms of annual amounts are typical 3-4 year periods.

The spatial distribution of development, of course, determining the condition of forests in four months (May, June, July, August) are decisive. The date of the most significant biomass production regarding differences between the various indices (EVI deciduous forest: June; coniferous: July).

Temporal and spatial analysis of deviation from the average helps the designation of areas at risk due to temporary and permanent reduction of biomass (Fig.4.). Overall, the negative characteristic differences. Forests quarter shows a negative deviation; 25 % are vulnerable to climate change. Seven percent of this difference is more than -0.25 EVI. A positive deviation of 42 % of the area is greater; over +0.15 EVI. Worst situation is in mixed forests, the negative difference in 38 % of the area observed (as well as the NDVI 30 %).

3.2. Long term changes in the area of Upper Kiskunság Lakes

As a matter of water management measures from the 19th century, and precipitation decrease from the 1970s the most striking change of wetlands has occurred in the century subsequent to the 1880s. During this period 84 % of water-rich areas disappeared and only 5 % of the total area remained waterlogged (Fig.5.) [6]. Conversely, after the extensive inundations of the 1999-2000 period and 2006 low water cover values, characteristic of the 1980s, returned shortly.

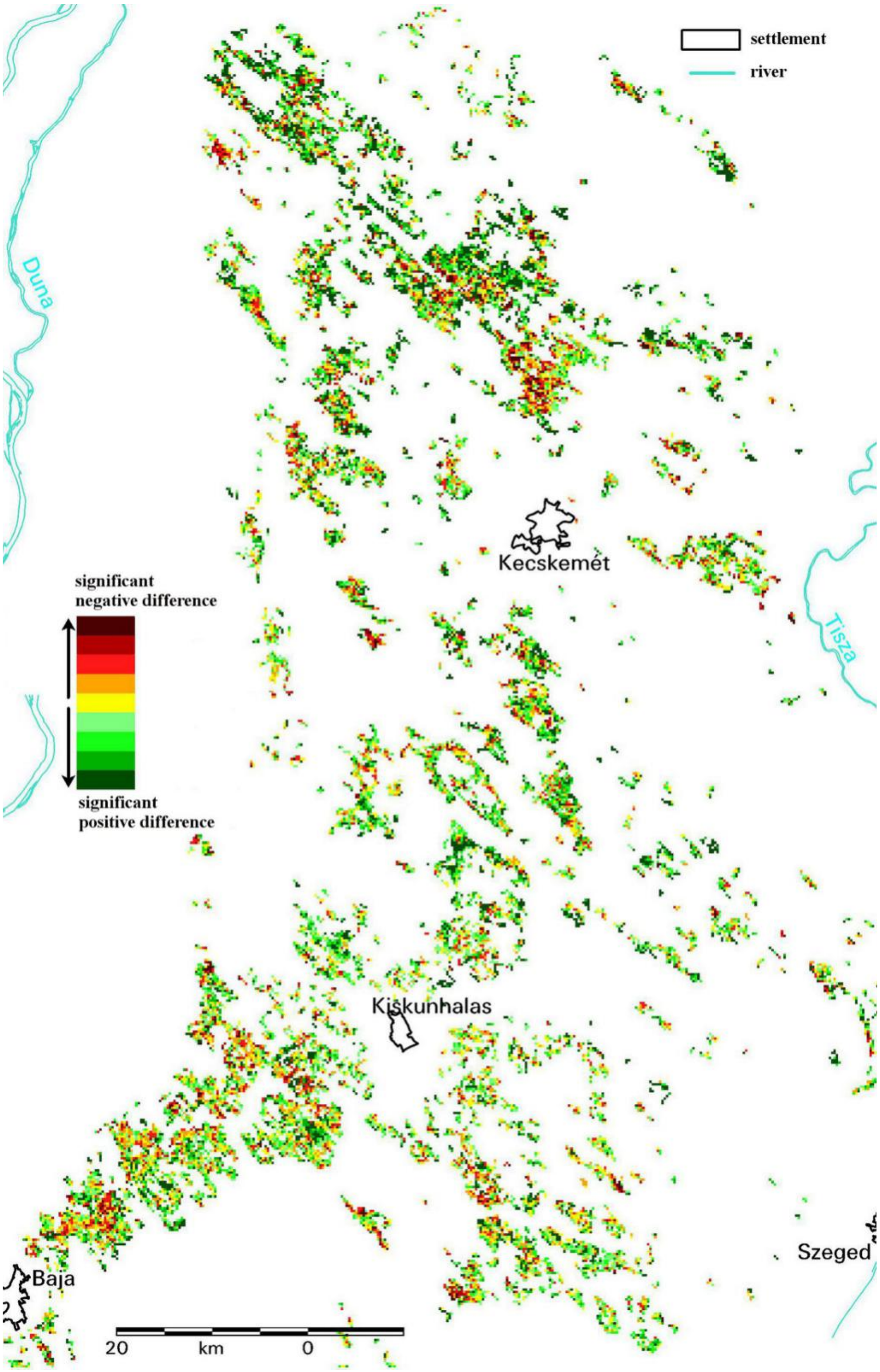

Figure 4. Climatic and spatial sensitivity of the sample area based on EVI index (2000-2011)

Regarding Figure 6, the category of “permanently waterlogged” stands for areas being swampy and covered by water for the entire 130 year study period. Wetland patches delineated in years of close to average precipitation are classified as “usually waterlogged“, while areas inundated during high waters are named “occasionally waterlogged”. The category of “moderately drying” stands for areas which underwent a lake to swamp or swamp to dryland transition and also for territories which were covered by water only during the greatest inundation periods. The class of “drying” collects those originally waterlogged territories which were usually dry in the past few decades. If the dry phase was continuous and permanent since the 1980s the patch was considered to be "severely drying". The category of "getting wetter" signs an opposite process and marks surfaces which were originally dry but become waterlogged. When determining the degree of degradation, especially because there were questionable areas, two scenarios, an optimistic and a pessimistic were outlined. In case of the optimistic version always the more favourable, i.e, higher water content category was attributed for ambiguous patches (for example in case of overlapping between categorises such as "occasionally waterlogged" and "moderately drying"), while in case of the pessimistic version evaluation was made the other way around.

Based on the spatial analysis of the 1999–2003 period, 22 % of the study site had a variable water content, though the degree of variation was moderate. The optimistic and pessimistic versions of the long term analysis were refined with the spatial results of temporal variability, meaning that those patches were analysed further where variations were low. Based on the refined map, the aridification value of the pessimistic version decreased from 33.5 % to 24.7 %. This way 20 % of the study site would remain a wetland. The 6.5 % value on the optimistic map decreased to 5.6 %.

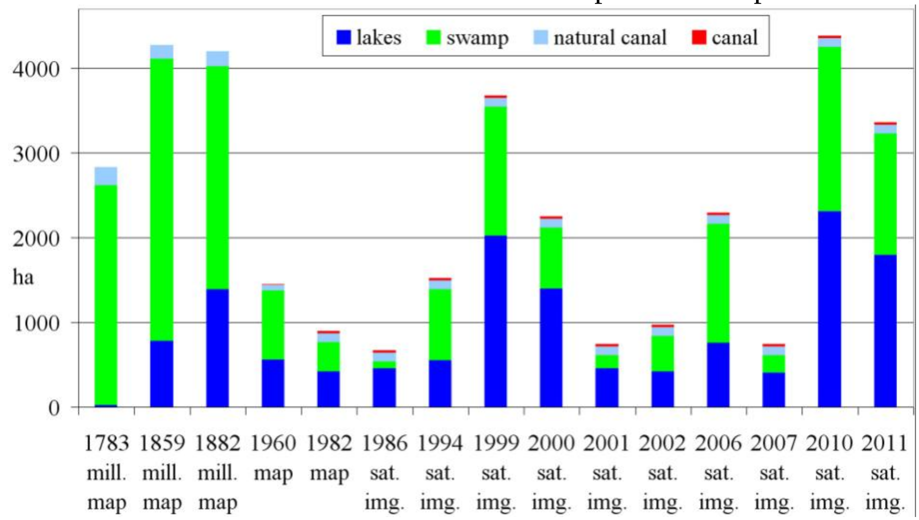

Figure 5. Hydrogeographical change of wetlands

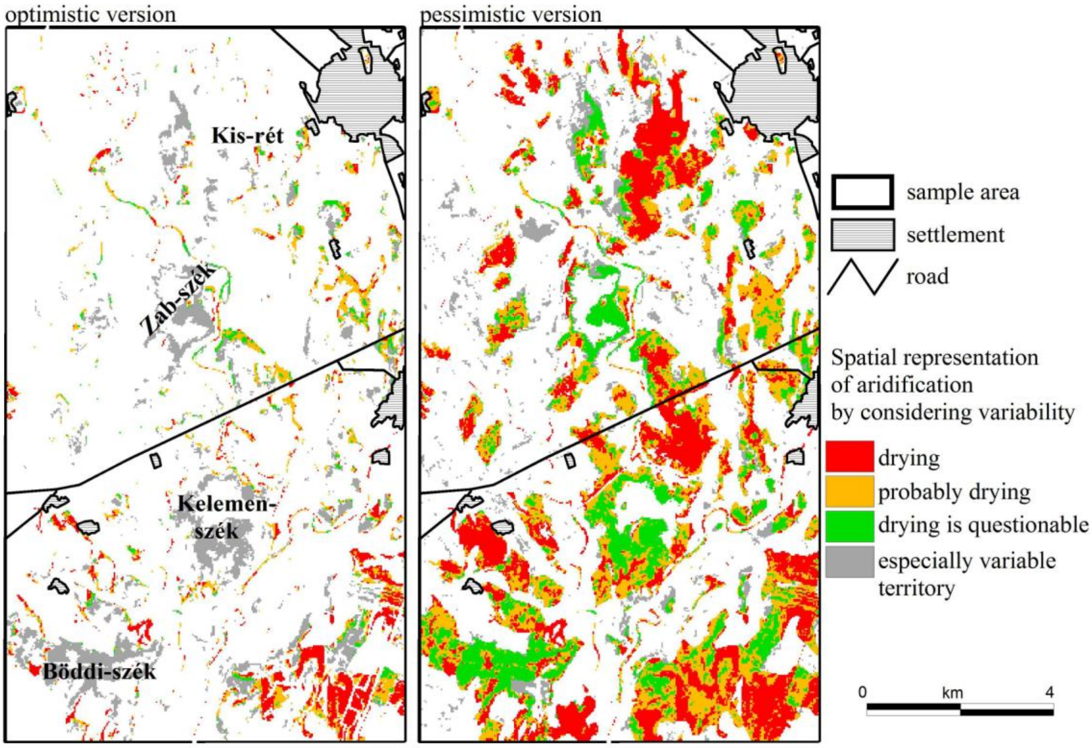

Figure 6. Spatial representation of aridification by considering variability

4. Conclusions

The aridification, drought problem; the expected rate of problems can be well evaluated in the landscape factors examined. It would be wrong if the highly variable plots only one position will be adopted. Frame to the landscape change regarding. Continuous mapping of a large and highly variability areas be solved only by remote sensing methods.

After a dry 1980 candidate from the late '90s, when wetter years are favorable, but no positive effect overall. Much of the area is only partially revived for a short time and can result in precipitation.

Acknowledgements

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