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APLICATIONS OF THE GIS TECHNIC IN EVALUATING THE EROSION PROCESS ON THE SLOPE LANDS.

BY

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Abstracts: This paper presents a GIS application to prognosis and evolution process of land degradation through erosion. The results from the research show the advantages of using these GIS techniques and argues the importance of this area of environmental engineering.

Using Geographical Information Systems technology for the management of environmental parameters has become a normal fact.

These techniques can be used both for studies undertaken on small areas (by the order of a few hectares) and for impact studies of regional or even national level.

Key words: GIS, erosion pixel, programs, model MMT.

1. Introduction

Both globally and in our country, erosional degradation processes particularly affect the agricultural land, because of "coverage" worse that they provide land for agriculture but and inability to adapt farming practices to the requirements of perfect soil protection and conservation, subject to the above processes.

In Romania, this process of degradation (pollution in modern organic sense) is extended to almost half (47%) of the agricultural area of the country, that on about 7 million hectares, [4].

The negative effects of erosion are considerable for Romania, especially through continuous decline of soil fertility by clogging river and lakes, by impairing communication lines and socio-economic targets located in towns or on the slopes or the environment (by pollution, degradation of microclimate, geographical landscape of ruin, damaging people's living conditions, depopulation).

Using Geographical Information Systems technology for the management of environmental parameters has become a normal fact.

These techniques can be used both for studies undertaken on small areas (by the order of a few hectares) and for impact studies of regional or even national level.

2. The Importance of the Subject and Research Locations

When referring to the establishment erosional risk, especially large areas, this approach involves detailed knowledge of all factors involved in the process of degradation, that the parameters characterizing climate, topography, soil, the use of land, farming technologies, etc.

Given however that all these parameters have a spatial distribution, or receive a certain amount at each point in space, this complex action of monitoring can be achieved only within a spatial information system, [3].

If we want to establish the risk of the erosion, especially on a bigger plan, this approach involves the detailed knowledge of all the factors that participate in the process of deterioration also of all the parameters that characterize the weather, the relief, the soil, the way of utilization of the land, the technologies of agricultural exploitation. Knowing that all these parameters have a spatial distribution (which means they all have a certain value in each point of the space) the complex action of monitoring could be realized only in a informational system of the space (spatial informational system), [1].

By introducing this kind of technology a whole ecological monitoring could be obtained and in this way the capable parts could watch in a permanent condition the situation of the natural resources, generally the environmental factors and also of the anthropological impact, based on the parameters and measurements of spatial coverage and also of the temporal coverage which would assure the information necessary for the strategy and tactics to prevent the consequences of the environmental factors and of the human activities, to elaborate the prognoses and the distribution of the operational control over the actions of amelioration of the ecological situation, [5].

This study presents the GIS techniques referring to the evolution of the process of degradation of the territory by erosion in the hydrological basin of Antohesti (Fig.1) which is situated in the superior basin of Berheci River in Bacau County. On a surface of 3963 hectares, the relief is strongly fragmented, presenting a relief energy of around 330 m with averages slopes over 15%. The slopes are affected by the erosion and by the active sliding. The most popular soils are chernozem and the brown soils; concerning the distribution of the land there are: arable 47.2 %, pasture 26.78 % and forest 16.8%.

The choice for this hydrographic basin is motivated also by the fact that there was the possibility of the validation of the results obtained by the simulation, comparing them with the measurements of the alluvial deposits in the Antohesti accumulation (situated at the exit of the receiving basin).

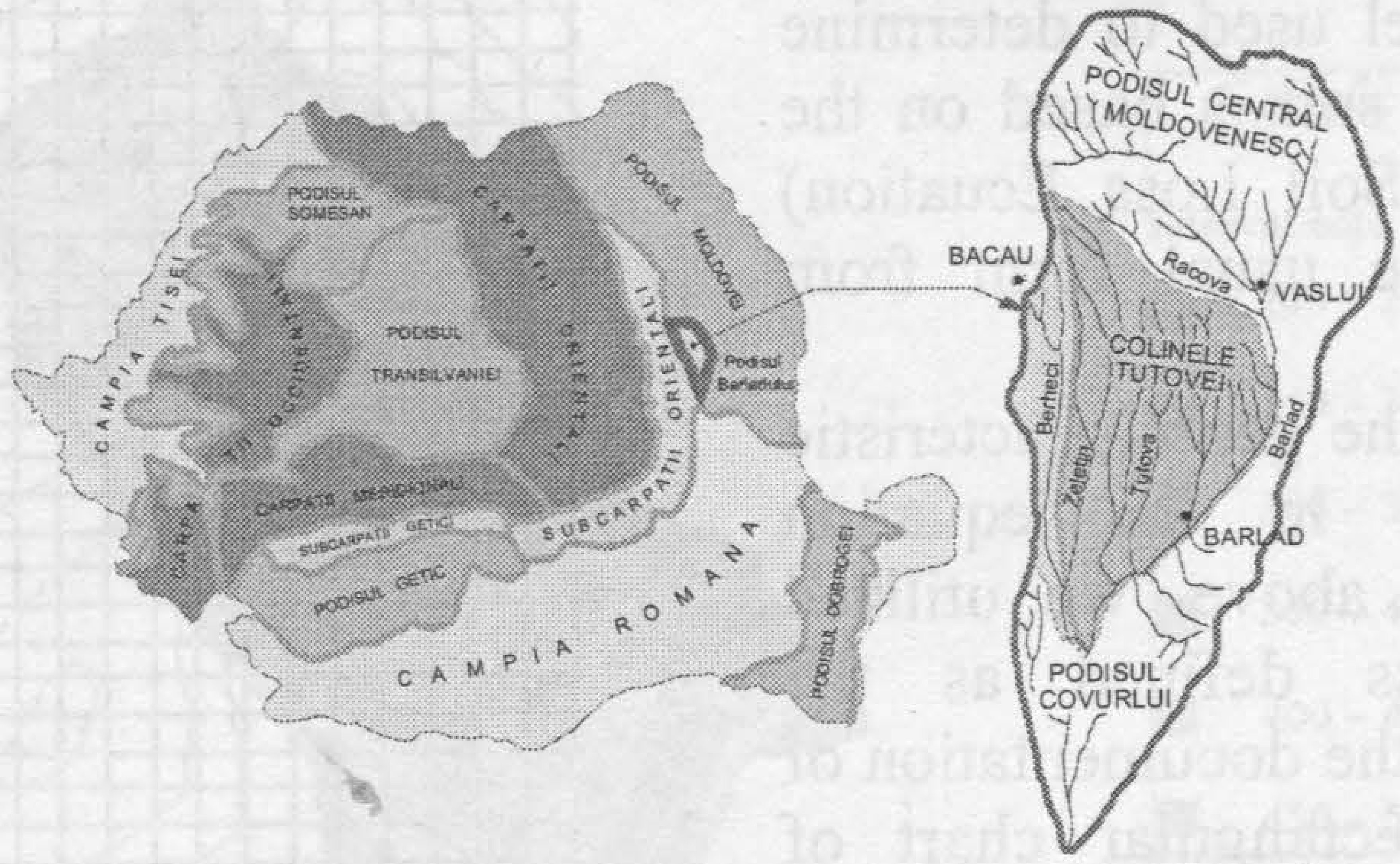


Fig. 1 – Research locations: hydrological basin of Antohesti (in the superior basin of Berheci River in Bacau County).

3. The Structure of the GIS Process

In our project, the geo-characteristic dates are represented as layers. This facilitated the analysis of the spatial variables and the distribution of the objects on the surfaces studied and the overall analysis of the information obtained, that supposes the simultaneous approach of more layers could be realized using the "overlay" technique.

The general chart of all the steps covered in this project [2] (for the theme mentioned above) is presented in Fig. 2.

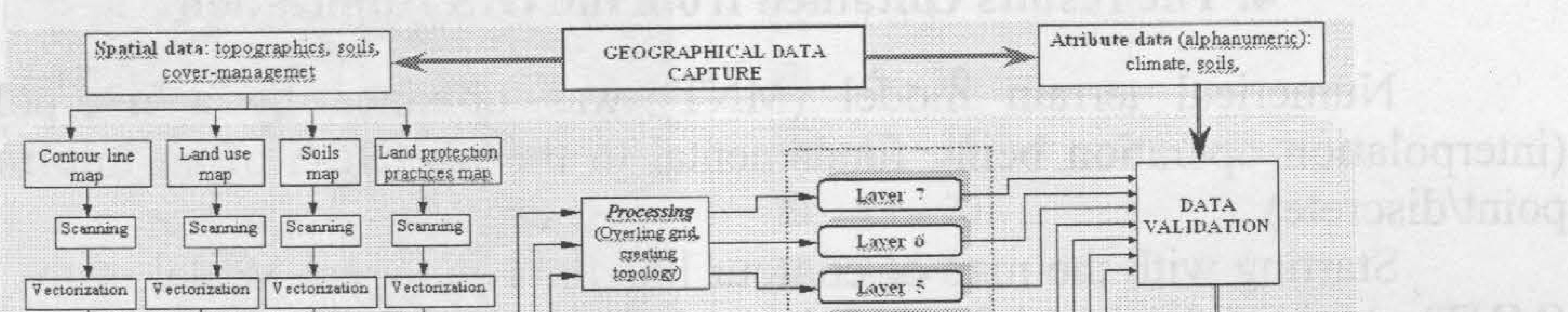


Fig. 2 – Data hide tide in GIS project from reality situation to erosion hazard.

Along the application we used a software type GIS Romanian GEO-GRAPH specialized for the operations with digital maps and for the interogations of the databases. The mathematical model used to determine the damage of the soil is based on the USLE (Universal Soil Loss Ecuation) equation under the usual form from Romania.

In order to set up the geo-characteristic database included in the equation already mentioned above, we utilized the raster process defined as the superposition over the documentation of the maps of a rectangular chart of squared cells calculated 25 x 25 m (figure 3). In this way the calculation of the water erosion in the basin already studied was made on approximately 190,000 cells. In a first stage we've created the informational layers regarding the relief of the territory because the information about the relief is essential for the formational process of erosion for the slopes.

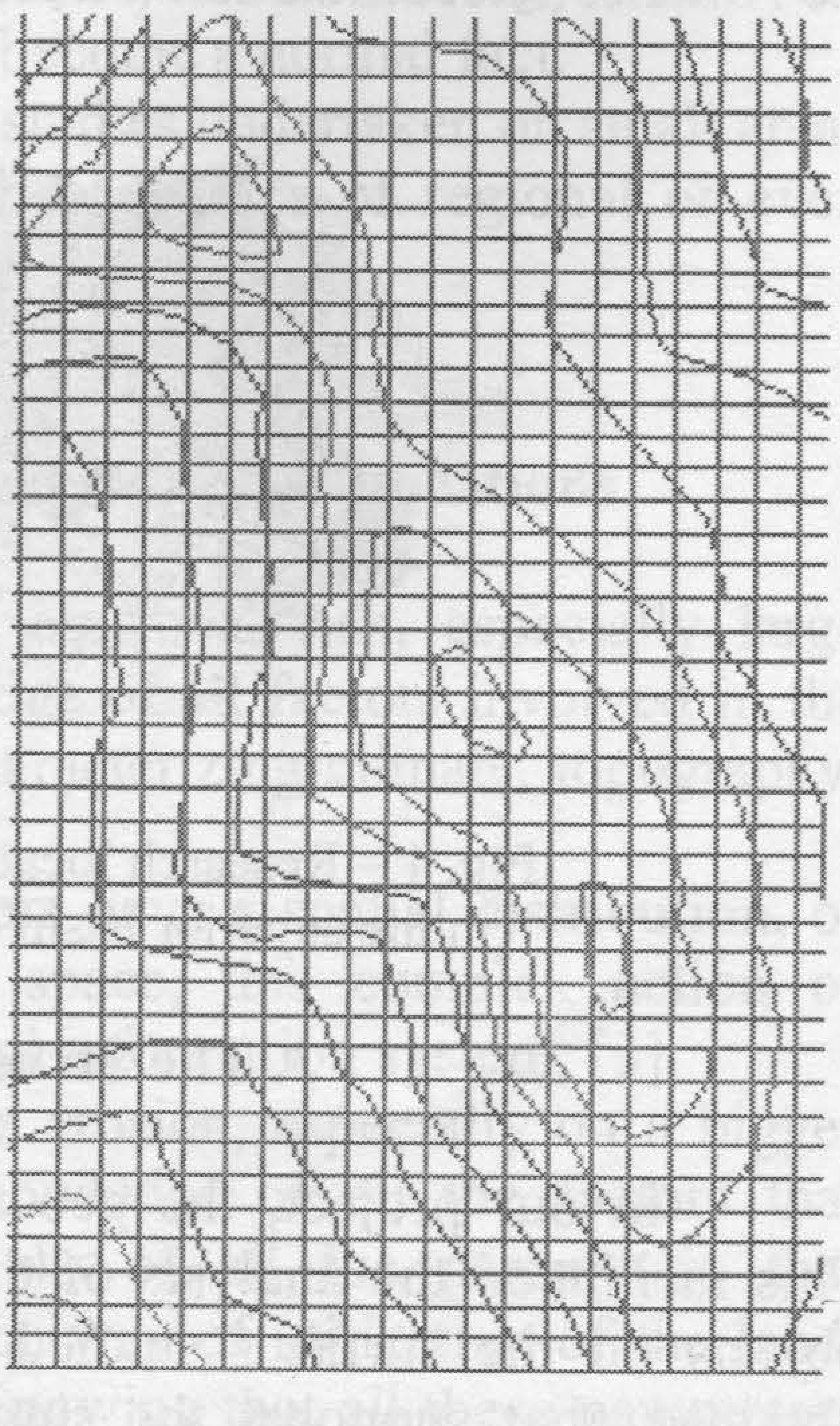


Fig. 3 – Detail of the overlapping grid over vectorial (numeric) plan.

4. The results Obtained from the GIS Application

Numerical terrain model (MNT) was obtained by a interpolation (interpolation operation being fundamental to the operation of an information point/discrete).

Starting with the map of contour line the Numerical Model of the Land (MNT) obtained furnished for GIS the main layers as:

Layer 1 - Elevation map (Fig. 4);

Layer 2 - Slopes classes map (Fig. 5).

Mathematically speaking, the slope (tilt to a horizontal surface) and orientation (direction determined in relation to the cardinal points) are properly determined in a point if the surface is described by an analytical function (gradient of the surface); in this case, these two parameters should be redefined for each pixel (cell) basis. The inclination of the land I was calculated from the slope and value (expressed as a percentage %), after his relationship Wischmeier şi Smith, [9]:

$$I = \frac{0,17 + 0,12i + 0,017i^2}{6,613} \qquad (1)$$

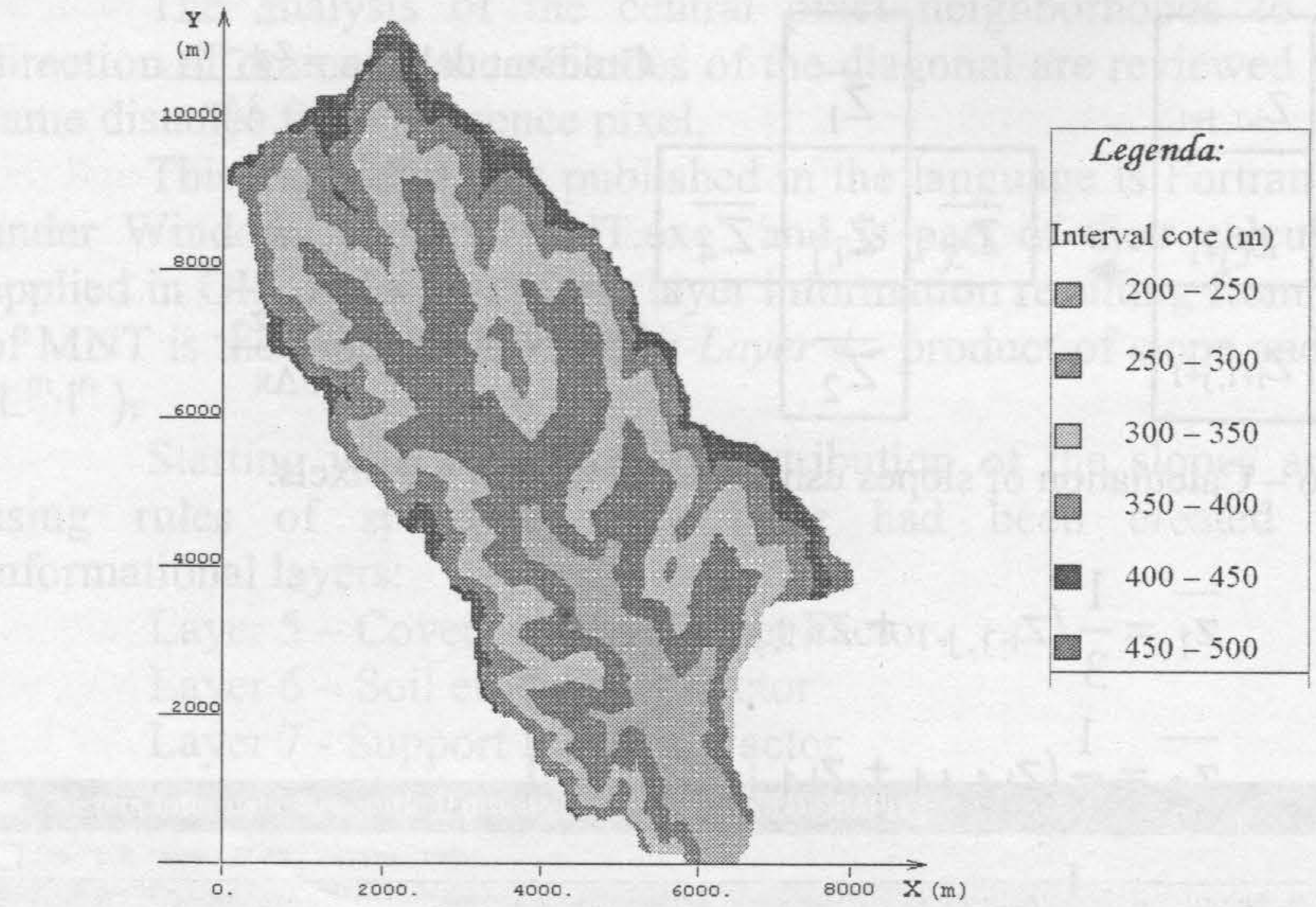


Fig. 4 – Layer 1: Elevation map.

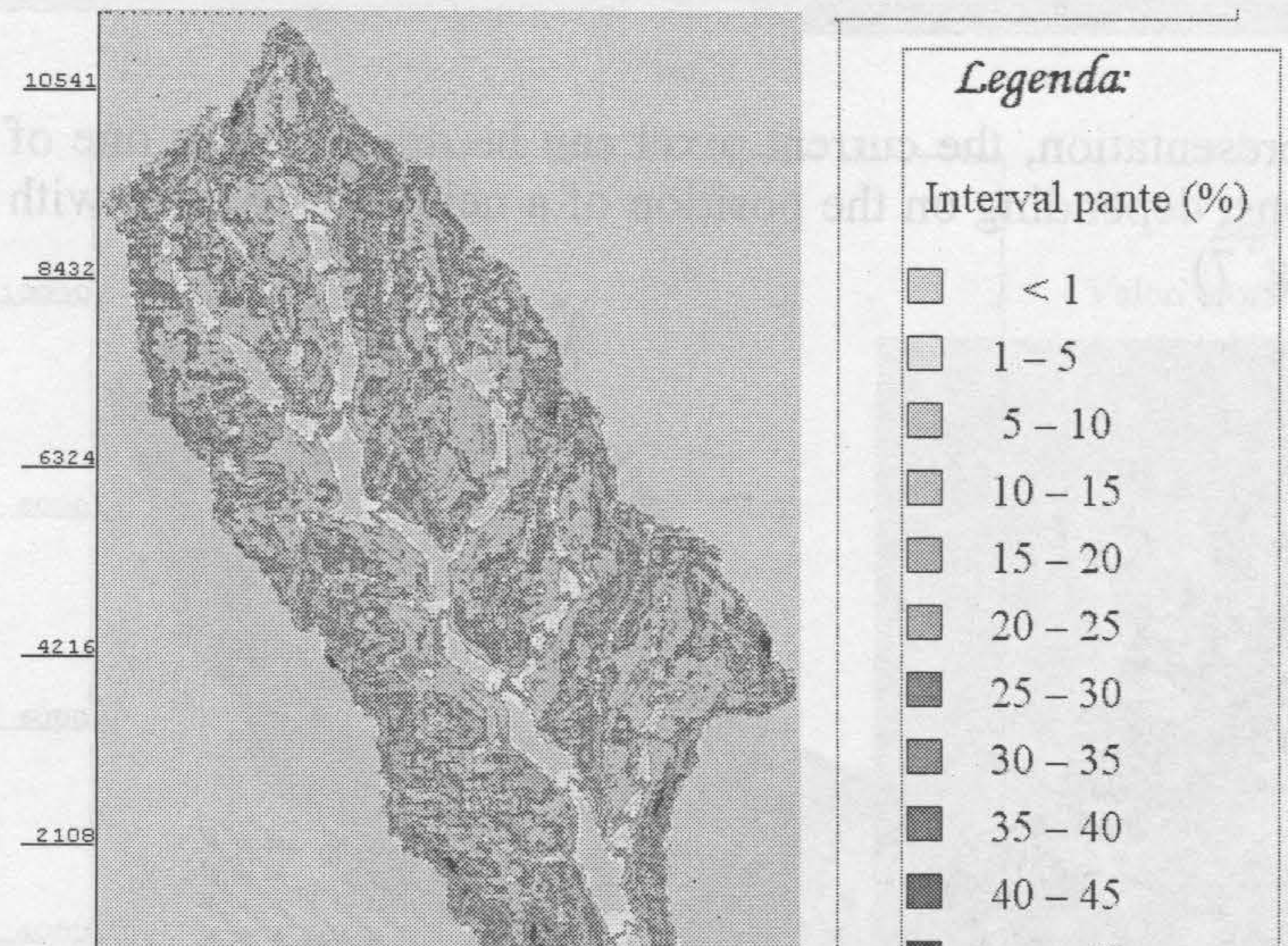
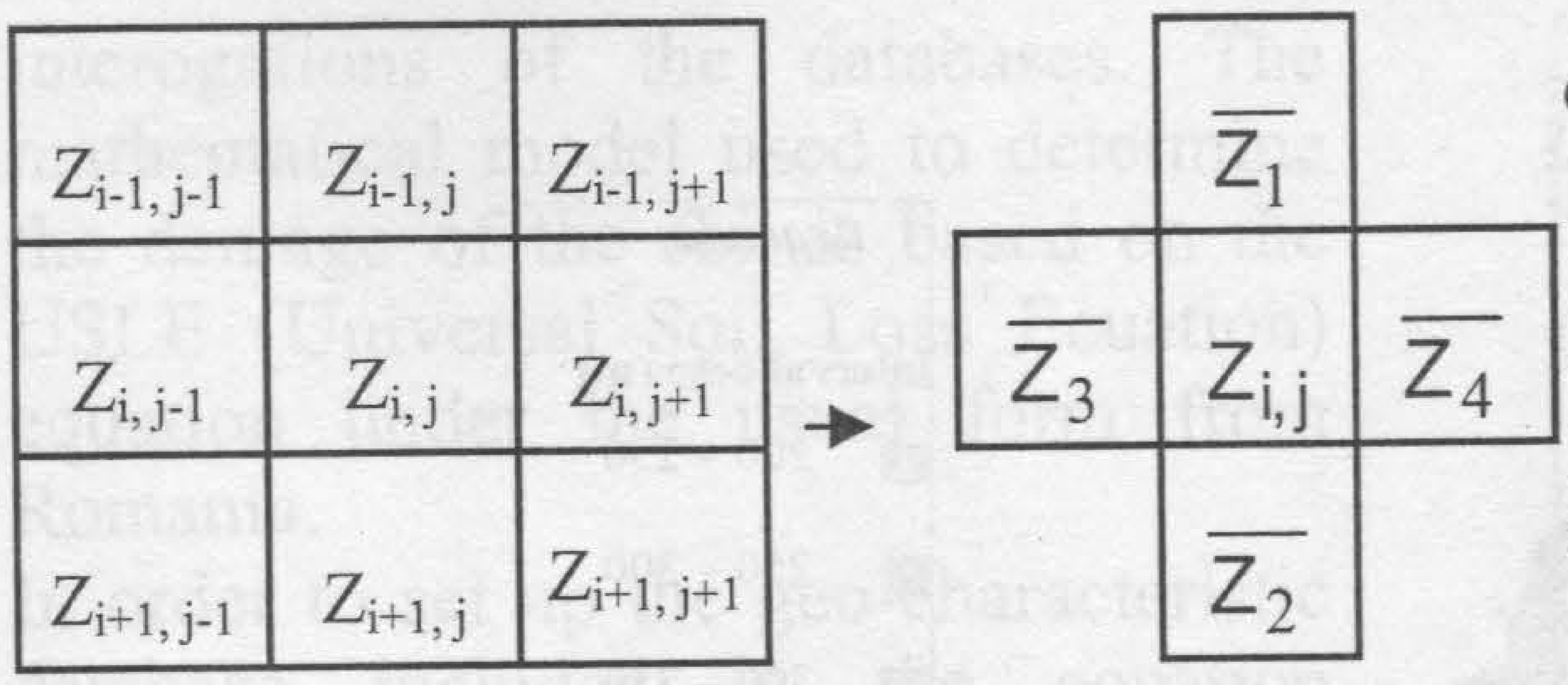


Fig. 5 – Layer 2 - Slopes classes map.

Calculation of slopes (gradients) and guidelines to do after 8 directions (Fig. 6), starting from an average altitude of the pixel, both parameters were estimated by using a window of 3 x 3 pixels. For example, the direction of lines and columns that have used the relations from next figure:



$$\text{Gradient column} = \frac{\overline{z_3} - \overline{z_4}}{3\Delta x}$$

$$\text{Gradient line} = \frac{\overline{z_1} - \overline{z_2}}{3\Delta x}$$

Fig. 6 – Calculation of slopes using a window of 3 x 3 pixels.

(2) $$\overline{z_1} = \frac{1}{3}\left(z_{i-1,\,j-1} + z_{i-1,\,j} + z_{i-1,\,j+1}\right)$$

(3) $$\overline{z_2} = \frac{1}{3}\left(z_{i-1,\,j-1} + z_{i-1,\,j} + z_{i-1,\,j+1}\right)$$

(4) $$\overline{z_3} = \frac{1}{3}\left(z_{i-1,\,j-1} + z_{i-1,\,j} + z_{i-1,\,j+1}\right)$$

(5) $$\overline{z_4} = \frac{1}{3}\left(z_{i-1,\,j-1} + z_{i-1,\,j} + z_{i-1,\,j+1}\right)$$

The raster representation, the current pixel can be drained after one of the 8 possible directions, depending on the position of a neighboring pixel with the lowest altitude (Fig. 7).

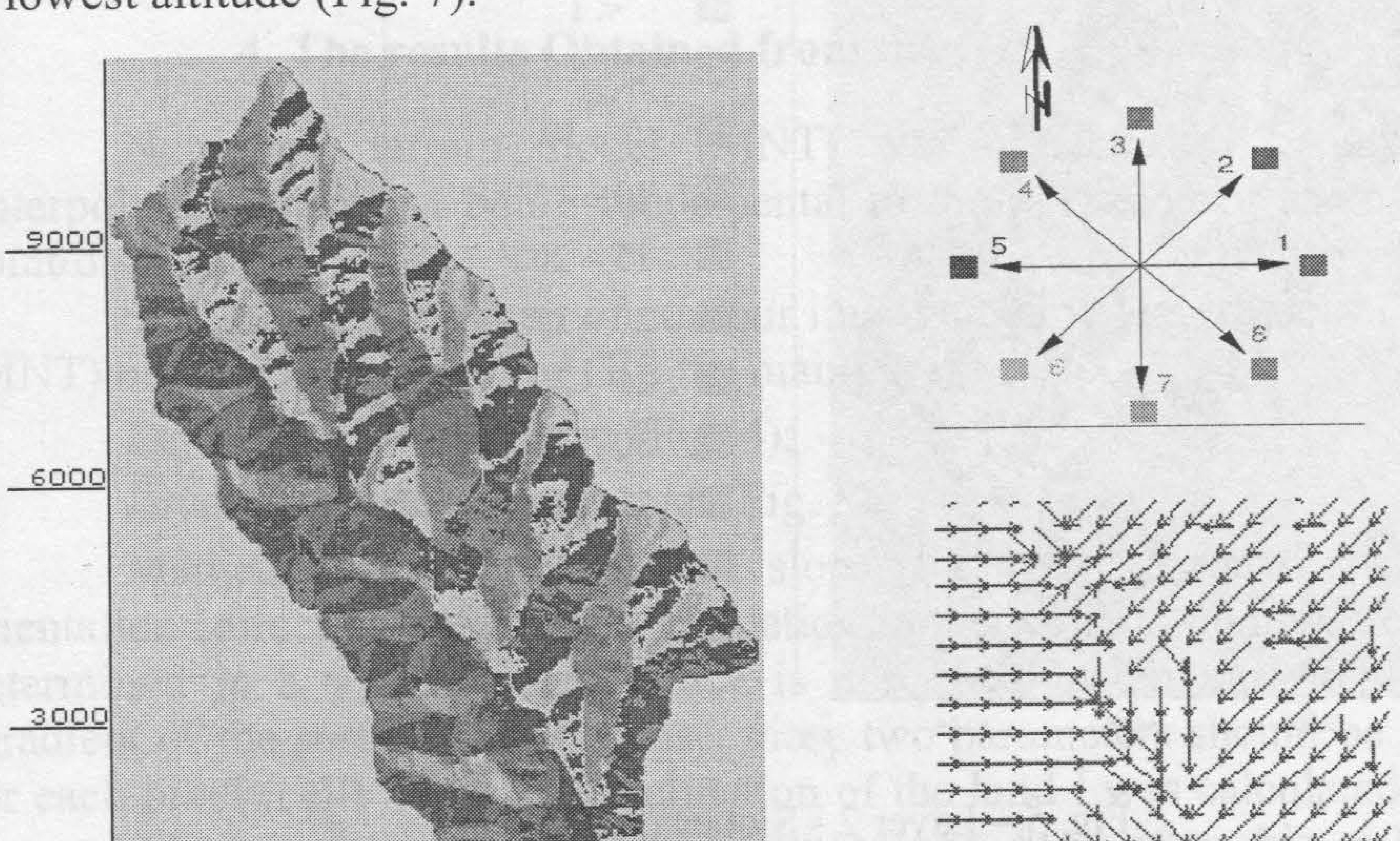


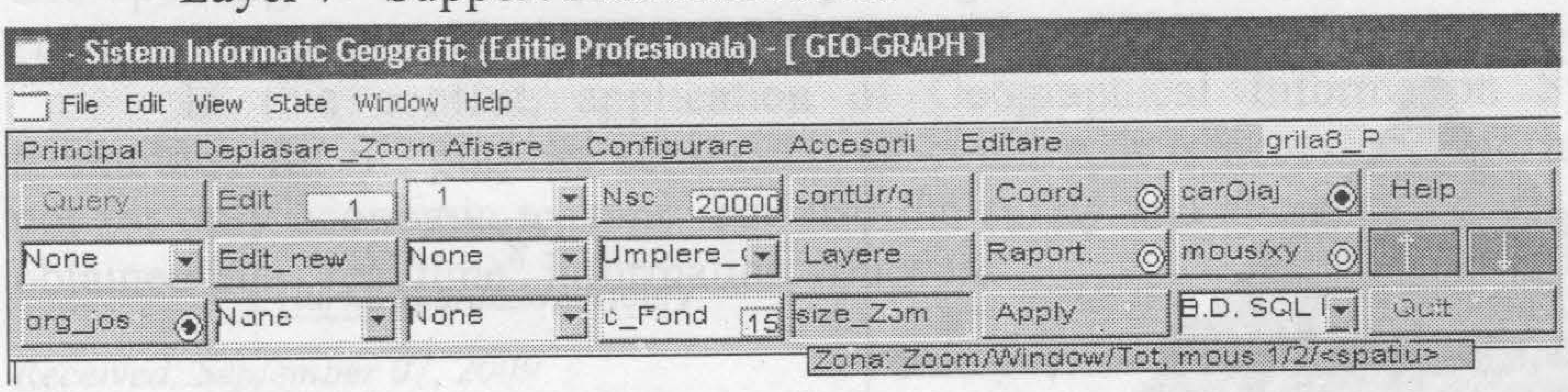
Fig. 7 – Layer 3: Drain direction map.

The analysis of the central pixel neighborhoods to determine the direction of drainage, the altitudes of the diagonal are reviewed to maintain the same distance from reference pixel.

This algorithm was published in the language is Fortran Power Station under Windows, called "MNT.exe" and is part of their calculation modules applied in GIS project. A fourth layer information resulting from the application of MNT is the topographic factor: *Layer 4* - product of slope and length factors ($L^m \cdot i^n$).

Starting with the plans of distribution of the slopes and of the soils using rules of spatial topology there had been created the following informational layers:

Layer 5 – Cover – managemnet Factor
Layer 6 – Soil erodability Factor
Layer 7 - Support Practical Factor



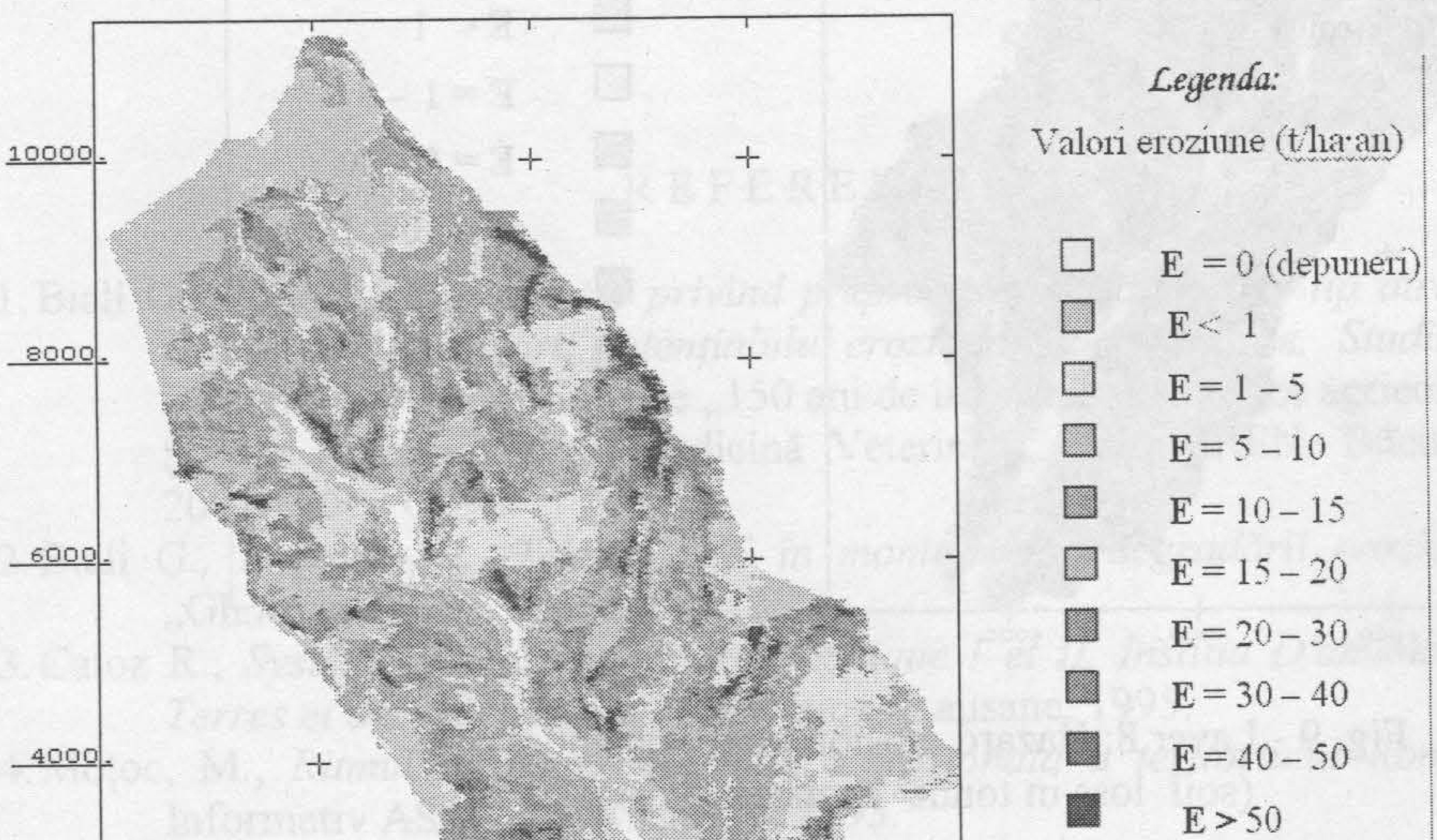


Fig. 8 - Layer 8: Hazard erosion map - effective risc (tonne/ hectares · year).

Including the 7 layers mentioned above in the USLE equation with the software GEO GRAPH it's been obtained the informational layer of the erosion hazard (*Layer 8*) in 2 ways of simulation: effective risk, determined by the combined action of all the parameters from the equation USLE (Fig. 8) and the potential risk (in which the factors could be controlled in the basin of reception (Fig. 9): layer 5 and layer 7 would not be considered).

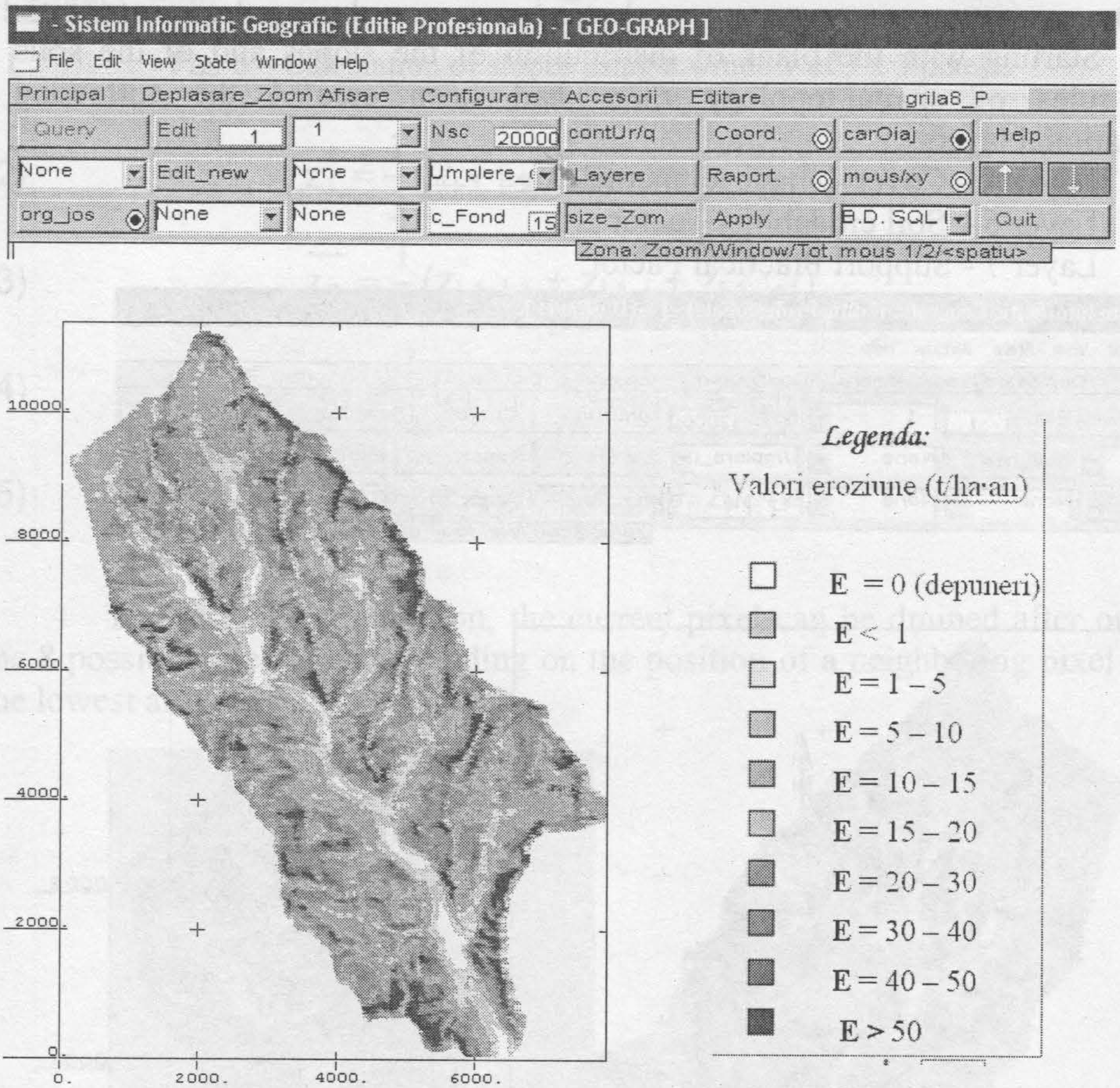


Fig. 9 - Layer 8: Hazard erosion map - potential risc (soil loss in tonne/ hectares · year).

5. Conclusions

By implementing these techniques we can performed an integrated environmental monitoring, which the authorized personal permanently can monitor the status of natural resources in general environmental factors and human impact, based on parameters and indices of spatial and temporal coverage, to provide the information necessary strategy and tactics to prevent the consequences of environmental factors and human activities, of preparing the of forecasts and exercise operational control on measures of recovery (improvement) of the ecological situation.

In the context of natural and socio-economic conditions in Romania, using Geographical Information Systems (GIS) to monitor the space-time evolution of land degradation through erosion and associated processes is a requirement for high current, justified primarily by economical reasons and the speed with which to obtain necessary information in real time making the most appropriate decisions to improve the situation.

Increase accuracy while the research activities on land degradation by erosion using GIS techniques can be achieved by diversifying the methods of data acquisition (including photogrammetry and remote sensing), development and updating of databases, but also by using mathematical models to simulate erosional processes, like WEPP, EPIC, GRASS, AGPNS.

In this context, application of Geographical Information Systems technology for the purpose set out in our country, it is necessary and justified not for only economic reasons, but also the safety and speed of which can be obtained in a "real time" information you want.

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APLICATII ALE TEHNICII GIS IN EVALUAREA PROCESULUI DE EROZIUNE PE TERENURILE IN PANTA.

(Rezumat)

In aceasta lucrare este prezentata o aplicatie GIS in prognoza si evolutia procesului de degradare a terenurilor prin eroziune. Prin rezultatele obtinute in urma cercetarii se arata avantajele folosirii acestor technici GIS si se argumenteaza importanta aplicarii in acest domeniu al ingineriei mediului.

Utilizarea tehnicii Sistemelor Informaţionale Geografice pentru gestionarea unor parametri referitori la mediu a devenit astăzi un fapt obişnuit. Aceste tehnici pot fi utilizate atât pentru studiile întreprinse pe suprafeţe mici (de ordinul a câtorva hectare), cât şi pentru studii de impact la nivel regional sau chiar naţional.