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# ASSESSING THE VULNERABILITY TO CLIMATE CHANGE IN THE ROMANIAN PART OF THE TISZA RIVER BASIN

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**ABSTRACT** - Clime change represents a current and important issue; in addition to the disputed global warming, at local or regional levels, floods could also be a consequence of this phenomenon. If the potential effects are assessed in terms of exposure, sensitivity, and vulnerability, a GIS methodology, based on statistical indicators and GIS modelling was used to assess the overall vulnerability of the Tisza river basin and define the flood-prone area. Even though specific indicators exhibited high values in some NUTS III units, the overall vulnerability of the regions appears to be low.

**Keywords**: clime change, adaptability, vulnerability, Tisza, CORINE

## INTRODUCTION

Clime change is 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. Evaluating particular scenarios related to changes of temperature and precipitations has a central place among clime change studies. 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, p. 9; Condé and Richards, 2008, pp. 3-4; Petrişor, 2010).

Taking into account the importance of these issues, 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, p. 2). 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 conducted by researchers from Hungary and Slovakia in addition to the Romanian ones.

An important clime change issue relates to floods, due to their catastrophic effects. From a planning perspective, it is important to delineate the flood-prone region in order to substantiate a strategy consisting of "do-s" and "don't-s" regulating the human activities within. While other

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countries which share the Tisza river basin (*e.g.*, Hungary or Slovakia) had such a region precisely defined by law (Jelinek et al., 2007, p. 17; Slovak Hydrometeorological Institute, 2006, p. 7), Romania has a different situation. If using the principles regulated by Law no. 575 of 2001 on the national spatial plan – areas at risk (Parliament of Romania, 2001), according to which the area could be defined by the sum of NUTS V/LAU II units where such events occurred, the flood-prone region of the Romanian part of the Tisza river basin consists of all but one such units, covering 1/3 of the national territory. Such an approach is not consistent with the reality; the explanation consists of neglecting the temporal scale (such events occur more or less frequently in different places), as well as the spatial one (the flood-prone area within such units does not consist of the entire administrative territory, but of a smaller section).

A precise delineation should take into account the geomorphology of the territory. Parameters such as slope, geological structure, and hydrographic features are crucial; in addition, floods could be due to the runoff, as well as due to the existing water bodies and courses. Since the assessment of the first requires a digital elevation model analyzed using specific tools, such as the GIS-based viewshed analysis (Buhmann and Pietsch, 2008), used in conjunction with statistical hydrographical data, and because such advanced instruments were not available, we focused on a definition based on existing water bodies and courses. Provided that such a definition is not complete, the paper proposes it as a start point for further research, and not as a final output.

Within this framework, the use of CORINE data can play an important role in assessing the impact of clime change (Petrişor, 2008). Starting from the definitions given by Jensen (2000, p. 13) according to which land cover characterizes what is actually there from a biophysical viewpoint, Petrişor et al. (2010) considers that land cover is reflected by the first level of CORINE classification (CLC1: artificial/urban areas, agricultural regions, forests/semi-natural areas, wetlands, water), while land use, reflected more or less detailed by the last two CORINE levels, shows the designation of each parcel based on the type of geosystem, *i.e.*, "natural use" in natural or less anthropized systems that preserved their structure in time, and socioeconomic use for medium/strongly anthropized systems. The first class of CORINE – level 1 is "urban/built-up area", and presents a particular importance for planning purposes.

The study presented in this paper aims to propose a definition of the flood-prone region and calculate specific environmental indicators assessing the vulnerability of clime change using a GIS-based methodology relying on CORINE data within the Romanian part of the Tisza river basin.

## DATA AND METHODS

The study utilized three datasets: (1) Romanian territory subsets of 1990 and 2000 CORINE land use (level 3) data, freely available for downloading from the European Environment Agency at the URL http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=1109, (2) data on Romanian water bodies and courses and (3) the NUTS III divisions of the national territory, both from the National Institute for Research and Development in Constructions, Urbanism and Sustainable Spatial Development URBAN-INCERC, URBANPROIECT branch.

Defining the flood-prone area relies on building buffers around the water bodies and courses. The width of the buffer is proportional to its importance; the important courses have a larger buffer (500 m), while the minor ones have a smaller buffer (100 m). Following the definition of the region, the vulnerability was assessed overlaying other layers of information.

In order to exemplify the methodology, the following images exemplify the computation and analysis of a specific ESPON – Climate indicator, the share of built-up areas within the flood-prone region. *Figure 1* displays the entire flood-prone region, defined by merging all the buffers; a detail is displayed in *Figure 2*.

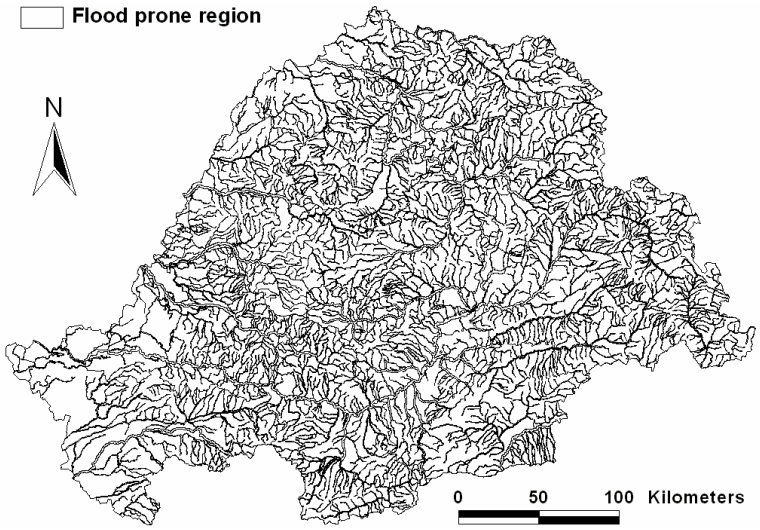


**Figure 1.** *The flood-prone region in the Tisza river basin (black)*

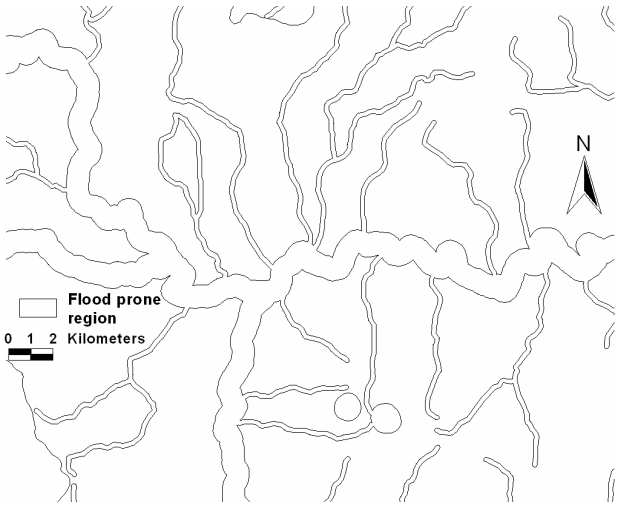


**Figure 2.** *Detail of the flood-prone region in the Tisza river basin*

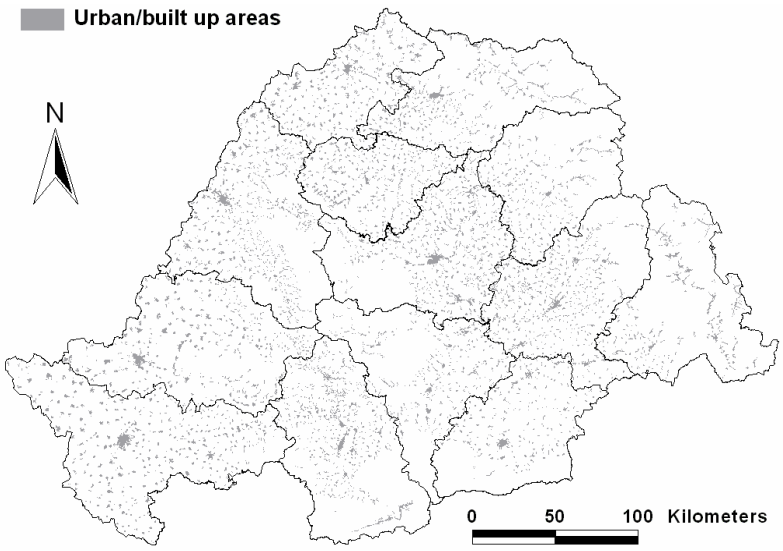


**Figure 3.** *Urban/built-up areas in the Tisza river basin*

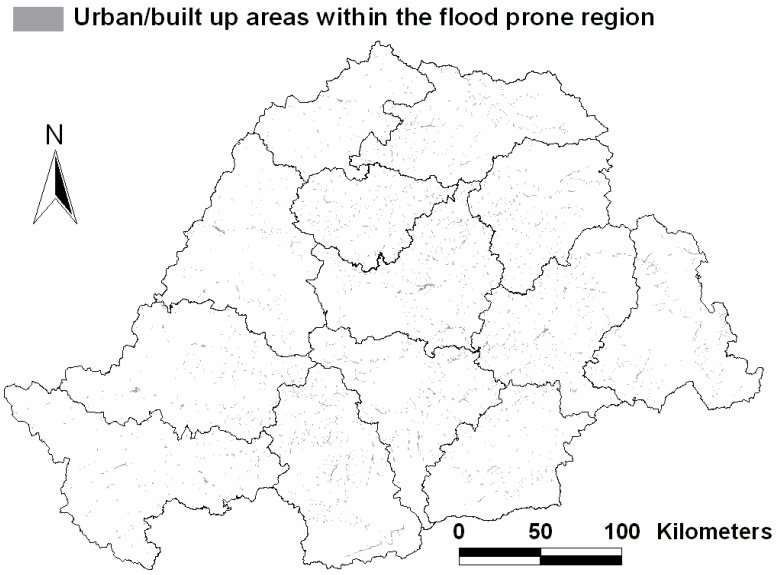


**Figure 4.** *Urban/built-up areas within the flood prone area in the Tisza river basin*

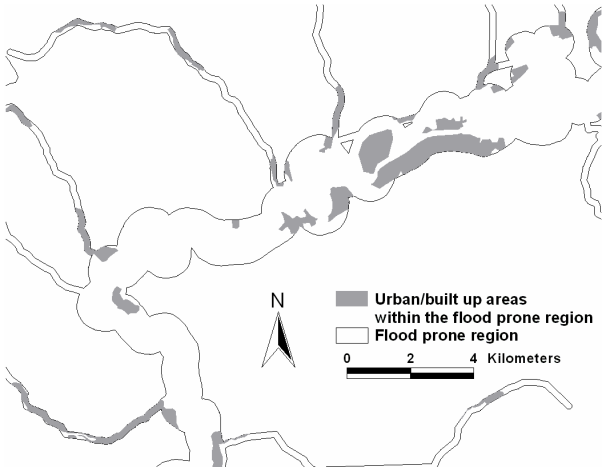


**Figure 5.** *Detail of the flood-prone region in the Tisza river basin*

The next step consisted of selecting the urban/built-up areas of the Tisza river basin (*Figure 3*) situated within the flood prone region (*Figure 1*). The result for the entire basin is displayed in *Figure 4*, and a detail presented in *Figure 5*. The selected areas were clipped by the limits of NUTS III units (counties) in order to perform the computation of the specific indicators, using the Spatial Analyst extension of ArcView 3.X. The results were tabled values for each NUTS III unit. The values were displayed as chloropleth (graduated colour) maps, defining each time five classes (corresponding to very low, low, average, high, and very high values) using the "natural breaks" grouping in ArcView, chosen as the best way to pinpoint the gaps of the spatial distribution of the values of each indicator between the NUTS III units.

## RESULTS AND DISCUSSION

The results are displayed below. *Table 1* summarizes the NUTS III values for several indicators; their spatial distribution is displayed in the maps presented in *Figure 7* to *11*: the share of urban/built-up areas (*Figure 7*), the share of arable land, vineyards and orchards (*Figure 8*), the share of major highways (*Figure 9*), the share of connecting roads (*Figure 10*), and the share of railroads (*Figure 11*).

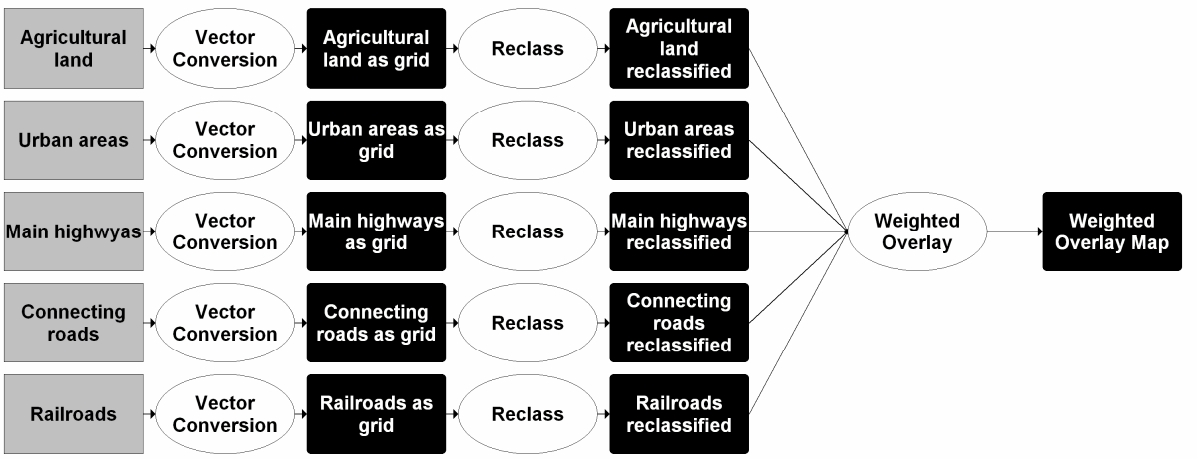


**Figure 6.** *GIS model for assessing the overall vulnerability based on the weighted overlay of the spatial distributions of selected indicators within the flood region in the Tisza river basin*

**Table 1.** *Values of specific indicators assessing flood vulnerability in NUTS III units (counties) of the Tisza river basin (values indicate the share of area situated within the flood region)*

| County | % urban/built up areas | % major highways | % connecting roads | % rail-roads | % arable land, vineyards, and orchards |
|---|---|---|---|---|---|
| Timiş | 32.86 | 7.57 | 10.34 | 10.90 | 58.14 |
| Satu Mare | 18.02 | 6.70 | 6.10 | 9.59 | 45.41 |
| Sălaj | 13.40 | 26.31 | 18.62 | 32.13 | 24.34 |
| Sibiu | 31.51 | 6.91 | 6.26 | 14.42 | 13.98 |
| Mureş | 18.46 | 20.67 | 21.66 | 70.38 | 23.30 |
| Maramureş | 32.68 | 25.35 | 20.43 | 52.17 | 7.92 |
| Harghita | 25.42 | 25.29 | 18.05 | 41.33 | 9.23 |
| Hunedoara | 30.51 | 41.56 | 22.29 | 63.58 | 7.82 |
| Cluj | 28.18 | 21.68 | 20.75 | 35.33 | 23.11 |
| Bistriţa-Năsăud | 26.02 | 38.66 | 23.96 | 33.74 | 13.69 |
| Bihor | 24.16 | 5.88 | 7.21 | 10.03 | 32.79 |
| Arad | 8.70 | 19.35 | 13.99 | 18.76 | 40.30 |
| Alba | 8.53 | 18.86 | 21.17 | 18.59 | 17.74 |

The different indicators do not show a consistent pattern. Only the communication routes (major highways, connecting roads, and railroads) seem to be well developed on a gradient exhibiting high values from the south to the northeast of the region.

In a final step, a GIS model (*Figure 6*) was developed to combine the information offered by the six indicators used in the study: the share of urban/built-up areas, the share of arable land, vineyards and orchards, the share of major highways, the share of connecting roads, and the share of railroads. Since the first one describes the social vulnerability, the second assesses economic vulnerability, and the last three ones describe all together the infrastructure, the weights assigned to them correspond to the sectors: the share of urban/built-up areas – 33%, the share of arable land, vineyards and orchards – 33%, the share of major highways – 12%, the share of connecting roads – 11%, and the share of railroads – 11%. Slightly higher shares assigned to indicators in some sets reflect their importance. The indicators are relevant for the physical vulnerability, including the transport infrastructure, economic activities (agriculture), and social impacts (against the urban/built-up areas).

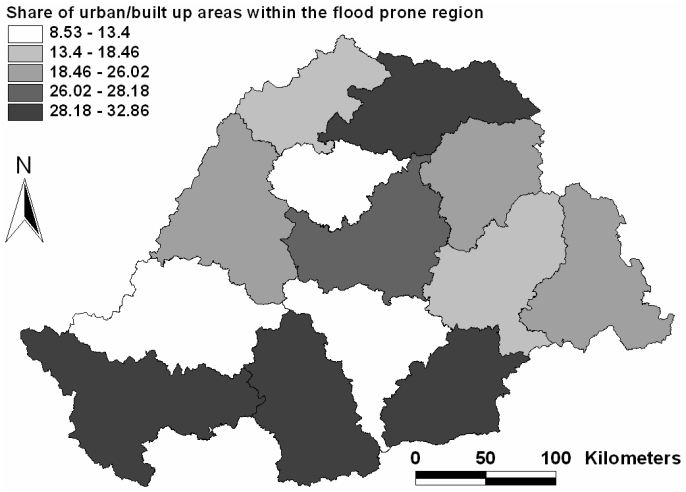


**Figure 7.** *Distribution of the share of urban/built-up areas within the flood region in the Tisza river basin per NUTS III unit*

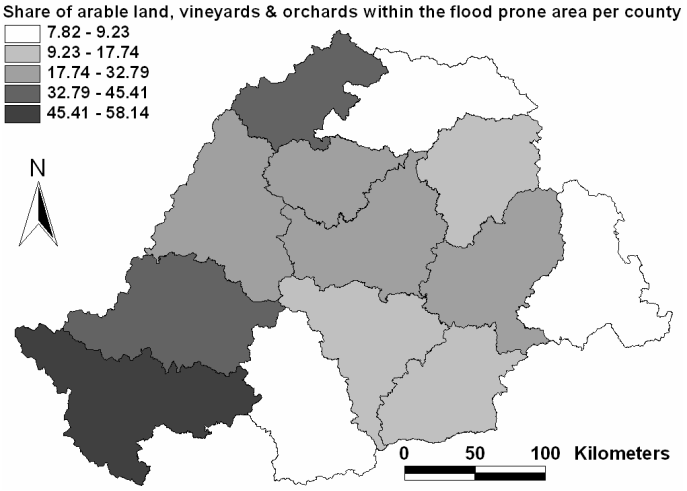


**Figure 8.** *Distribution of the share of arable land, vineyards, and orchards within the flood region in the Tisza river basin per NUTS III unit*

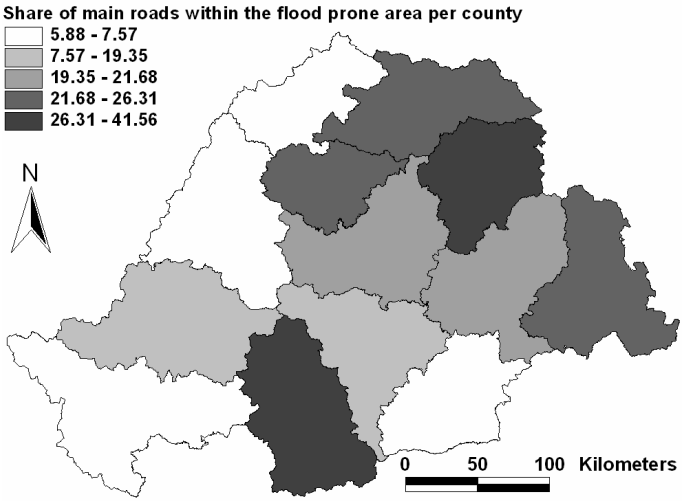


**Figure 9.** *Distribution of the share of major highways within the flood region in the Tisza river basin per NUTS III unit*

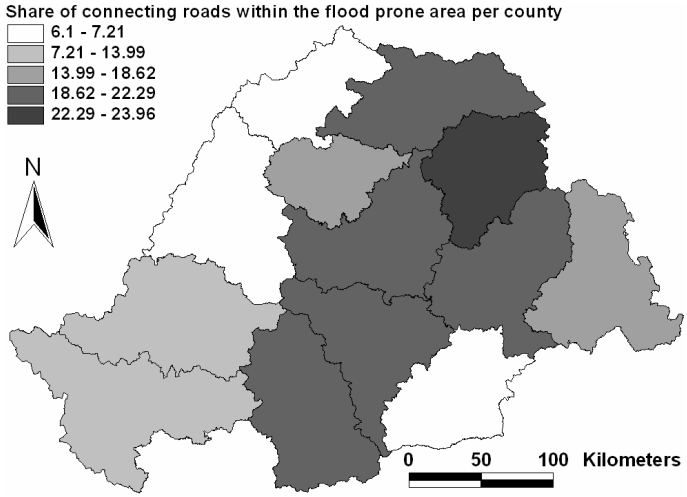


**Figure 10.** *Distribution of the share of connecting roads within the flood region in the Tisza river basin per NUTS III unit*

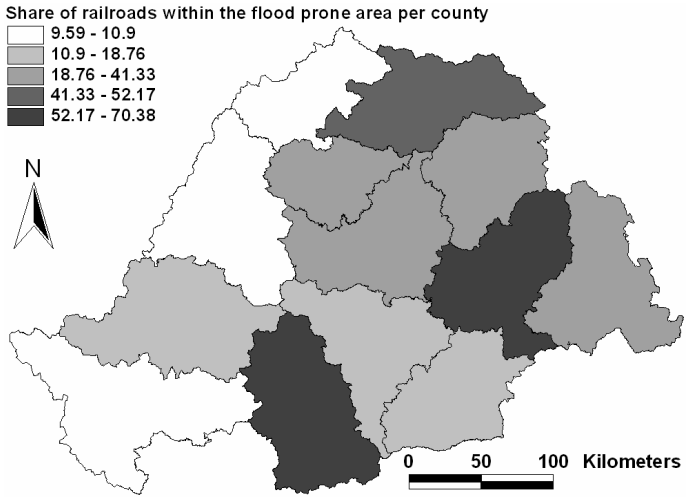


**Figure 11.** *Distribution of the share of railroads within the flood region in the Tisza river basin per NUTS III unit*

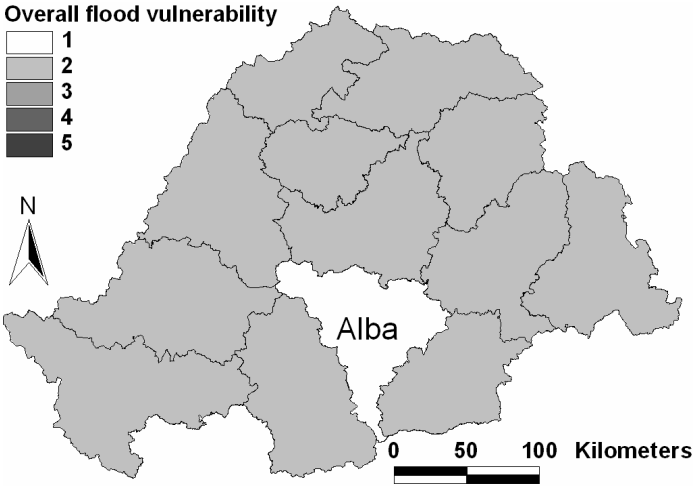


**Figure 12.** *Distribution of the overall vulnerability within the flood region in the Tisza river basin per NUTS III unit*

The final map, resulted from overlaying the spatial distributions of all selected indicators within the flood region using the weights presented in the methodological section, is displayed in *Figure 12*.

The generalized final map indicates that the overall vulnerability is low in most counties and very low in Alba County. In conclusion, even though climate change could represent an issue, the results indicate that floods are not likely to prevent the development of the region, based on assessing the economic, social and infrastructure dimensions of development using the indicators proposed by the research project.

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