

IMPORTANCE OF TOPOLOGY IN A GIS PROJECT OF MONITORING THE SOILS IN AGRICULTURAL LAND

Gabriela BIALI, Paula COJOCARU

“Gheorghe Asachi” Technical University of Iasi, 65 Mangeron Blvd, Iasi, Romania

Corresponding author email: gbiali@yahoo.com

Abstract

This paper presents the advantages of using the topology in a GIS project. The study was conducted on two watershed with mainly agricultural uses. We presented a model for creating the topology designed to monitoring the soils in the basins studied.

In the present application, we qualify the graphical objects as soil units on the map. After the topology there was possible the grouping in thematic layers depending on their type and on many other information from the attribute-type database (erodability, humus content, texture, structure, pH etc.). Topological relations were created through an own program in Fortran language under Windows). The topological structure of spatial database in this GIS project is under Geo-Graph software. The existence of topology also brings another major advantage of the project: facilitates the creation of key links between databases, the important step towards the query.

Key words: database, GIS, layers, soils, topology

INTRODUCTION

Topology is a mathematical procedure to explicitly define the spatial relations: defining connections between lines, identification of adjacent polygons, defining a polygon as a set (an aggregate) of lines. The spatial relationships between geographic objects of a map are plotted on that map, but their interpretation depends on the person that reads the map. Creating the topology in a GIS makes explicit certain relations between objects. In other words, the topology is a codification of spatial relationships between the objects of a layer that are connected or are adjacent (lines, nodes, polygons). For example, the topology of a line means knowing the start and end points (nodes) and the polygons to the left and right. The generation of topology represents the process of building topological relations between the objects of a layer (Renard K., 1996).

Explicit generation of topology may be mandatory after subsequent changes or updates of the graphical database (disconnected topology), or may be implicitly assumed by the software (dynamic topology).

As regards the mapping, the relations and functions of graphical elements will always be targeted towards the effectiveness of storage

and the location of spatial elements. In the past, the amount of mapped information and diversity of usable data sources have made it difficult to establish such functions.

Separation of spatial elements from their thematic attributes and organizational structure of these ensembles foreshadowed spatial databases used today in GIS.

Thus it appeared the topological structure (for storing data in vector model), which is based on adjacency properties and spatial relationships between different elements (objects) of a map. Lack of topological relations in a vector representation, reduces much the query possibilities, even if the user manages to deduce on his own, visually, some of these relationships (Biali G., Popovici N., 2003).

The topological model (corresponding to the numerical maps and plans where, not only the data are digitally represented in vector format, but they are also added the topological relations between objects), incorporates for a map or a plan in vector form three sets of data:

- Identifiers of characteristics of the land to be plotted in vector map or plan, and which, corresponding to their geometry, are divided in three generic types: point objects, line objects and surface objects;

- Thematic attributes of characteristics, being organized in a hierarchical classification scheme;
- Spatial data, which describe the geometric structure of vector maps or plans under three aspects: of topological relations between objects, of shape and size of objects, of their position (given by the pairs of coordinates).

MATERIALS AND METHODS

Main research of this work was editing the topology. The Geo – Graph system allows the creation of three types of topologies: dot, polygon and network. The topological structure (for storing data in vector model) is based on adjacency properties and spatial relationships of the elements (objects) of a vector plan. This allows setting up the structure of spatial data bank files, which are indispensable for the operation of the information system: keeping up to date, overlapping areas, shaping entities

by overlapping intermediary borders, generalization of the border route etc.

This paper exemplifies the creation of topology for the map of soil units in a 2 studies watershed, where through a GIS-type system there was determined the soil loss through erosion by applying “Universal Soil Loss Equation” (Wischmeier W., Smith D., 1978).

A rectangular grid of square cell was overlapped over the map with mapping of soil units, the pixel size being 25 x 25 m (Figure 1), for each graphical object being created then a primary database (“*graphical object*” being represented by the polygon limited by the boundaries of each soil unit).

The primary database should contain: graphical object number (unique in the drawing), the value of coefficient entering the calculation equation (soil erodability coefficient S) and the reporting as pixels of the graphical object.

The file is called *layer.tpg* and is created according to a certain type, like in the example in the Figure 2.

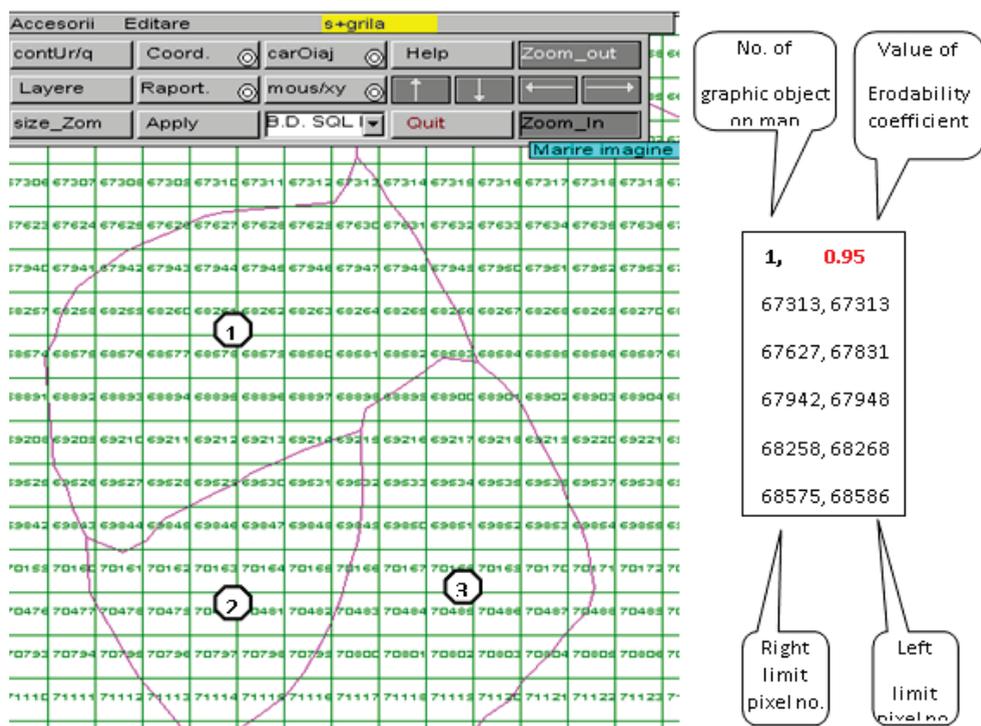


Figure 1. Detail of grid overlay over the soil unit plan in Antohesti watershed

RESULTS AND DISCUSSIONS

This operation can be done reading either on the screen, or on plotted plans, but there are some disadvantages such as: large number of graphical objects in a vector drawing (Figure 2) will lead to a long working time; the occurrence of errors due to incorrect assessment of membership of a pixel to an object or another or errors in loading the data from the keyboard.

In this context, this operation was executed automatically within the GIS project by creating the topology.

Within the Geo – Graph system by using the editing menu (fourth line from the main menu) there is possible both to prepare the plan in

order to create the topology and to create it automatically.

Editing is performed by having displayed permanently the cursor coordinates (absolute coordinates in double precision – the yellow bar under the main menu).

The flow of operations is as follows:

- Loading the vector drawing in Geo – Graph by the function from the main menu;
- Setting from the main menu the option “Serial no.” to have control of graphical objects viewed;
- Selecting with the mouse the graphical object (Figure 2);
- Resorting to “eDI_SET” key that automatically generates a window that defines the following parameters (Figure 3).

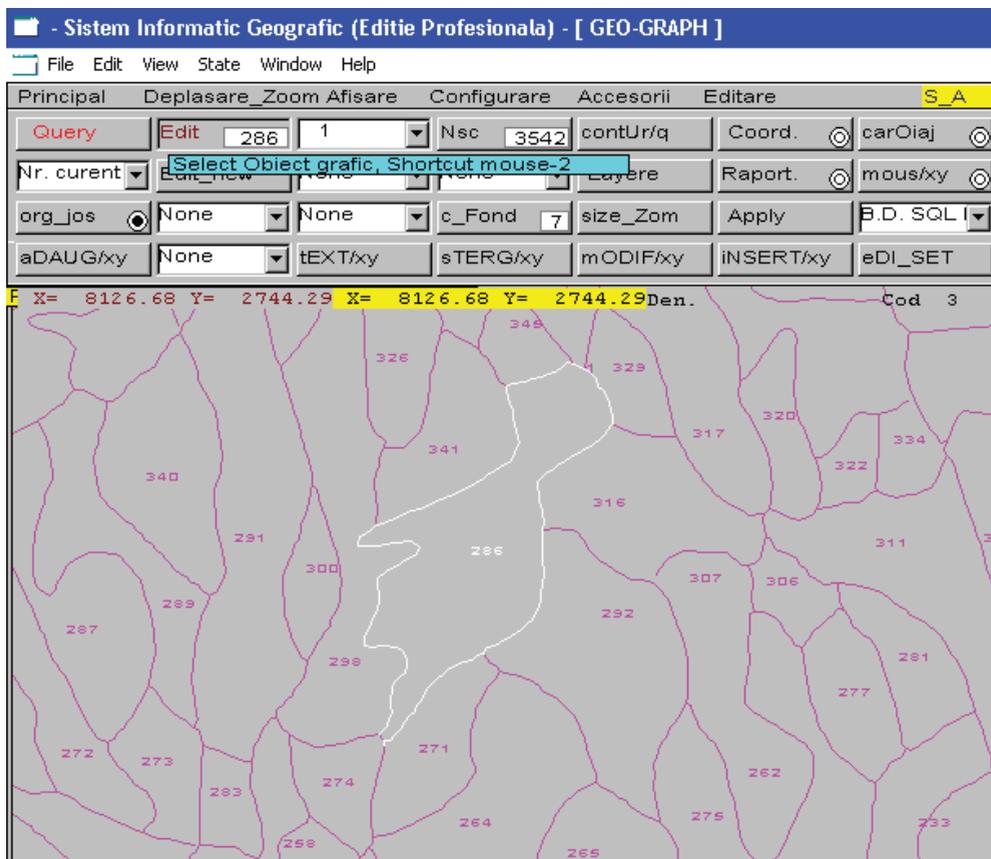


Figure 2. Selecting a graphical object in order to create the topology (in the example – soil unit in Antohesti hydrographic basin).

The dialog box that opens allows:



⇒ Name: is assigned to the soil unit, the coefficient value S;

⇒ Code no.: the window below ("Help primitive graphics") will automatically open: the code for vectored graphical object is chosen;



⇒ Layer no.: the drawing and filling color code of polygon is defined.

Figure 3. Editing the parameters for selected graphical object

The result of the process described can be viewed by selecting from the main menu the "Name" key (Figure 4).

Knowing the S factor is very important in applying equation USLE (Moțoc M., Tuhai A., 1998).

The value of erodability soils was determined for each unit of soil knowing soils physical characteristics and using the soil erodibility the nomogram (Foster G.R, McCool D.K., Renard K.G., Moldenhauer W.C., 1981).

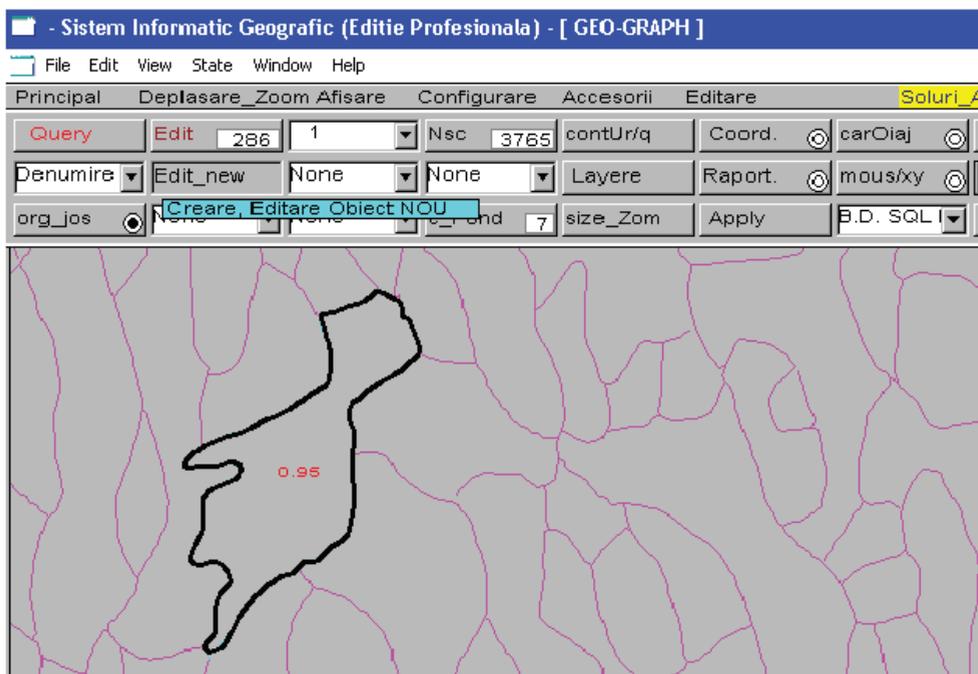


Figure 4. The result of editing operation of the graphical object and assigning the erodability coefficient "S"

It is important to know the maximum admitted limits of software when editing the graphical objects; this is possible through the “Design Information” command (Figure 5):

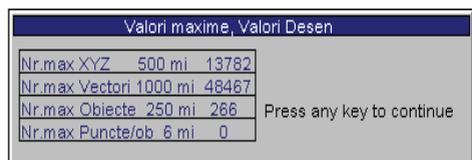
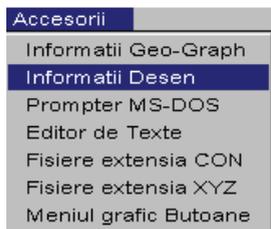
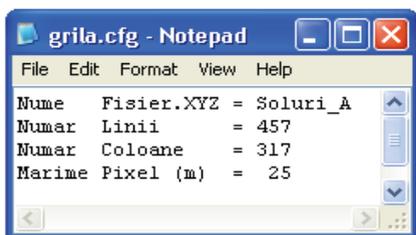


Figure 5. Vector drawing information

The window represents the maximum values accepted by the Geo – Graph system as well as the current values of the drawing.

At the end of these operations ASCII saving of vector drawing is made, the files thus obtained being necessary for the next processing. The way of creating the graphical object topology within a hydrographic basin is based on the “Topology.exe” program (Figures 6, 7).



Name	Ext	Size
grila	cfg	105
Soluri_A	CON	108.004
Topologye	exe	195.072
Soluri_A	ICX	69.664
Soluri_A	XYZ	142.170

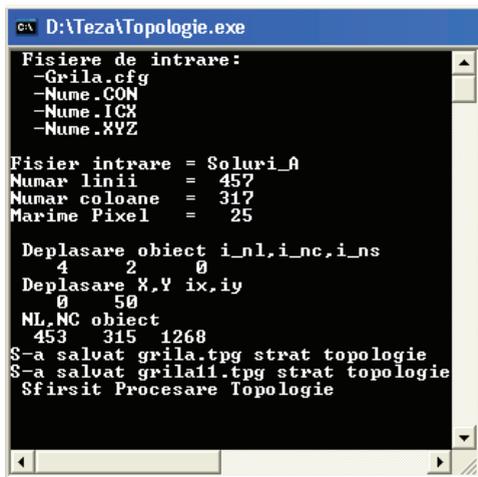
Figure 6. Configuration of input data in topology.exe program

The name of corresponding layer to be processed is set, in turn, in the “*grid.cfg*”.

The other three files (*.xyz*, *.icx*, *.con*) have resulted from the previous processing.

The principle of the program consists of a scanning line by line in the graphical object, with the step less or equal to the size of the cell. Based on the pattern recognition method, the vector line is translated on the pixel contour receiving automatically its number (according to the example in Figure 1).

The resulting file contains related intervals and values according to the topological interpretation of program input vector drawing.



a.

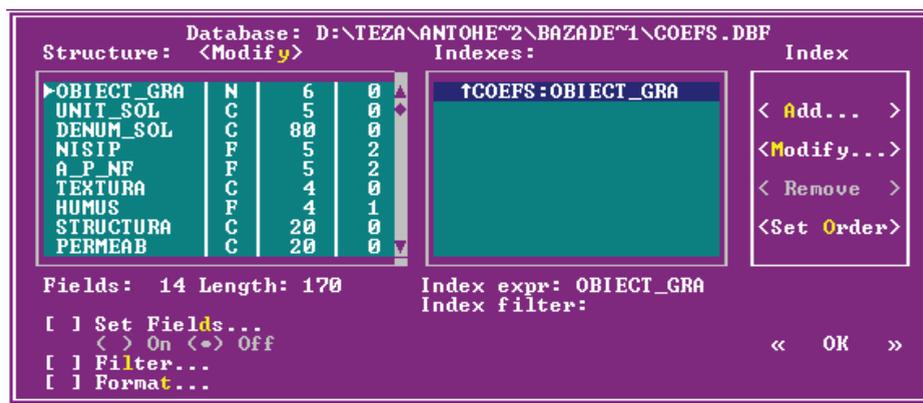
Name	Ext	Size
grila	cfg	105
Soluri_A	CON	108.004
Topologye	exe	195.072
Soluri_A	ICX	69.664
strat	tpg	122.219
Soluri_A	XYZ	142.170

b.

Figure 7. Automatic creation of topology:
 a. program running;
 b. resulting files.

The resulting file – “layer.tpg” is renamed as the number of information layer entering the next processing, according to the settings of the computer program; in the example shown, the information layer of the soil units is “layer 6.tpg” (Figure 10).

With this topology there was possible: to assign the erodability coefficient for each soil unit separately (Figure 4), to create the attribute-type databases (Figure 8), graphical georeferencing of objects on vector plans – layers of soils (Figure 9), (Biali G., Statescu FI., 2013).



Humus	Structura	Permeab	Ph	N	P	K	Coef_s
2.4	astructurat poliedr	mica	6.15	0.12	2	110	1.11
2.2	poliedrica	mica	8.25	0.07	19	195	1.11
1.0	glomerulara	moderata	8.60	0.06	4	90	1.18
1.0	glomerulara	moderata	8.60	0.06	4	90	1.13
3.1	astructurat	moderata	6.45	0.15	174	500	1.20
1.0	glomerulara	moderata	8.60	0.06	4	90	1.11
3.1	astructurat	moderata	6.45	0.15	174	500	1.20
1.0	glomerulara	moderata	8.60	0.06	4	90	1.18
2.4	astructurat poliedr	mica	6.15	0.12	2	110	1.11
1.0	poliedrica mica	mica	6.30	0.18	1	135	0.80
3.1	astructurat	moderata	6.45	0.15	174	500	1.20
1.0	glomerulara	moderata	8.60	0.06	4	90	1.18
1.0	poliedrica mica	mica	6.30	0.18	1	135	0.86
3.2	poliedrica	mica	6.35	0.14	6	250	1.15
3.3	astructurat granular	mica	7.70	0.19	115	332	1.23
1.3	poliedrica	moderata	6.85	0.08	4	195	0.95
2.4	astructurat poliedr	mica	6.15	0.12	2	110	1.11
2.2	poliedrica	mica	8.25	0.07	19	195	1.11
3.3	astructurat granular	mica	7.70	0.19	115	332	0.89
1.0	poliedrica mica	mica	6.30	0.18	1	135	0.80

Figure 8. Example database attribute soils

If it was to recap for shortprocess as follows: I started with the plans of situation with soil mapping;were driven steps: scanning, automatic vectorization software as Corel Draw, OCR Trace module, filter module coordinated with "dxfin.exe" rescue ASCII and binary forms;resulting vector plans (Figure 9).

Apply the "topology.exe" and are assigned soils units the coefficient of S erodabilityand fill color code. Resulting layers of soil information with the distribution coefficient erodability S, (Figure 10), to be applied correctly equation USLE.

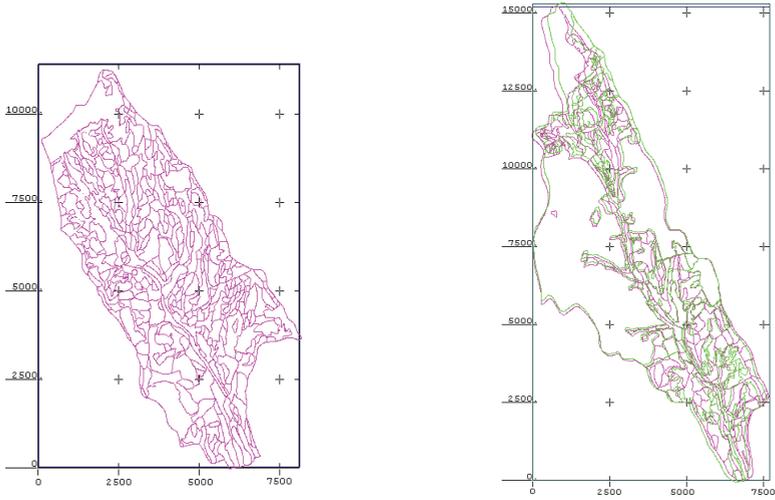


Figure 9. Vector plans of soil in the two watersheds studied

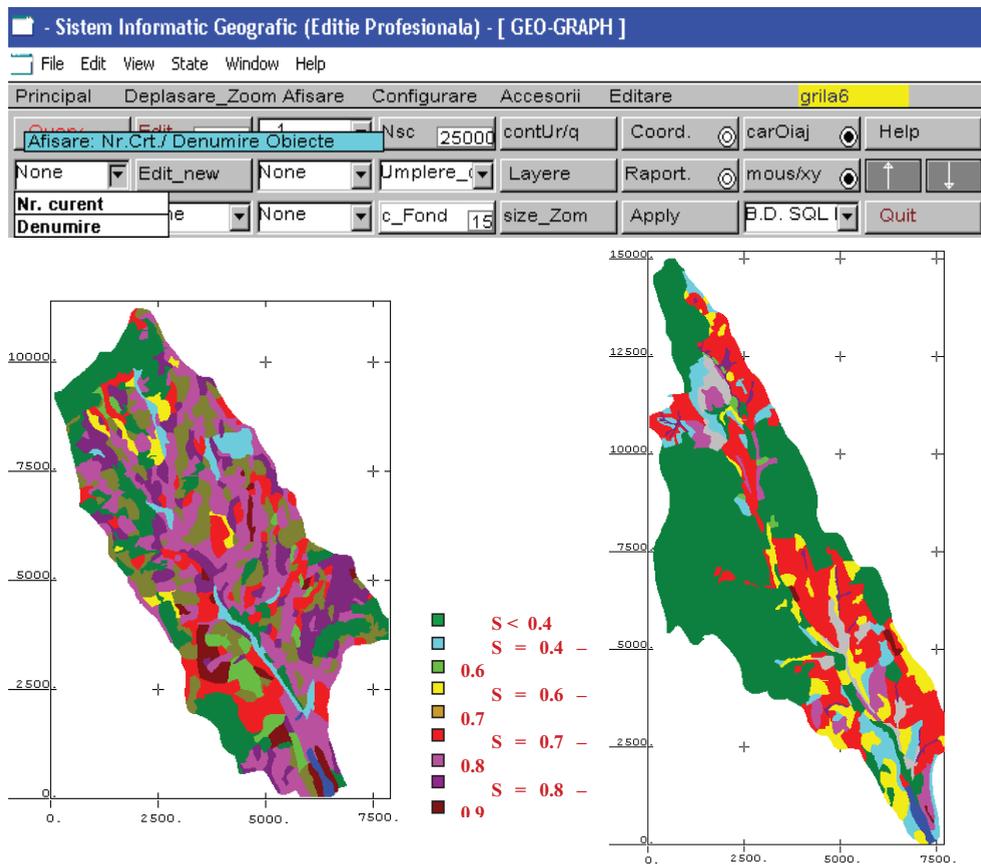


Figure 10. Layers of erodability coefficient (S) in the those two watersheds studied

CONCLUSIONS

Most GIS store topological relations as part of the data model. In this case, editing spatial characteristics of a layer alter its topology. Therefore, for this project there was necessary to reconstruct the topology in order to restore spatial relations after the graphical objects (ground units) were vectored. Phases for setting up graphical and alphanumeric databases, as well as the generation of topology, were created separately within this project, but many GIS environments allow today a quasi-simultaneous approach.

Creating and storing topological relations provided the following advantages:

- the data is stored more efficiently, and therefore it can be processed faster and it can process large data sets;
- enables to make analyses, such as modelling leakage along the connection lines in a network by combining the adjacent polygons with similar characteristics and overlapping the geographical objects;
- redundant data is eliminated;
- it helps identifying the errors resulting from digitization.

In the context of developing the GIS project the topology is of particular importance.

When designing a GIS, but, also subsequently, when adding and editing vector data within a GIS project, certain conditioning regarding both the composition of geometric entities and spatial relations between graphical elements shall be complied with.

The GIS project in this paper presents a particular case of creating topological specifications of vector entities for the soils in a hydrographic basin.

The advantages in this application are major:

- it guarantees the compliance and accuracy of graphical information;
- it creates the conditions of connection between graphical entities and associated attribute databases;
- the analysis and spatial query functions become possible.

REFERENCES

- Biali G., Popovici N., 2003. GIS techniques for monitoring erosion decay."Gheorge Asachi" Publishing House, Iasi, ISBN 973-621-043-X.
- Biali G., Stasescu Fl., 2013. Application of GIS technique in land evaluation for agricultural uses, Environmental Engineering and Management Journal, **11**, 821-828.
- Motoc M., Tuhai A., 1998. A few issues on assessing soil erosion effects as well as anti-erosion measures and works. Soil Science Magazine, Tome.1.
- Foster G.R, Mc Cool D.K., Renard K.G., Moldenhauer W.C., 1981. Conversion of the universal soil loss equation to SI metric units. Journal of Soil and Water Conservation, Nov-Dec. p. 356-359.
- Renard K.G., Foster G.R., 1996. Predict soil erosion by water: a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE), USDA – ARS, Agricultural Handbook, 703.
- Wischmeier W.H., Smith D.D., 1978. A universal soil loss equation to guide conservation from planning, Transactions of the 7th International Congress of Soil Science, Wisconsin, USA 7, 418-425.