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AGRICULTURAL IMPACT OF THE EXPOSURE TO CLIME CHANGE IN THE ROMANIAN PORTION OF TISZA RIVER BASIN

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Abstract: *Clime change represents an important issue for the scientific community regardless of the specific field of study due to the environmental effects and impacts on the economy (especially agriculture) and human communities. The environmental impacts include the loss of biodiversity (species and ecosystems), while agricultural impacts include the exposure to heat, changes of the precipitation regime, and dispersion of diseases and pests. The assessment of particular scenarios related to changes of temperature and precipitations plays a central role among clime change studies, including predicted impacts on the ecosystems. This study addresses the exposure to clime change in the Romanian part of the Tisza river basin, using a novel approach based on the Geographical Information Systems modeling in conjunction with factor analysis to pinpoint the most affected counties based on clime data reflecting the current situation and 2100 predictions by generalizing the micro-scale situation at the county level. The results suggest that the actual precipitations explain 85% of the clime variability, the counties most affected by predicted clime change (Arad and Timiş) are situated in the western part of the region, and the economic sector most affected by predicted clime changes is agriculture, provided the predominance of agricultural areas in the most affected counties. While consistent with other studies, the results benefit upon the strength of the statistical tools, and could be used by the local authorities from the territorial units at risk to elaborate strategies resulting into the mitigation of effects and diminishing the agricultural loss. The methodological limitations of the study are first of all due to the fact that it relies on predictions, which in their turn assume the climatic response to increased greenhouse gases of the National Center for Atmospheric Research climate model, CCM3, at T42 and T170 resolutions, and due to the over-generalizing effects of GIS modeling.*

Keywords: *clime change, agricultural impact, exposure, GIS, factor analysis, Tisza*

INTRODUCTION

Due to the environmental effects and impacts on the economy (especially agriculture) and human communities, clime change represents an important issue for the scientific community regardless of the specific field of study. The assessment of particular scenarios related to changes of temperature and precipitations have a central place among clime change studies, including predicted impacts on the ecosystems. The environmental impacts include the loss of biodiversity (species and ecosystems), while agricultural impacts include the exposure to heat, changes of the precipitation regime, and dispersion of diseases and pests (SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY, 2007; CONDÉ AND RICHARDS, 2008; PETRIŞOR, 2010).

Due to these effects, the ESPON project “Climate Change and Territorial Effects on Regions and Local Economies in Europe” aims to classify the European regions based on the predicted impacts of clime change, defined in terms of several concepts: (1) exposure: nature and degree to which a system is exposed to significant climatic variations, (2) sensitivity: degree to which a system is affected, either adversely or beneficially, by climate related stimuli, (3) adaptive capacity: ability of a natural or human system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences, and (4) vulnerability: degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (GREIVING ET AL., 2009). Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

The current study is part of the Romanian contribution to the project, and aims to assess the exposure to clime changes in the Romanian part of the Tisza river basin, as part of a case study carried on by researcher from Hungary and Slovakia in addition to the Romanian ones, using a novel approach based on the Geographical Information Systems modeling in conjunction with factor analysis to pinpoint the most affected counties based on clime data reflecting the current situation and 2100 predictions by generalizing the micro-scale situation at the county level.

MATERIAL AND METHODS

Data were downloaded from the DIVA-GIS project developed by Robert Hijmans, freely available from http://www.diva-gis.org in a program readable by a Geographical Information Systems (GIS) application called DIVA-GIS. The program can be downloaded from the same webpage and used free of charge. In addition, the software is compatible with other GIS-type products, including ESRI ArcView 3.X used for the next analyses (HIJMANS ET AL., 2001). DIVA-GIS was used to read the climate data and export them as shape files (ESRI ArcView format). The spatial projection was changed from WGS-1984 to the Romanian National System, STEREO 1970. A subset for the Tisa river basin was clipped using the Geoprocessing Wizard in ArcView (ESRI, 1999). Two data sets were used: (1) the actual clime data set was described by HIJMANS ET AL. (2005); two subsets, referring to temperatures and precipitations, computed for a 2.5^0 longitude × 2.5^0 latitude grid and covering the period 1950-2000, were used; (b) predicted climate data for 2100, described by GOVINDASAMY ET AL. (2003), are based on $2\times CO_2$ concentration and CCM3 model, and use SSTs based on those from NCAR coupled model, Climate System Model (CSM); data were computed for a 2.5^0 longitude × 2.5^0 latitude grid and cover the period 1950-2000.

The 2.5^0 longitude × 2.5^0 latitude grids were interested with the county boundaries using the Geoprocessing Wizard in ArcView. The results consisted of grid units or fractions of these assigned to each country. The Geoprocessing Wizard in ArcView was used to compute the average values of actual and predicted temperatures and precipitations within each county using the “dissolve” option. This function deleted the boundaries between grid units within the counties, producing polygons corresponding to each county, with the average values of actual and predicted temperatures and precipitations assigned to each county (Figure 1). Four datasets, corresponding to the four variables, were the start point for determining the exposure. A fifth dataset, containing all variables, was derived using the spatial assignment function in the ArcView Geoprocessing Wizard. The DBF file associated with it, containing the four variables, was used for the factor analysis.

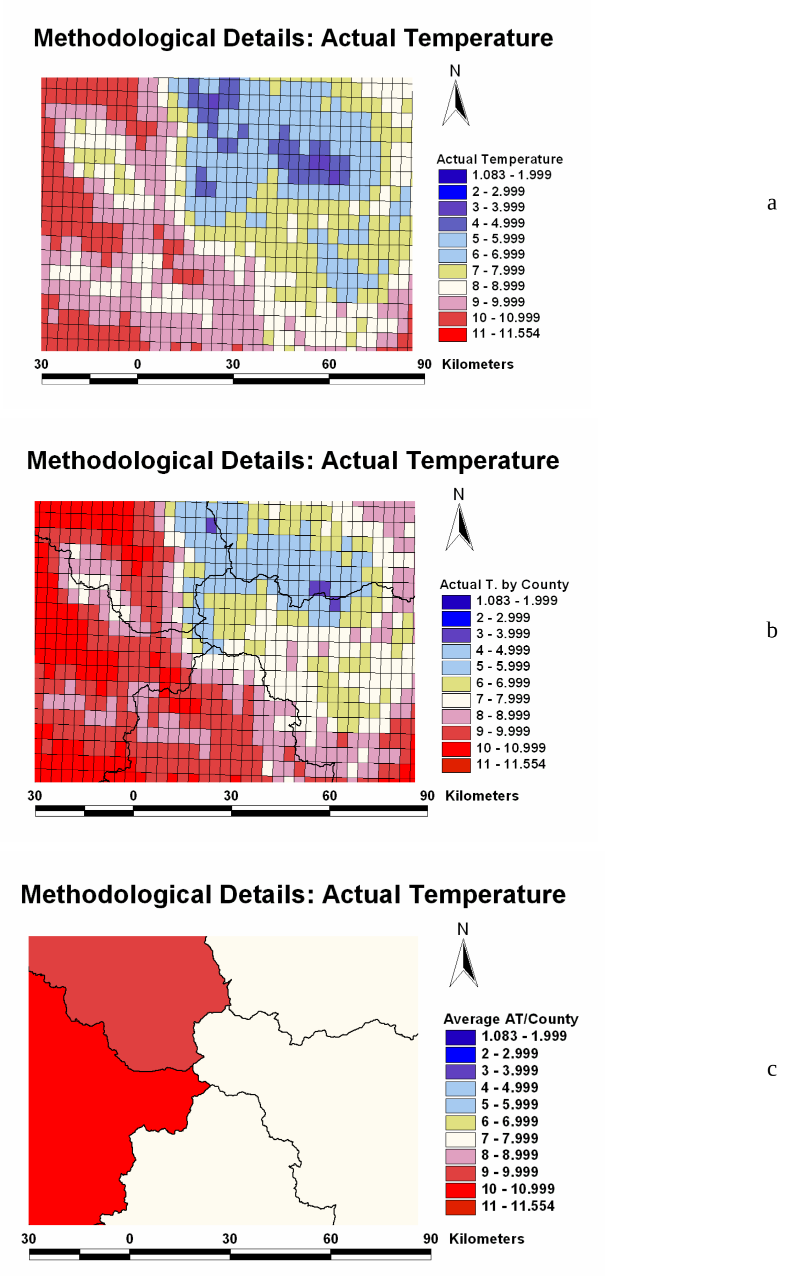

Figure 1. Displaying details of the methodology used to derive average values per counties: actual temperature exemplified: (a) raw 2.5^0 longitude × 2.5^0 latitude grid data; (b) 2.5^0 longitude × 2.5^0 latitude grid data clipped by county boundaries; and (c) county averages of actual temperatures.

Factor analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 12 (SPSS, 2003). The extraction method used was Principal Component Analysis The four variables were the actual temperature (AT), predicted temperature (PT), actual precipitations (AP), and predicted precipitations (PP). The results are displayed in Table 1 below.

The results suggested that only one variable, the actual precipitation, explains 85% of the variance and the other ones should be disregarded. However, in the absence of other data, we decided to keep all variables, but assign them in the final model weights proportional with the percentage of variance explained.

GIS modeling employed the ArcView Model Builder extension (ESRI, 2000) to build a final map of the exposure. The model started with the four datasets described previously. Each dataset was processed due to the software requirements, and the final results were overlaid based on the weights derived from the factor analysis (Table 2), with several slight modifications explained below.

Table 1

Displaying the results of the factor analysis. Extraction Method: Principal Component Analysis

Total Variance Explained			
Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
AP	3.4150000	85.375	85.375
PP	0.5450000	13.631	99.006
AT	0.0400000	0.992	99.998
PT	0.0000651	0.002	100.000

Table 2

Displaying the weights and classes used in the GIS modeling of exposure

Variable	Weight (%)	Values	Class
PT	1	8.51 - 9.48	1
		9.48 - 10.45	2
		10.45 - 11.41	3
		11.41 - 12.38	4
		12.38 - 13.35	5
AT	1	5.82 - 6.82	1
		6.82 - 7.81	2
		7.81 - 8.81	3
		8.81 - 9.80	4
		9.80 - 10.80	5
PP	13	585.37 - 620.88	5
		620.88 - 656.39	4
		656.39 - 691.91	3
		691.91 - 727.42	2
		727.42 - 762.93	1
AP	85	616.11 - 647.82	5
		647.82 - 679.52	4
		679.52 - 711.23	3
		711.23 - 742.93	2
		742.93 - 774.64	1

The final reclassification of each variable uses a 1 to 5 scale, minimal values being assigned to highest temperature classes, respectively to lowest precipitation classes. Their combination also uses a 1 to 5 scale, 5 corresponding to the highest level. The final model is displayed in Figure 2.

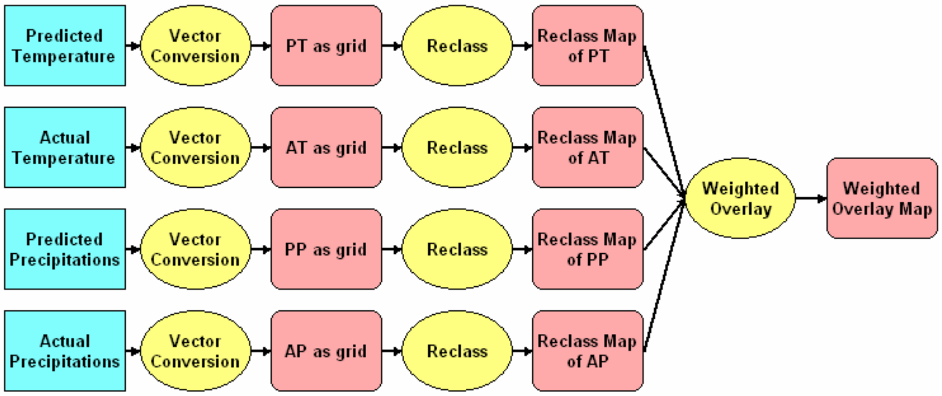

Figure 2. Displaying the GIS model of exposure to clime changes in the Romanian part of Tisa river basin

The modified weights reflect our intention to keep all variable in the models. Consequently, variables explaining less than 1% of the variance received weights equal to 1%, and weights of variables explaining more than 1% were truncated to their integer value.

The resulting map was compared with the land cover in order to pinpoint the most affected systems.

RESULTS AND DISCUSSIONS

The results, displayed in Figures 3 and 4, consisted of four maps corresponding to each variable at NUTS level III (counties) within the Romanian part of Tisa river basin (Figure 3) and one final map (Figure 4) resulted from running the GIS model presented in the previous section. The figure suggests that the two counties from the west of the region, Arad and Timiş, will suffer mostly due to clime changes.

If the map displayed in Figure 4 is overlaid with the land cover, depicted in Figure 5, it can easily be noted that the economic sector most affected by predicted clime changes is agriculture, provided the predominance of agricultural areas in the most affected counties.

The methodological limitations of the study are first of all due to the fact that it relies on predictions, which in their turn assume the climatic response to increased greenhouse gases of the National Center for Atmospheric Research climate model, CCM3, at T42 and T170 resolutions – horizontal grid spacing of 300 and 75 km respectively (GOVINDASAMY *et al.*, 2003). Second, while GIS modeling allows for extrapolating the results at a different scale, it tends to over-generalize them especially when moving from the micro to the macro-scale.

CONCLUSIONS

1. The results suggest that the actual precipitations explain 85% of the clime variability.

2. The counties most affected by predicted clime change are situated in the western part of the region.

3. The economic sector most affected by predicted clime changes is agriculture.

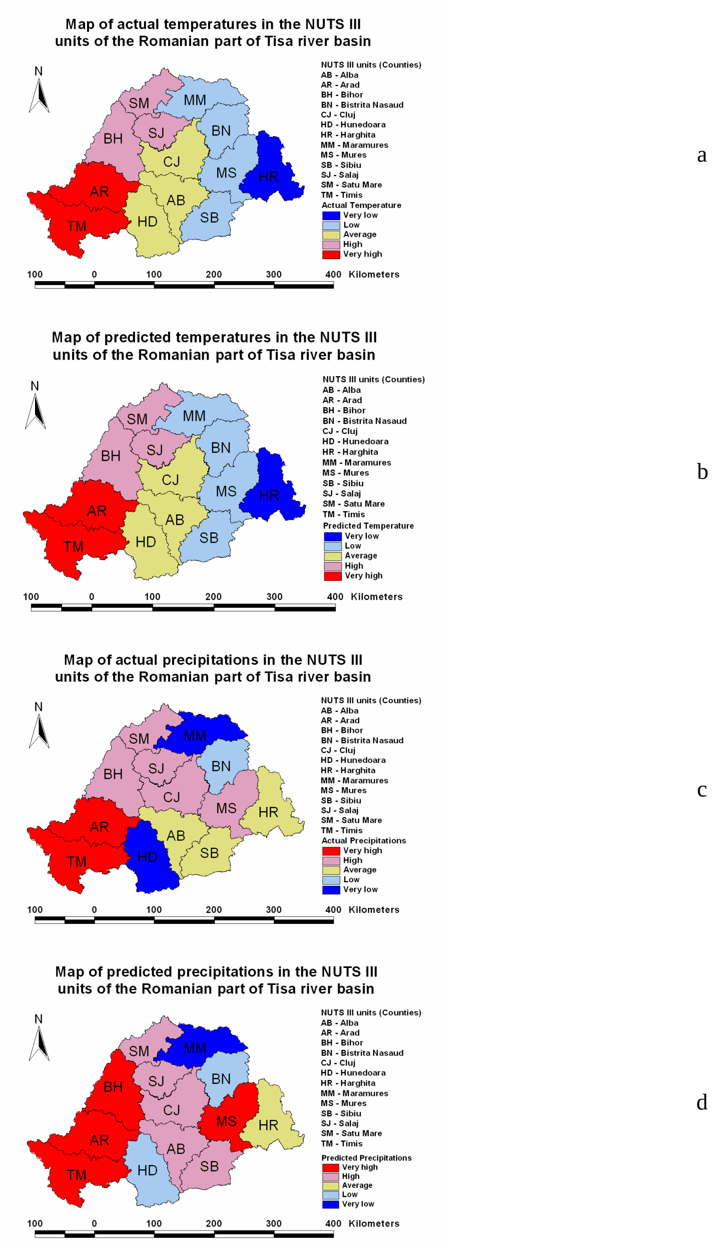

Figure 3. Describing the exposure to climate change in the NUTS III units of the Romanian part of Tisa river basin for each variable individually: (a) map of the distribution of actual temperatures; (b) map of the distribution of the predicted temperatures; (c) map of the distribution of actual precipitations; and (d) map of the distribution of the predicted precipitations.

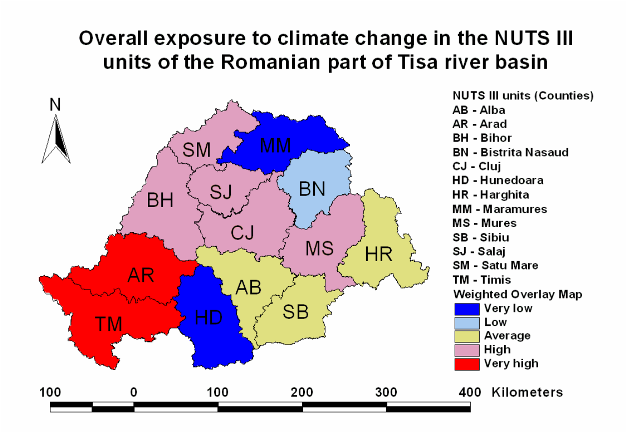

Figure 4. Describing the overall exposure to climate change in the NUTS III units of the Romanian part of Tisa river basin

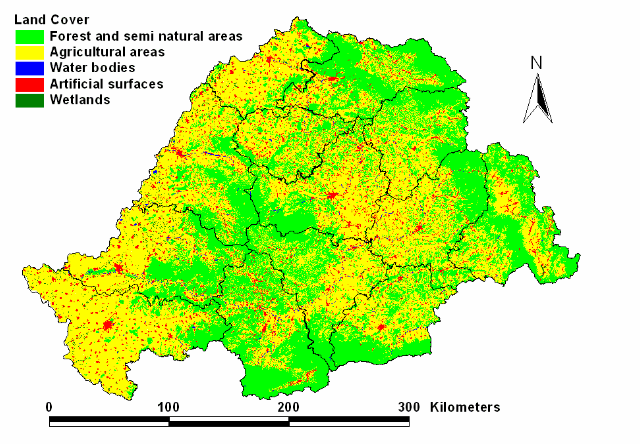

Figure 5. Land cover of the Romanian part of the Tisza river basin

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