GIS for Environmental and Landscape Assessment
(A Case-Study: Târnava Mare River Corridor, Transylvanian Tableland)

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***Abstract**: This paper is focused on the minimum data sets for environmental and landscape indicators. The study was structured on the following steps: setting up the environmental indicators; configuration of database (type and quality of database); using the data sets and indicators on GIS support. The methodology of study and results of Digital Terrain Model (DTM) and Land Cover Data Sets assessment are presented. Some preliminary landscape metrics were calculated - using Patch Analyst extension of ArcView package - on the basis of both CORINE data set, and a 1:50000 land cover map. All preliminary results will be implemented into the Digital Terrain Model analysis and object-oriented image analysis for this area.*

Introduction

Policy makers and the public at large need reliable and well-synthesized information about the environment without getting lost in detail. This is why experts have recently expressed increasing interest in a reduced number of environmental indicators selected from existing larger data sets. The call for higher-order, more integrative indices is also becoming louder and reservations continue to be voiced about the limitations of aggregated indices, their perceived opacity, and potential for misinterpretation.

By combining the information contained in two or more indicators, aggregated indices make it possible to convey simple messages about complex environmental issues. Among their strengths is the potential to simplify the public communication process and to reach audiences that currently receive little environmental information at all. However, reducing the number of indicators by condensing information also runs the risk of misinterpretation because users are not always aware of the scope and limitations of the index methodology, and because the message conveyed may be distorted by data gaps.

However, the indicators'relevance varies by country and by context. They must be reported and interpreted in the appropriate context, taking into account places'different ecological, geographical, social, economic and institutional features.

The article discusses the various aggregation methodologies used for each of the indicators and identifies the strengths and weaknesses of the resulting indices for decision making and public information. The methodology is applied to assess the environmental decline in Copşa Mică area and Târnava Mare Corridor (Romania).

The Copşa Mică Area, one of the Europe's most polluted sites, is situated within Târnava Mare Corridor (part of Transylvania Tableland) in central part of Romania (Figure 1) and its environmental decline is due to the pollution type and its effects upon territorial systems, human health, ecosystems, quality of life and more environmental components (air, soil, water, vegetation, fauna, other human components).

From environmental point of view, Târnava Mare Corridor is a very interesting region because the relations between environmental system and human activity are very unstable. As an economic and human axe of the Târnavelor Tableland, the corridor is a distinctive region, geographically and environmentally ("junction environmental region").

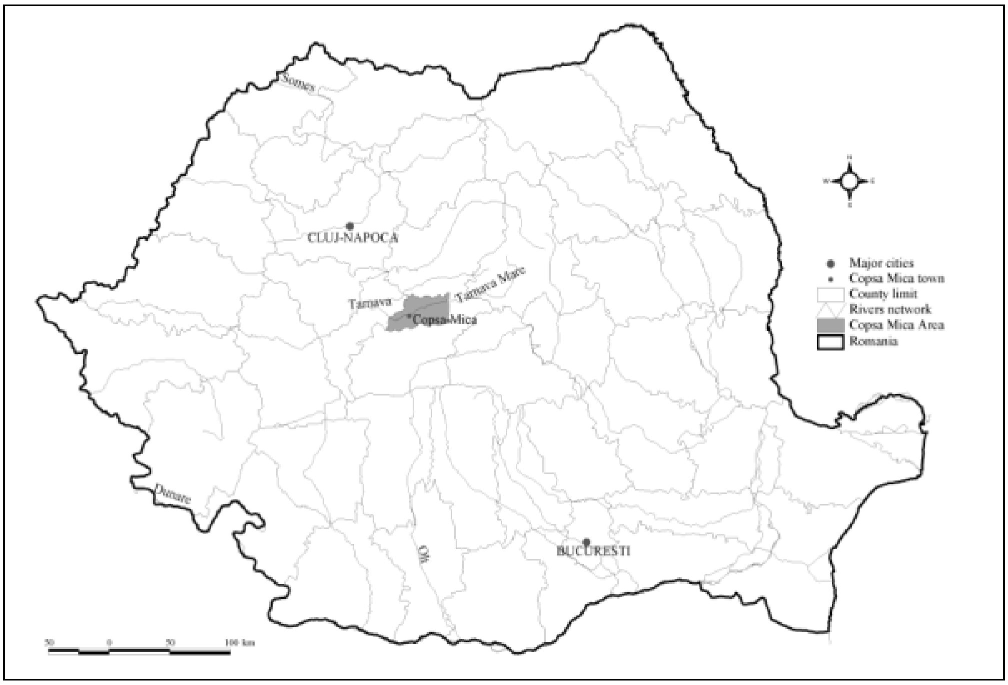

Figure 1. The Geographical Location of Copşa Mică Area in Romania
and Târnava Mare River Corridor

We may consider Târnava Mare Corridor as a „running and convergent" environmental model (Muntean, 2003), where Târnava Mare River and Copşa Mică Area were determinant factors. Practically, the human activities capitalized the entirely natural components and influencing them at a large scale.

The study was structured on the following steps: setting up the indicators: environmental indicators; quality of life indicators; others indicators (demographical, social, health, geographical); configuration of database (type and quality of database); using the data sets and indicators on GIS support.

Material and method

The methodology of analysis and assessment of environmental decline (Muntean et al., 2003) is based on:

- Integrated Territorial Analysis (ITA) of geographical components;
- Environmental Impact Assessment (EIA) of environmental decline (based on RIAM matrix elaborated by Pastakia and Jensen in1998);
- Aggregated Environmental Index (AEI, viewed as a tool for planners and decision factors);
- EIA based on combined Leopold's Matrix and RIAM (Muntean, 2004);
- the assessment of human pressure (index of human pressure based on following indicators: demographical pressing; environmental resources, infrastructure; human impact on the environmental components);
- The build up of environmental data base and using GIS approach based on large part of these indicators.

All data and indicators of our study were selected from official data and scientific reports existing in Romania (Environmental Assessments and Studies, Urban General Plan, Legal Normative, Environmental Protection Agency reports).

The environmental indicators are regarding to: terrain attributes, water, atmospheric features, natural vegetation, fauna, soils, buildings, habitational space, green spaces, and landscape indicators.

The quality of life indicators (social, economic, health) are focusing on: human health, life expectancy, rate of unemployment, educational achievement, and level of incomes (UNDP, 2002).

All these indicators are presented and evaluated to obtain an aggregated environmental index (AEI), which is an expression of the RIAM matrix assessment (Muntean *et al.*, 2003). This AEI has some methodological and practical advantages: is easy to "read" and "understand" by decision makers and assessors; facilitate an objective comparison between different areas and environmental components; is useful to realize a map of environmental impact.

The selection and building of the minimum data sets are actions which depend on the data quality, data accessibility, importance and relevance of environmental data within the Romanian context. Despite of all official reports, this context is characterized by "uncertainty" and partial lack of environmental data.

GIS techniques sustained the decline assessment and they were used for: mapping the environmental components; cartographic presentation of the EIA results (environmental scores); evaluating the human pressure on the territory and mapping the land use/land cover categories of Târnava Mare Corridor.

The main outcomes of these actions were represented by some thematic maps of Copşa Mică area and Târnava Mare Corridor: map of environmental impacts; map of human pressure on territory; map of land use/land cover (European CORINE base, 1992) (Figure 2).

The selection of minimum data sets for landscape indicators. We consider that the standardization amongst CCMS partners is a very important point in order to get comparable results, based on the similar methodologies.

Even if methods are the same, their application on different data sets (in term of quality, resolution, scale) will lead to different outputs. The standardization is a requirement which is strongly dependent on data availability and accessibility at local and national level.

We realized an assessment of the most available data sets, whose results could be used as a starting point towards the necessity of data sets standardization. In our case, these types of datasets are: Digital Terrain Models (ASTER DEM, SRTM) to derive terrain attributes and Land Cover data sets (CORINE LC) to capture landscape structure indicators.

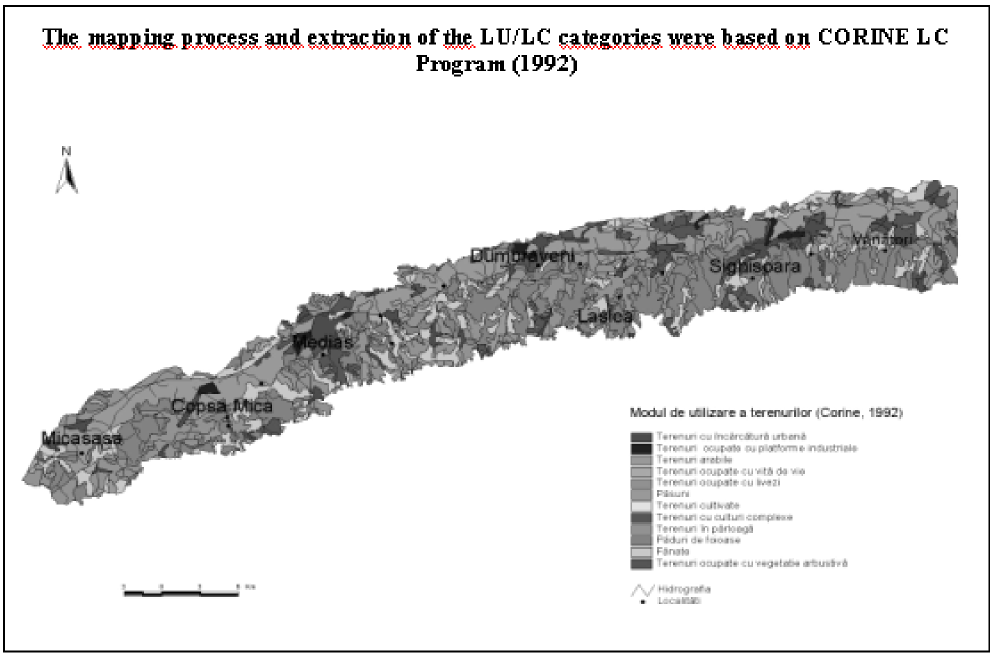

Figure 2. Map of Land Use/Land Cover in Copşa Mică Area and Târnava Mare Corridor

The DTM assessment was based on ASTER (Advanced Space Borne Thermal Emission and Reflection Radiometer) DEM and SRTM (Shuttle Radar Topography Mission). These DTMs were chosen to be evaluated because of they are the most available DTMs.

They were compared against 10 m contour lines generated DTM and we observed some errors in the stream flow direction. The visual comparison between different DTMs shows us these errors (Figure 3).

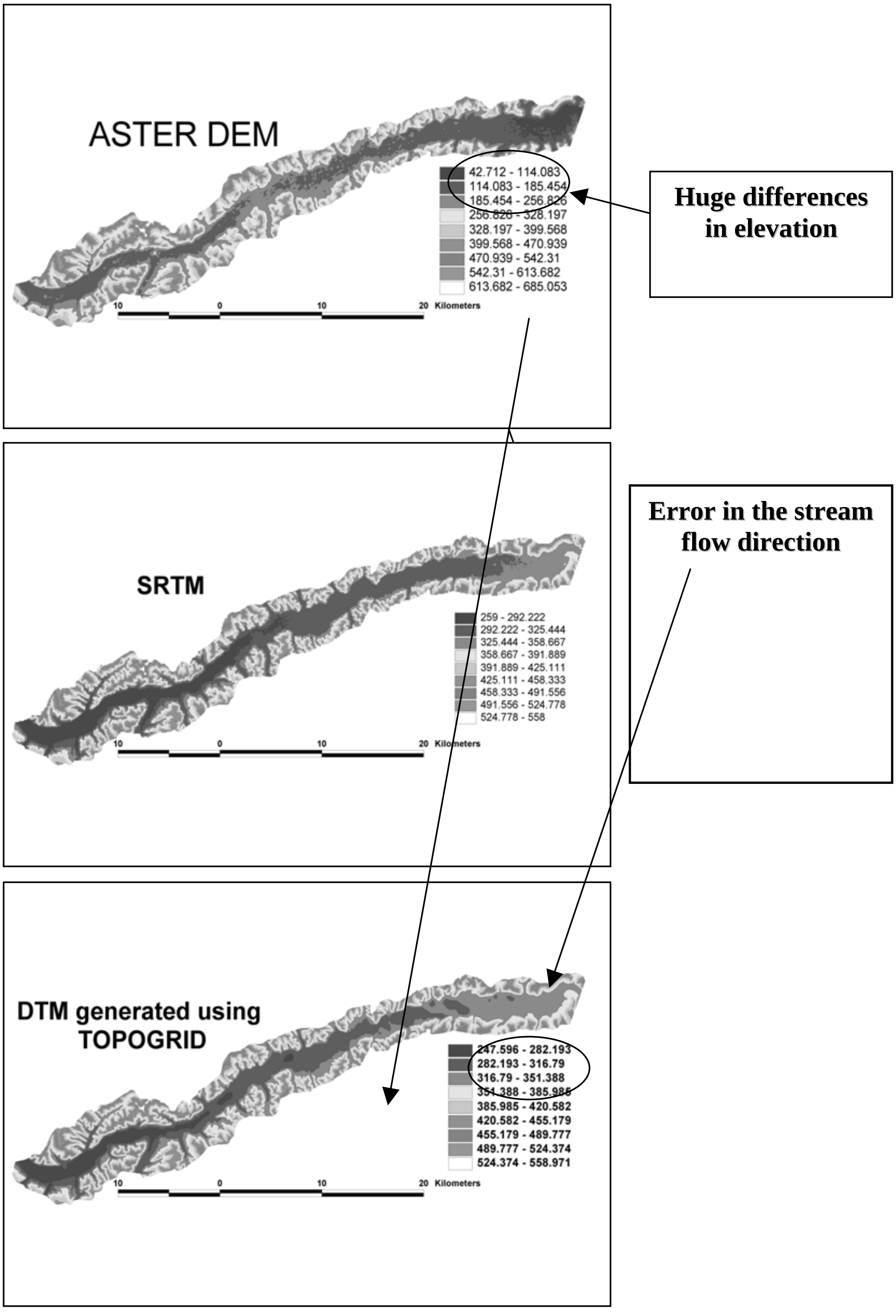

Figure 3. Visual comparison between different DTMs and differences within the images

Because of it is broadly available for European space, we choose the CORINE LC data set in our evaluation. Some landscape metrics index, namely number of classes (NC), mean patch size (MPS), edge density (ED), and Shannon's diversity index (SHDI) were calculated (using Patch Analyst extension of Arc View package) on the basis of both CORINE data set, and a 1:50000 land cover map.

Landscape metrics on 1:50000 land cover map basis and CORINE LC dataset were calculated. Although the two data sets presented are built at different scales (1:50000 vs. 1:100000), a great part of index are surprisingly close in term of values.

Even if absolute values are very different (see ED), they are however proportional, which means that landscape structure is correct assessed eventually.

Number of classes were reduced in two situations, because of merging together small areas of less important land cover categories (e. g. vineyard).

Very close values are also obtained for MPS and SHDI. However, for the Copşa Mică area, which covers a more fragmented hilly area, the values of SHDI are quite different. This happens because areas less than 15 ha are captured in the CORINE data set as homogeneous agricultural areas.

Results and discussion

Although there are important differences in resolutions between SRTM (90 m) and contour lines generated by DTM (10 m), elevations stand within a range of difference of under ± 50 m. Differences in elevation are recorded mainly in the sharp contact areas. ASTER DEM is very different from the contour lines generated DTM in term of elevation range (± 150 m).

Practically the two surfaces appear too far away from each other to be useful. Better results might be obtained by using absolute models, but this would make the acquisition more complicated. Whether the 90 m resolution of SRTM is considered satisfactory, and its assessment in other areas produce results as good as in our area, this dataset could be used within the CCMS national projects in order to assure comparable outputs.

After this preliminary assessment, CORINE data set seems to be confident enough for landscape metrics applications. This assessment and its results could be discussed and applied in the future development of our project.

Conclusions

The next step in our study is to develop a distributed model of the landscape in order to use resulting facets as basis for the environmental assessment and planning. This model is based on Digital Terrain Model analysis and object-oriented image analysis (eCognition 3.0), following a methodology created by Blaschke and Drăguţ in 2003.

The next challenge is the validation of the methodology, indicators, database and results in practice through the calibrating of the spatial model of Copşa Mică area and Târnava Mare Corridor. So, we shall try to realize some comparisons between our results and similar studies or methodologies made in other countries.

Acknowledgements

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References

Blaschke, T., Drăguţ, L. (2003), *Integration of GIS and object-based image analysis to model and visualize landscapes*, ISPRS workshop "Challenges in Geospatial Analysis, Integration and Visualization II", September 8- 9, 2003, Stuttgart, Germany, 18-23.

Mac, I., Muntean, O.L., (2000) *Geosystem: constraints and environmental decline*, The 29th International Congress of Geography, Abstracts book, 189-190, Seoul.

Muntean, O. L. (2004) *Impactul antropic asupra mediului înconjurător în Culoarul Târnavei Mari (sectorul Vânători-Micăsasa). Studiu de evaluare şi planificare a mediului înconjurător*. Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca.

Muntean, O. L., (2003), *A study of environmental reconversion in Copşa Mică area (Romania)*. Würzburger Geographisches Manuskripte, Heft 63, Würzburg am Main.

Muntean, O. L., Drăguţ, L., and Baciu, N. (2003) Environmental decline assessment in Copşa Mică area (Romania). EcoSys, Bd. 10: 98 – 106, Kiel.

Pastakia, C. M. R., Jensen, A. (1998), *The Rapid Impact Assessment Matrix (RIAM) for EIA*, Environmental Impact Assessment, 18: 461- 482, Elsevier.

UNDP (2002), *Human Development Report*, Oxford University Press.