

## DATABASE SEARCH IN A GIS APPLICATION INTENDED FOR MAPPING THE USE CATEGORIES AND ANTI-EROSION SYSTEMS IN ANTOHESTI WATER CATCHMENT AREA, BACAU COUNTY

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### **Abstract**

*There is no news that the use of GIS technique in the engineering field takes place at high level, and has a very well defined place in environment engineering.*

*This paper shows a sequence of a GIS application in the field of quantification of soil loss as a result of water erosion. The GIS application is exemplified in a water catchment of approximately 4000 ha in Berheci Superior of Bacau County, with intensive water erosion processes, both at the surface and in gullies.*

*After the development of databases (graphic and alphanumeric), the determination of connections (keys) between them is very important, in order to enable interrogation. Interrogation ensures the value of GIS application, and in this application we can notice 2 interrogation methods. The development method of the interrogations, as well as the response manner in the own designed concept, with a relational alphanumeric database are shown.*

*This paper shows the importance of correlated databases in the context of statistical analyses for large areas. Following these analyses and by means of the GIS, the most intelligent ecologic and anti-erosional management solutions can be taken in torrential hydrographic water catchments.*

**Key words:** database, interrogation, erosion, GIS, agricultural management.

### **INTRODUCTION**

The use of Geographic Information Systems technique for the management of certain parameters on the environment became a current usual fact. These techniques are widely used both for the studies conducted on small areas (of few hectares) as well as for impact studies at regional or even national level.

The region monitoring and management operations imply a significant volume of data and processing and analysis means. In this context, the determination of the quality of soil and in particular of those impaired by erosional degradation becomes extremely important both for the agricultural owners and for the decision makers in agricultural management area.

If we refer to the determination of the erosional risk, particularly for large areas, this implies the thorough knowledge of all factors that intervene in the performance of the degradation process, namely the parameters which characterize the climate, landscape, soil, use of lands, agricultural operating technologies etc. However, considering that all these parameters

have a spatial distribution, namely receive a certain value at each point in space, the complex monitoring action can only take place within a Geographic Information System

The implementation of these techniques also enables an integrated ecological monitoring, through which the competent bodies can permanently monitor the status of natural resources, generally of the environment factors and anthropic impact, based on the spatial and temporal parameters and coverage indicators, which ensure the information framework required for the strategy and tactics on the prevention of consequences of environment and human activity factors, for the development of forecasts and for the exercise of the operative control on the actions concerning the recovery (improvement) of the ecological status.

In the activity of fight against soil erosion, the purpose of a GIS consists of ensuring the data acquisition, storage and processing. But the most important part is that of providing information (results) which can synthetically characterize, at all times, the status and progress of the degradation process of lands as

a result of torrentiality, drainage and sedimentation, in order to take decisions in due time (Statescu Fl., Zauca D.C., Pavel V.L., 2013).

The use of GIS is required and justified in particular as a result of the provided opportunities related to the review of the multitude of spatial distribution factors which intervene in the triggering and performance of the erosional processes, high costs and long time required for the monitoring thereof through other methods, in particular with respect to large areas.

One of the main components of a Geographic Information System is the database which consists of a graphic database (layouts or georeferenced maps in a projection system) related to an alphanumeric or attribute-type (non-graphic) database (Renard K.G., Foster G.R., 1996).

## MATERIALS AND METHODS

### Study area

This paper sets out a study, performed through GIS techniques, concerning the evolution of land degradation process through erosion in the reception basin of Antohesti water catchment area, of Berheci river higher water catchment area, Bacău County (Figure 1).

The reception area is of 3963 ha, with a highly fragmented relief, hilly type and average slopes of more than 15 %. The slopes are affected by surface erosion, deep and. The sloping land was affected by sheet erosion, gully erosion and by active landslides.

Dominant soils are chernozems and brown soils, and the most extended uses are: arable land – 47.2%, pasture land – 26.78% and forest – 16.8%, (Biali and Popovici, 2003).

### Data and methodology

In order to determine the soil loss following the surface erosion we used the Universal Soil Loss Equation (USLE) in the form used in Romania – ROMSEM (Moțoc M., Tuhai A., 1998.) and which includes the parameters of spatial distribution concerning: the pluvial erosivity (K), the soil erosivity (S), the gradients and length of discharge on versants (i, L), the purposes of the land (C) and the existing anti-erosion arrangements (Cs).

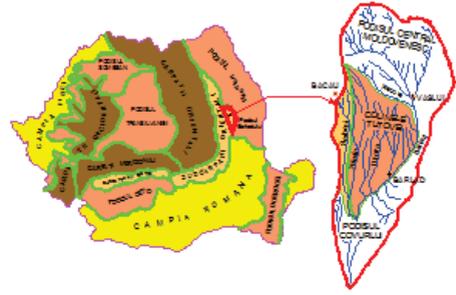


Figure 1. Location of research (Berheci catchment)

In order to develop the geo referenced database and an attribute-type database, respectively, required for the storage and processing according to the algorithm of the above mentioned equation, the raster procedure was used, which consisted of the overlap of the cartographic documentation (site plans 1:25.000) of a rectangular grid with the cell / pixel size of 25 x 25 m. The USLE equation was successively applied within GIS project, in order to determine the potential soil loss (potential risk) and the actual soil loss (actual risk) corresponding to each cell.

The GEO-GRAPH Geographic Information System, a GIS - type software, developed by Suceava IT Service Company was used in this application for the implementation of techniques of the Geographic Information Systems.

The GEO – GRAPH system is distinguished as an open system through the structure of the ASCII format input data. This structure enables the access to the drawing information located outside the system, thus facilitating the data integration with other systems or with files generated by the user by means of own software. The user is able to generate own software which will generate input data recognized by the GEO – GRAPH system, such as: data taken over from the total stations as files of coordinates and outline or data from files such as *.dxf* type, generated following vectorization (Biali Gabriela, Cojocaru Paula, 2015).

The GEO – GRAPH Geographic Information System contains the following primary modules:

- CAD module for the representation of vectorial drawings and raster images.

- The alphanumeric data interrogation module with spatial graphic localization.
- The import / export module of vectorial drawings.
- The module for generation of symbols and representation of cartographic elements on digital plans.
- The module of “drivers” for the connection with input / output peripherals.
- The module of background raster image vectorization.
- The interrogation module

The interrogation module of this GIS application performs the interrogation of alphanumeric data by means of SQL controls, both in xBase data management system and in relational S.G.B.D. in the client / server system. This module enables powerful facilities provided to the user in order to develop the own application. In this context, we could mention:

- definition of the database structure;
- definition of the index keys for access to the database;
- definition of relations between the tables (joins);
- definition of views (hypothetic tables defined by the user);
- definition of the connection relation between the graphic information and the alphanumeric information (rule setting);
- SQL controls editing by the user.

The alphanumeric database was developed and managed with FoxPro 2.6 in Windows. This S.G.B.D. is a relational system for the management of databases. In a simple meaning, a relational system implies several databases (commonly referred to as “tables”) opened at the same time, connected by means of common fields. The number of databases and common connecting fields define the complexity of the Satabase management system. Figure 2 shows the number of tables which set out the alphanumeric database in the application.

The *.dbf* tables of the database were automatically generated following several processing actions (except for “Coef S” table, which refers to the soil characteristics according to the soil unit sheets, based on which the S erodability coefficients were determined).

Name	Ext	Size
CoefS	DBF	65,422
Cote	dbf	1,877,480
Directii	dbf	1,877,480
Eroziune	dbf	1,877,480
Folosint	dbf	2,743,996
Pante	dbf	1,877,480
Sisteme	dbf	2,743,996
Soluri	dbf	2,743,996

Figure 2. “.dbf” files which set out the alphanumeric database of the GIS project

For each *.dbf* table, the structure was defined first by: the names of fields, the type and length thereof, depending on the nature of data to be uploaded.

The structure defined in a first stage can be changed by the user at all times, by means of the “*modi stru*” control, but it is extremely important to remain unchanged as of the moment of defining the “connection keys” between the alphanumeric database and the graphic database, otherwise the interrogation turns out incorrect and even impossible.

The key of a GIS consists of creating the connection between the alphanumeric database and the graphic one.

In order to enable the database interrogation both by “Fox keys” and “SQL keys”, the projection of correlation between the files of the alphanumeric database and the graphic one is required in the stage following the completion of *.dbf* tables.

The *.ast* type are thus developed, based on the following rules:

- ⇒ the files with *.ast* extension should have the same name as the *.dbf* files (tables);
- ⇒ the creation in the work directory of the file referred to as “Catalog.ast” which contains the list of all tables regarding which an interrogation “connection” is intended and the fields indexed for the connection between tables (Figure 3);
- ⇒ these files should be edited by maintaining the structure of each table in FoxPro through the “*disp stru*” control, by specifying the connection fields between tables for interrogation purposes.
- ⇒ indexation of fields in the database, required for interrogation purposes (Figure 4).

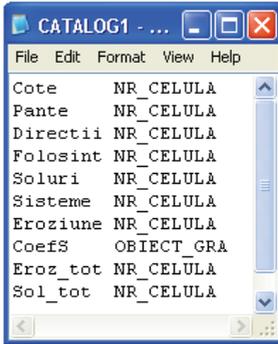


Figure 3. Sequence with the “Catalog.ast” work directory

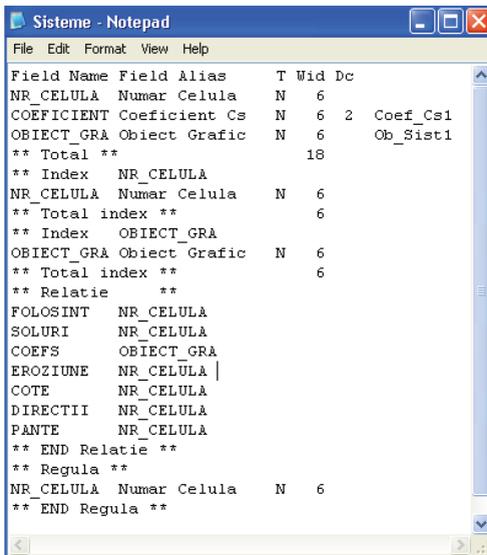


Figure 4. Editing syntax of an .ast type file

Few rules to comply with:

- ⇒ The “Field Name” should be as identical as possible with the one set out in the .dbf table;
- ⇒ “Field Alias” represents the description of fields (not more than 15 characters);
- ⇒ The “Coef\_Cs1” and “Ob\_Sist1” provisions mentioned on the right side mean that, upon the database interrogation for the two fields, supporting tables, called dictionaries, shall be displayed; these dictionaries are developed by the user, with no specific format requirements, in order to provide additional and extremely fast information for interrogation;
- ⇒ For each separate table there should be specified the indexed field, as well as the “Relation” of the relevant table with the other

tables of the database (by means of the field description).

## RESULTS AND DISCUSSIONS

Two types of interrogation were used in the GIS project contemplated herein: through “Fox Keys” and through “SQL language”.

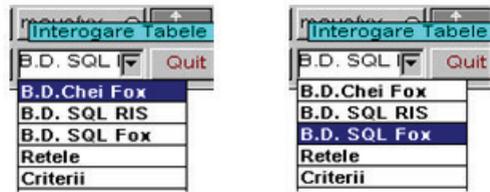


Figure 5. Sequence of the potential interrogation types of the application

The main menu of the Geo – Graph system enables the user to select the interrogation options.

In the first option, *Relation – Fox keys*, the interrogation takes place from the graphic database towards the alphanumeric database (as in the example set out by Figure 6).

The interrogated graphic object (cell in this case) shall be highlighted compared to the rest of the graphic background (the chosen selection color is white).



Figure 6. Interrogation of the database by means of “Fox Keys”

Immediately after the click, the first table of the Catalogue shall be displayed in the screen area (Figure 7) with the information computed and saved in the database.

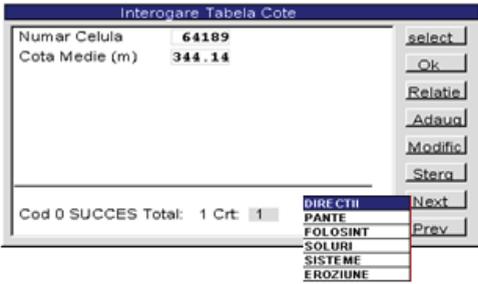


Figure 7. Answer of the interrogation by means of the function "Relation – Fox keys": first "Cote" table

By accessing the "Relation" button, a window will be opened next to the table, which enables the selection for interrogation of the other tables with which the active table has connection keys defined by the index; thus, the other elements may also be displayed for the same cell, solely by switching from one table to another (Figure 8 - 13).

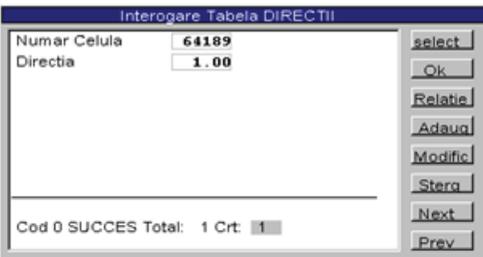


Figure 8. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Directions" table



Figure 9. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Gradients" table

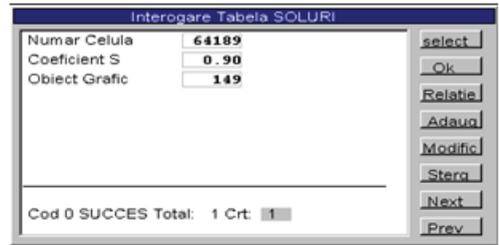


Figure 10. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Soil" table

The update of the alphanumeric database can be easily performed by clicking the "Add", "Change", "Delete" buttons.

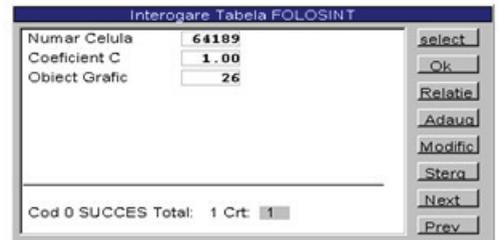


Figure 11. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Purpose" table

The "Next" button enables the user to view, one by one, the interrogated graphic objects.



Figure 12. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Systems" table



Figure 13. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Erosion" table

In case of interrogation through the SQL language, click on the “Table” button in order to select the intended interrogation topic, either by selecting a table of the database, or by selecting a virtual table, (the „views” can be recognized based on the contents of the “underline” character of the name thereof). Following the selection of the table or view, the interrogation key is automatically selected. The key represents a group of fields which will receive values in order to meet the interrogation requirement, and afterwards the system performs the search of entries in the database. Figure 14 shows an example of answer of the interrogation in a virtual table, namely “Tabel Eroz\_tot”. Thus, when the interrogation topic is selected, the system tries to fill-in values that meet the set out requirements, the fields defined through the “Eroz\_tot.ast” file, by

using the name of the selected object (cell) as input data.

The second interrogation type based on SQL keys can take place by clicking the “Select” button and setting out, with the keyboard, numeric values, the cell or cells which meet the interrogation requirement following to be displayed (Figure 14). Thus, the “Select” button enables the performance of an interrogation from the alphanumeric database towards the graphic database (Biali Gabriela, Statescu Fl., 2013).

The following example shows another SQL interrogation: it aims at identifying the areas of the water catchment with the “non-productive” use category (Wischmeier W.H., Smith D.D., 1978); thus, only the “C coefficient” field is filled-in by specifying the interrogation requirement (Figure 15).

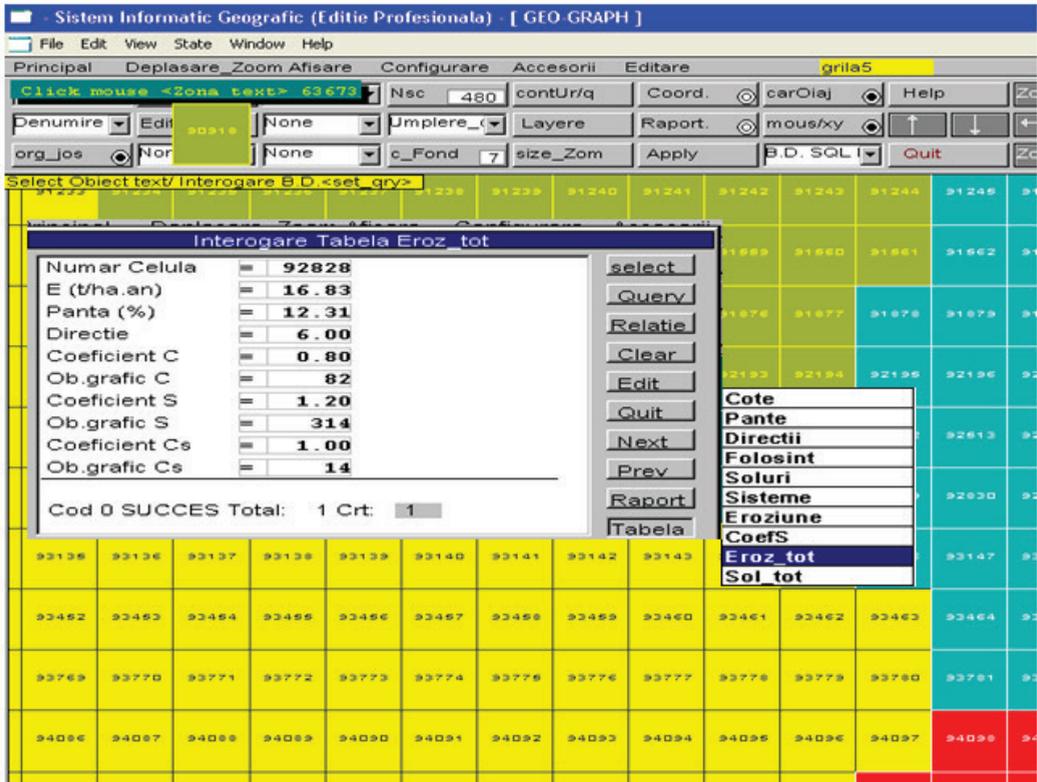


Figure 14. Answer of the SQL interrogation on the information layer of purposes in Antohești water catchment; List of interrogation selection possibilities

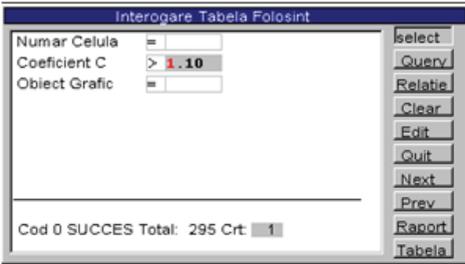


Figure 15. Example of interrogation based on SQL keys

The answer of the interrogation brings in the center of the screen the first cell that meets the requirement, as well as the interrogated table. The lower part of the interrogation shows the total number of cells which meet the interrogation requirements, and the fields are filled-in with the values of the first cell which was identified in the list (Figure 16). The answer consists of 295 cells, which represent  $295 \times 25 \times 25 \text{ (m}^2\text{)} = 18.4375 \text{ ha}$ .

By clicking the “Next” button, the entire list is displayed, both graphically and alphanumerically.

Within the GIS application, the system was designed so as to enable the user to generate their own criteria by means of the SQL language, by clicking the “Edit” button or operating changes in the window, through the selected interrogation controls (Figure 17).

The interrogation is performed by means of SQL controls, and does not require the existence of the key in the database (as in the case of the previous interrogation). It should also be mentioned that the Client / Server databases do not use interrogation keys, but only SQL controls.

The following example shows a criterion-based interrogation by means of editing an own SQL control. The interrogation has two requirements, namely: it is intended to identify the area of the water catchment occupied by plough land (which means  $C > 0.8$ ) and no protective anti-erosional systems apply ( $C_s=1.0$ ).

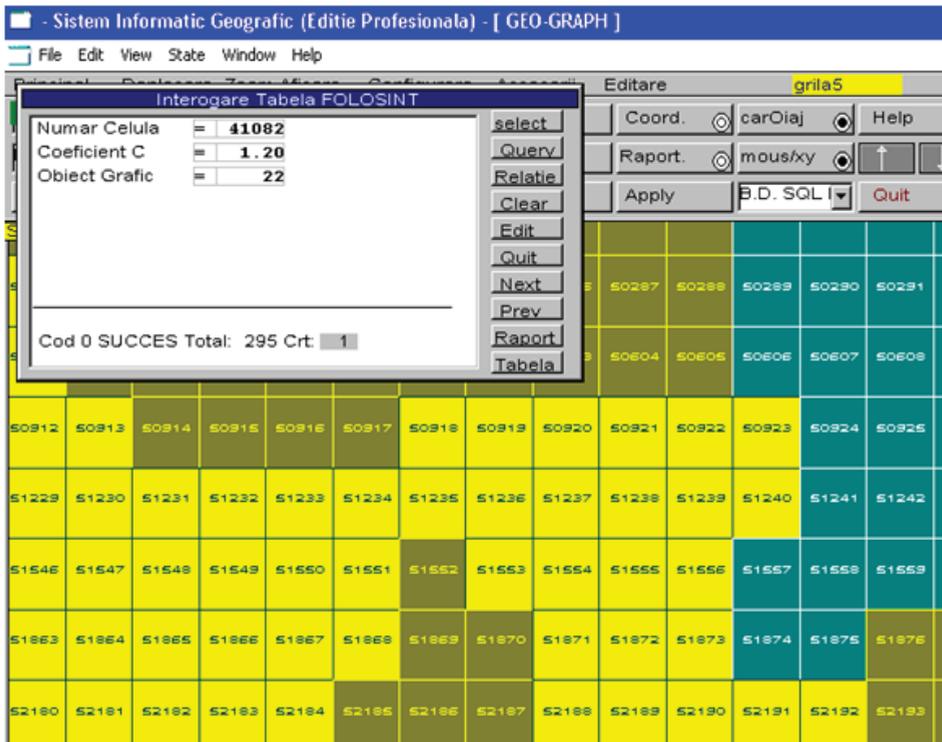


Figure 16. Criterion-based interrogation by means of SQL language; answer of the interrogation

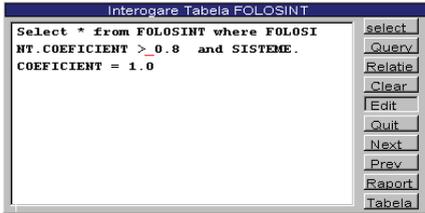


Figure 17. Syntax of the criterion-based interrogation SQL control

The answer of the interrogation in a graphic form is showed in Figure 18. All colors were deactivated and only the areas that met the interrogation requirements are highlighted.

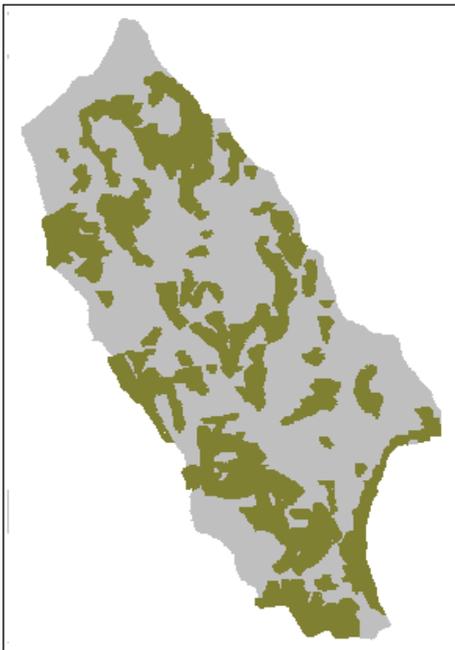


Figure 18. The answer of the interrogation in a graphic form

## CONCLUSIONS

The implementation of the Geographic Information Systems (GIS) in the analysis of erosional processes for large areas ensures the possibility to perform a complex monitoring on the quality of versant soil and enables the timely performance of the most appropriate protection and preservation actions concerning the fertility thereof.

The use of GIS for the analysis of land degradation processes and for the forecast of the time progress thereof is possible for both the relatively small plots of certain holders, located more or less uniformly within a territory, as well as for larger areas, water catchments or regional and administrative units.

A major advantage of the GIS consists of the possibility to perform an interrogation on any uploaded information layer, the database being a relational one.

The possibility to conduct statistics based on the information obtained after processing such. If, for values of C, S, Cs coefficients, one could have determined with a certain approximation the related areas, directly from the site plans, in case of landscape parameters (gradient, flowing directions) and erosion, in case of the analyzed water catchments, this would not have been possible.

One should note the facilitation of the criteria analysis due to the existence of virtual tables within the project. The criteria analysis enables us to obtain information from different layers.

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