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DATABASE ROLE IN A GIS PROJECT FOR AGRICULTURAL MANAGEMENT ON SOILS SUBJECT TO EROSION

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Abstract

The work hereby describes the setting up of database and its role within a GIS project. As already known, monitoring and management activities for a certain territory imply a significant amount of data as well as related processing and analysis means. In such context, it is particularly important for both farming landowners and agricultural management decision-makers to determine the quality of soils and especially those affected by erosion decay processes. Availability of a descriptive database is critical for a GIS to work well. An attribute value (descriptive) database is connected to the spatial database to enable query. It is well known that the cultures structure and culture anti-erosion systems are two of the main factors on which agricultural management approach for slope land plots depends. The study hereby presents the many advantages of a GIS system for territorial management, and particularly for potentially erosive land. It is important to set up a database as complete as possible, that users can easily manage in order to be able to take the best decisions regarding "eco-friendly agricultural policy".

***Key words**: GIS, database, SQL query.*

INTRODUCTION

In our country, erosion represents one of the biggest problems of agriculture, besides the drought phenomenon. Despite some anti-erosion improvements that covered 2.2 million ha (by 1990), currently we can confirm that erosion is a phenomenon that should be a warning signal for the society, especially that the investments in the field are on hold, agricultural properties are excessively divided, and the former sites are re-exploited, which is less in compliance with requirements of slope soil protection and conservation (Motoc al., 1988). Such decay process (pollution in modern ecological terms) is extended to almost half (47 %) of the country's agricultural area, namely on 7 million ha representing land affected by decay, of which 6.75 million ha of eroded land (including 0.25 million ha of active landslides and 0.25 million of land subject to wind erosion). On yearly basis, 150 million tons of soil are lost, including 1.5 million tons of humus, 0.45 million tons of soil with nitrogen, as well as significant quantities of phosphorous, potassium etc. (Statescu al. 2013). Specific annual losses of soil caused by erosion vary between 3.2 and 51.5 t/ha; the country weighted average is 16.28 t/ha·per year, much higher than maximum tolerable / acceptable losses of 3...6 t/ha·per year.

Monitoring and management activities for a certain territory imply a significant amount of data as well as related processing and analysis means. In such context, it is particularly important for both farming landowners and agricultural management decision-makers, to determine the quality of soils and especially of those affected by erosional decay processes. A few years ago, such activities were actually impossible to perform on extended areas. Currently however, the extraordinary progress of information technology and data acquisition techniques for data specific to a certain territory (including remote detection and aerial photography) have enabled radical changes in the area (Biali al., 2013).

The database containing alphanumeric (descriptive) and graphical georeferenced data for a certain territory, can be considered the most important component of the system, as the quality of such data is a key factor on which the performance of the future information system and future results depend.

In the case hereby of slope land plots affected by hydro-erosion, such data should synthetically define as close as possible the main factors causing erosion processes. One key factor is the manner of using slope agricultural land.

MATERIALS AND METHODS

Geographic Information Systems (GIS) were first developed in USA, in view of knowing better the soils quality and assessing agricultural land plots. Starting 1993, the US Natural Resources Conservation Service began to use Geographic Information Systems (GIS) for georeferenced data storage and processing in view of updating soil maps (Biali, 2003). That enabled to highlight extended options of geographic information systems in the study of soils production potential trend.

Considering the above, the GIS project (presented briefly in this work) covers the use of GIS technique in the study of soils affected by decay processes.

In view of knowing better the current state of the erosion process and to forecast the related consequences by using the Geographic Information Systems technique, the watershed of Antohesti reservoir (on 3963 ha area) of Berheci Hydrographic Basin (tributary stream of Barlad river), Bacau county, was considered for this research.

The losses by surface erosion of agricultural land in such watershed were estimated by USLE equation resulting from the relation below (Wischmeier al.,1978):

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

where:

A – annual average specific soil losses, (t/acre -year) or (t/ha-year);

R – annual index of rain water erosion added to the erosion caused by snow melt drainage, where such melt drainage is significant (ft·t·in/acre·hour·year);

K – soil erodibility factor (t/acre·hour/acre·tf·t·în);

L – factor of slope length on the drainage direction (ft) or (m);

S – factor of slope gradient on the drainage direction (%);

C – impact factor consisting in the use of cultures and soil works (dimensionless);

P –impact (dimensionless) factor including the influence of current measures and works against soil erosion (works along land contour lines, strip farming, grass filter strips, terrace farming etc.).

RESULTS AND DISCUSSIONS

In view of implementing GIS techniques, for developing the application hereby the GEO – GRAPH geographic information system was used, a GIS type software developed by the Information Services Company in Suceava city, based on an in-house developed software.

Raster procedure was used in order to set up the georeferenced database and an attribute-based database, as necessary for storage and processing according to the above mentioned equation. That consists in developing a raster type graphical database with each pixel (cell) of 25 x 25 m (details on figure 4 and 5).

According to the work hereby, GIS application covers the last two factors **C** and **P** with a critical role in simulating erosion and agricultural management processes (Renard al., 1996).

The first phase included vectorization of site layout plans on a scale of 1:10.000 with data related to land coverage/uses (figure 1) and types of land improvement coverage (figure 2).

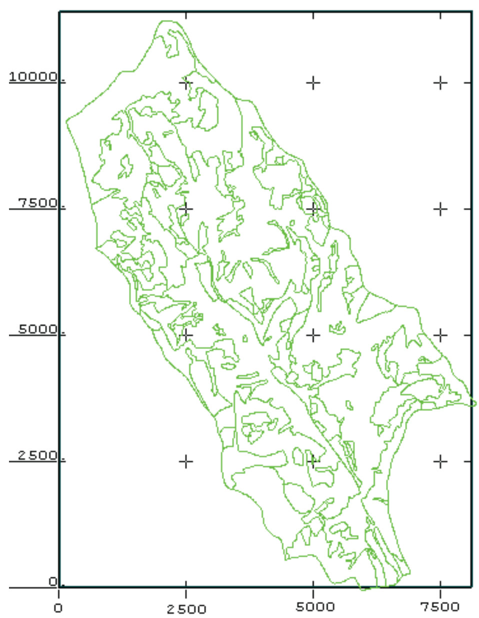

Figure 1. Vector data models of uses outline in Antohesti Hydrographic Basin

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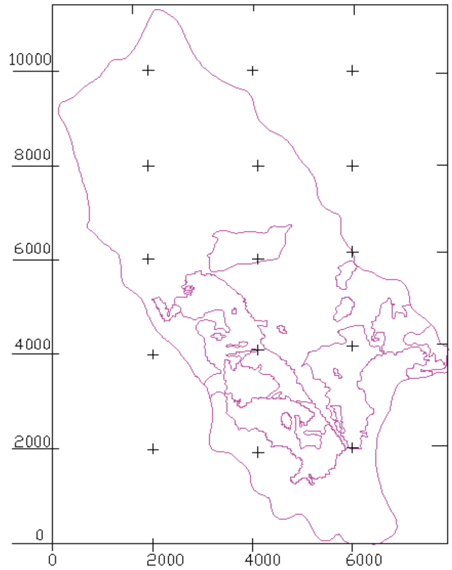


Figure 2. Vector data models of anti-erosion improvements in Antohesti Hydrographic Basin

The next phase consisted in setting up a polygon topology (figure 3) for each graphical object, which is represented as a use outline or an improvement type. The topology structure (to ensure vector data storage model) is based on proximity properties and spatial relations between elements (objects) defining a vector data model. That will enable developing the structure of spatial data base files, which are mandatory to ensure operation of the information system: updating, zones overlapping, entity outline by overlapping intermediate boundaries, generalizing boundaries outline etc.

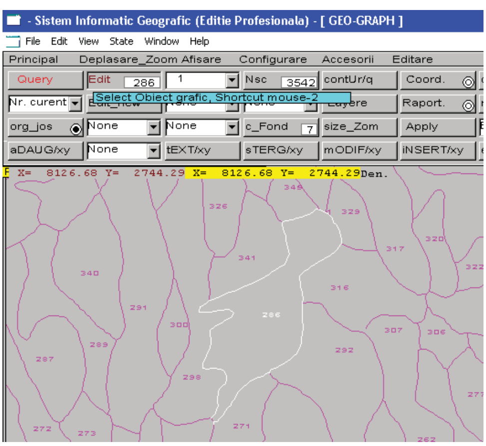
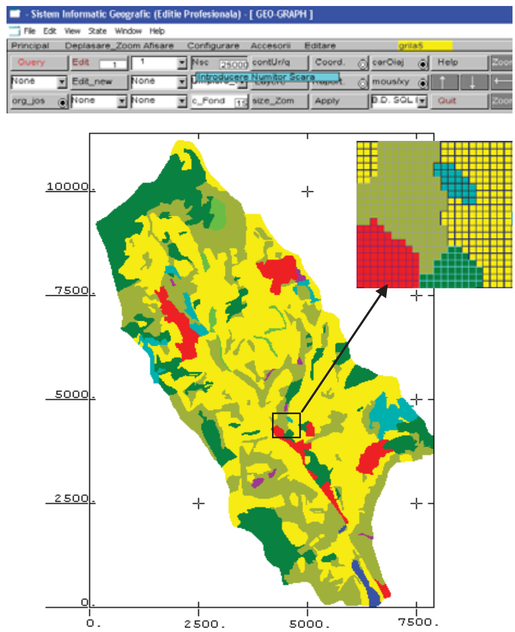


Figure 3. Selecting a graphical object in view of setting up related topology

Upon data processing, information layers are obtained regarding the distribution of C and P coefficients, which are integral part of a GIS project database, mainly enabling to assess soil losses caused by erosion.

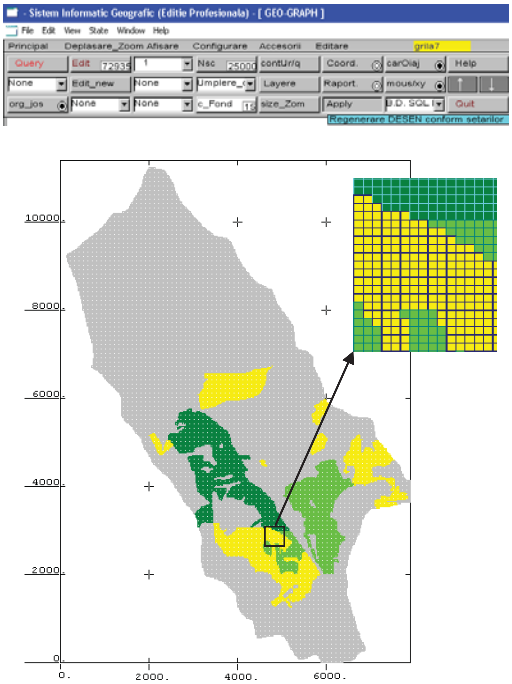
Information layers of land coverage in Antohesti Hydrographic Basin are represented in figure 4 (with details on cells). Cultural C Factor – land coverage / culture management reflects the beneficial effect of vegetation (farming cultures) on the erosion process. This factor helps to adjust the most reasonable culture management strategies to fight against slope land erosion.



C = 0.03 (Forest)
C = 0.3 – 1.0 (Arable land)
C = 0.02 – 0.03 (Hayfield)
C = 0.1 – 0.8 (Grazing)
C =0.6 – 0.8 (Vine areas and orchards)
C = 1.2 (Non -productive)
C = 0.05 (Built-up area)
C =0.0 (Reservoirs)

Figure 4. Spatial distribution of C coefficients. Information layers of land coverage / uses in Antoheşti Hydrographic Basin.

Information layers of anti-erosion measures in Antohesti Hydrographic Basin are represented in figure 5 (with details on cells). P Factor reflects the soil protection and preservation measures. It is a relative value factor due to extended variation range, implementation quality level and long term maintenance of anti-erosion measures.



P = 0.15 → terrace farming on arable land or terraces in vine areas and orchards

P = 0.30 – 0.60 → strip farming or grass filter strips on arable land

P = 0.50 – 0.90 → works along the land contour lines overall directionarabile

Figure 5. Spatial distribution of P coefficients. Information layers of anti-erosion measures in Antoheşti Hydrographic Basin.

CONCLUSIONS

1. Acquisition and storage of alphanumeric (digitized) data, computer-based processing, analysis and display of information obtained under various information layers (thematic maps, diagrams, analyses reports etc.) ensures a few significant benefits, such as:

- possibility to handle large multi-layer heterogeneous databases of spatial reference;
- extended flexibility for placing queries or interactively using the system;
- larger flexibility in configuring the information system in order to adjust it to a wide range of applications and users;
- diversified presentation (display) of information.

2. By implementing such techniques, GIS can also enable integrated ecological monitoring, which competent authorities may use in order to perform ongoing monitoring of environmental factors and anthropic impact.

3. Setting up a database based on spatial and time coverage parameters and indices, provides the information framework necessary to draft the strategy for preventing the impact of environmental factors and human activities.

4. GIS-enabled complex analyses help to make forecasts of erosion processes and exercise operational control of environmental restoration (improvement) measures.

5. Using Geographic Information Systems for analyzing and forecasting land erosion in our country is a topical issue, however in view of meeting such requirement continuous research is necessary; in order to pinpoint the specificities that should enable large scale implementation of such modern techniques.

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