IMPLEMENTATION OF GIS TECHNIQUES IN THE FORECAST OF SOIL EROSION IN THE WATER CATCHMENT ANTOHESTI, BACAU COUNTY

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Abstract

This paper introduces a modern solution for the determination of sloping land soil loss due to water erosion, based on Geographic Information Systems technique. Within the GIS project contemplated herein, the georeferential data is developed and represented as information layers, fact that enables the analysis of space variables and distribution of entities on the reviewed area. Thus, the overall analysis of acquired information can be performed through the so-called „overlay" technique**,** which implies the concomitant approach of several information layers, approach based on computation laws and procedures set out by the user. The endpoint of the GIS application consists of a thematic map that shows the surface erosion, in multiple options/scenarios.

Key words: *GIS, water erosion, spatial analysis*

The use of the Geographic Information Systems technique for the management of certain environment-related parameters is nowadays something common. These techniques are widely used for both the studies related to small areas (of few hectares) and for regional or even national impact studies. In the activity against soil erosion, the purpose of a Geographic Information System (GIS) consists of ensuring the acquisition, data storage and processing in order to acquire information which could synthetically and at all times characterize the status and evolution of soil degradation processes through erosion, torrentiality sedimentation, in order to ensure the decision-making, in due time, by the persons in charge with regional management.

The use of GIS is required and in particular justified due to the possibilities related to the analysis of the multitude of factors with spatial distribution involved in triggering and the performance of erosion processes, high costs and long time required for the monitoring thereof by means of other methods, in particular on large areas (Biali and Popovici, 2003).

One of the main components of a Geographic Information System is the database: graphic database (layouts or geo-referenced maps in a projection system) and alphanumeric or attribute-type database (non-graphic).

Within a GIS, the geo-referenced data is presented as layers, fact that facilitates the review of spatial variables and the distribution of entities on the reviewed surface, and the global review of acquired information, which implies the concomitant approach of several layers, can take place through the so-called *"overlay"* technique. The "overlay" technique is based on overlaying operations or combination of several layers (based on specific algorithms - determined by the user), which generate new layers and new attributes, respectively (*figure 1*).

MATERIAL AND METHODS

The assessment of erosion risk by means of GIS techniques in Antohesti water catchment area was performed based on USLE (Universal Soil Loss Equation) equation, equation with the largest applicability for the computation of soil loss, used in Romania, in the form proposed by Moţoc M. (Moţoc M., Tuhai A., 1998):

$$E = K \cdot S \cdot L^m \cdot i^n \cdot C \cdot C_s$$

where: E (t/ ha · an) is the annual average loss of soil through surface water erosion;

K (t/ha·an) - regional erosivity; the loss of soil by pluvial aggressiveness areas;

L^m (m) - length of drainage; m = 0.3 - 0.4

i^n (%) - average gradient of the land; n = 1.4

S - the erodability of the soil);

C - impact factor of use, crops and soil works;

C_s - impact factor of existing soil preservation actions.

Each parameter included in the universal equation of soil erosion represents an information layer within the database of the GIS project herein,

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and the thematic map on erosion risk represents the end product of such information system.

The chart below synthetically sets out the data used for the contemplated study and the output information, following the application of the Information System, for the above mentioned purpose.

RESULTS AND DISCUSSIONS

All these maps (presented in *figure 1*) were scanned with a 600 dpi resolution, and afterwards, in a first stage, these were subject to vectorization (the conversion of raster graphics into vector graphics) and afterwards to the geo-reference thereof into a reference system XY (*figure 2.a*); each level curve also received the third dimension, namely Z quota (*figure 2.b*).

We should mention that this study was performed in the „raster model", where above all the above mentioned information layers is placed a rectangular grid with square cells of 25 x 25 m (Biali and Popovici, 2003).

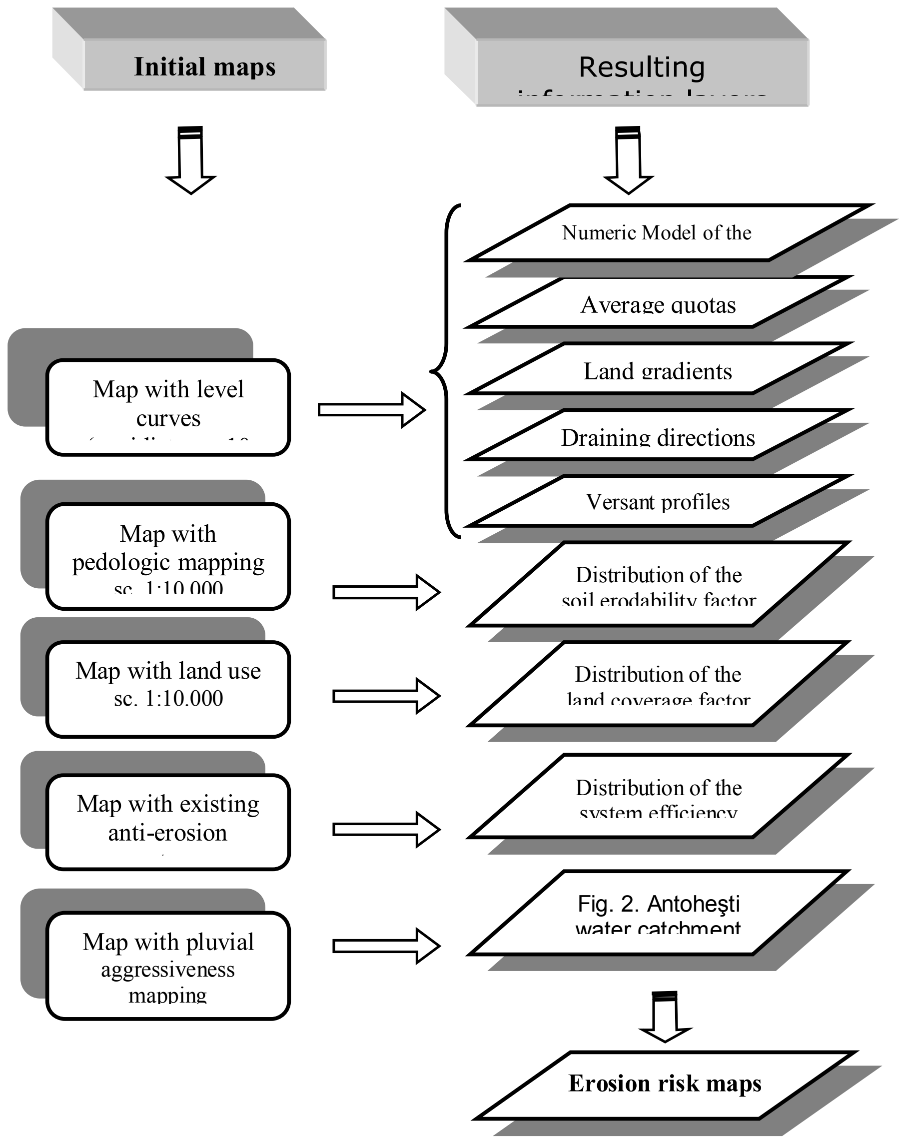

Figure 1 **Layers of geo-referenced graphic data on soil erosion forecast**

Thus, the entire processing as well as the acquired thematic maps referred to the cell level. The cell size was mainly determined based on the landscape nature and variation of the distribution of parameters included in the soil erosion forecast (soil, coverage of lands with various uses, distribution of areas with existing anti-erosion systems etc.).

Because the landscape-related information (L,I) is critical for modeling the erosion processes on gradient lands, and the numerical expression thereof has significant benefits, determined by the celerity of processing and compatibility with numerical mapping techniques.

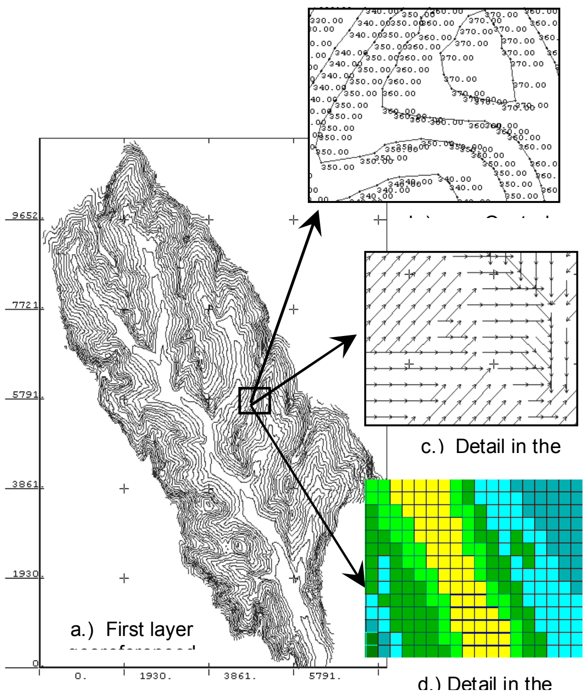

Figure 2 Antoheşti water catchment area – examples of information layers which characterize the landscape

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Name	↑Ext	Size	Date
[..]		<DIR>	11.11.2002 13:16
Cote	dbf	1.877.480	20.08.2002 20:07
Directii	dbf	1.877.480	20.08.2002 20:15
Eroziune	dbf	1.877.480	20.08.2002 20:17
Folosint	dbf	2.743.996	20.08.2002 20:16
Pante	dbf	1.877.480	20.08.2002 20:16
S_coef	dbf	65.252	21.08.2002 14:50
Sisteme	dbf	2.743.996	20.08.2002 20:17
Soluri	dbf	2.743.996	20.08.2002 20:17

Figure 3 "Dbf" files which set up the alphanumeric database of the GIS project

Here, the Numerical Land Models (MNT) enabled the performance of fundamental layers, such as:

- the map of gradients / land declivity or gradient (which integrates both the structure and morphogenesis effects) (*figure 2.d*);
- the map of versant exhibition/orientation (indirectly shows the evolution and dynamics of various geomorphological versant processes);
- map of lengths and draining directions (*figure 2.c*).

By accepting as usual source for the performance of a MNT the topographic maps with level curves, for a satisfactory reproduction of the landscape, three important factors have been taken into consideration: the scale of the map, the grid pace (size of the elementary cell or of the pixel), and the interpolation order.

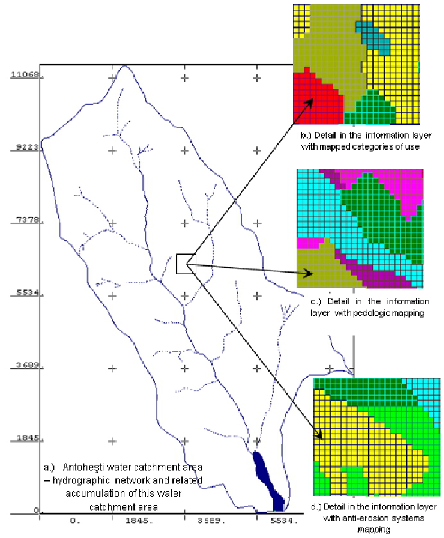

Figure 4 Antoheşti water catchment area - information layers concerning soils and landscaping (by color codes)

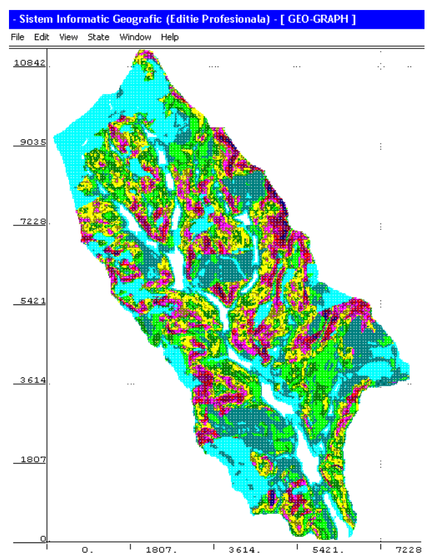

Figure 5 Antoheşti water catchment area - thematic map of soil loss due to erosion

As shown in *figure 1*, in addition to the level curve map, the maps with soil mapping, of the categories of use and anti-erosion systems of the analyzed water catchment area were also used (*figure 4.a*). Similarly, these have been subject to vectorization and were geo-referenced based on the same system of axes (in order to ensure a correct overlaying during the processing stage). This was followed by one of the most important stages of the GIS project, namely the development of topology.

The topological structure (in our case of polygon type) enabled us to develop the structure of the spatial database files, which are critical for the operation of the information system: the update, overlaying of areas, and delineation of entities by defining the frontiers (neighborhoods). The lack of topological relations in a vector representation significantly reduces the interrogation opportunities.

To this end, each graphic object on the plan (e.g., a certain type of soil- figure 4.c, or a category of use - *figure 4.b*) represents, within the system, a graphic entity defined by a unique number in the graphic database and placed by means of XY coordinates, and, according to the approached research method, is divided into square cells of 25 x 25 m (*figure 4 b, c, d*). In the attribute-type database (alphanumeric), for each cell one can find the characteristics (values) relevant in order to determine the soil loss due to erosion. All such data was stored in filed managed under the Database Management System (SGDB) of relational type FoxPro 2.6 under Windows (*fig. 3*).

Thus, for each cell which contains the data required for the "universal equation of soil erosion" within the used information system, the soil loss due to water erosion was determined (*figure 5*).

We should mention as follows:

- the size of the cell can be changed automatically (based on the set up of topology);
- the opportunities ensured by a GIS enable the simulation of a variety of land management cases, and for each separate case a different map is generated.

CONCLUSIONS

The use of GIS techniques enables the easy, computerized storage and processing of complex spatial and alphanumeric data originating from various sources and which characterize a certain region.

The implementation of the Geographic Information Systems in the study of erosion processes on large areas enables a complex monitoring of the versant soil quality and the planning of the most appropriate protection and preservation actions related to the fertility thereof.

Compared to other assessment processes of the productive potential of certain agricultural plots of land impaired by permanent degradation processes, the GIS techniques provide the decision makers in the regional management field with information in real time and at much lower costs.

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