3D IMAGE MODELS IN A DYNAMIC ENVIRONMENTAL GIS

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ABSTRACT:

The modern digital cartography, represented by numerical cartography, digital elevation models (DEM, DTM, DSM), orthoimages or the same like photo textured on DEM, is the metrically correct and highly descriptive system on which integrate any other source of information. These three-dimensional models in dynamic GIS can provide an interesting tool for the environmental and territorial data management. Aim of this research is to set up procedures for generating a three-dimensional map with maximum characteristics of description and the best accuracy, in order to be over the bi-dimensional GIS mapping system. DTMs, orthoimages and their 3D models overlay are performed by softwares dedicated to digital photogrammetry (ER Mapper, Surfer) and CAD designs (3dStudio Max, AutoCAD 2000). Successively these representations have been elaborated within the GIS system for a series of different themes and queries, which can be of a great support for a decision system. The use of geographic computerised system is fundamental to acquire, manage and revise all sort of information. This work shows how to create a complete, as far as the cartography is concerned, three-dimensional database within the GIS system. Digital sensor derived images, or digitalised images, remote sensing acquired, or any other spatial referred qualitative or quantitative data can be used as data for the application of new methodologies and new procedures for the cartographical elaborations and their representations. Their final products, or the intermediate ones, are easily managed by very well and worldwide known systems, such as the GIS one.

1. TERRITORIAL MANAGEMENT IN A GIS

The dynamic development of urban and extra-urban areas demands more right instruments for a correct environmental analysis, planning and screening. Because of territorial complexity, these instruments must be organized in an Information System, that having the territory and its information as object, it is called *Territorial Information System* (SIT) (Buscarlo et al., 2001). His greatest assignment is to let meaningful data and to transform it in "information". An important contribution in territorial information adjournment is given by *Geographical Information System* (GIS), computer aided instrument for the organization, data banking and processing of the multi aspects of the territory. GIS runs data of SIT in an efficient and effective way. The use of computer technology is fundamental with the advantage that information in a GIS can be updated and modified very quickly in comparison with the traditional cartography. In this contest we can understand as the traditional 2D maps are often restrictive and overcome by more complete products, very descriptive, which permit a three-dimensional and realistic representation. Today GIS, managed and completed by modelling instruments, is going to open a new age of *Decision Support System* (DSS) in every context: local, regional, interregional, for territorial management and planning. We are going towards GIS virtual age, where dynamism, real-time representations and DSS are only one thing. In this special innovative process the overlay mapping of images on three-dimensional support (DEM) becomes a layer on which putting other layers of different blind, to produce the new layer of project, using the topological overlay. The three-dimensionally management of the cartographic data (vector, raster or both combined as an orthoimage 3D) gives us the possibility to have all the potentiality offered by the two typologies, without being tied to the formats. Special analysis becomes simple and gives us a thematic map with realistic characteristics.

2. MAP PROCESSING ON DIFFERENT SCALES IN AN ENVIRONMENTAL GIS

We use a geological-environmental analysis, made in Ancona (Italy), to localize some right areas for urban dump. The information has been stored in a database and we were able to elaborate a map of synthesis of different informative layers, by a topological overlay (Ceccarelli et al, 2001, Provincia di Lecce, 2001). The first part of experimentation has concerned the way to insert and process the data in a GIS to build a cartographic database on which to report the thematic analysis. We have used MapInfo software Professional 6.5. So we have collected the Regional Technical Map of Marche on scale of 1:10.000, in MapInfo format, to provide a mapping overlay of files, which contains administrative limits with relative toponymy and to obtain a map in the Italian reference (Gauss-Boaga). Each layer is made by a set of data: the alphanumeric data (Figure 1) and the map (Figure 2), tied by a biunivocal correspondence.
Through simple queries, it is possible to select data relative to the Province of Ancona, represented also by a prism map (Figure 3), and to individualize the town of Ancona in the same map (Figure 4).


Lim_Com [Dati]

ID	Comune	Provincia	ZON/	ISTAT	COD_ENTE
1	Acqualagna	PS	M	11041001	101
2	Apecchio	PS	M	11041002	102
3	Auditore	PS	M	11041003	103
4	Barchi	PS	M	11041004	104
5	Belforte all'Isauro	PS	M	11041005	105
6	Borgo Pace	PS	M	11041006	106

Figure 1. The table of the alphanumeric data

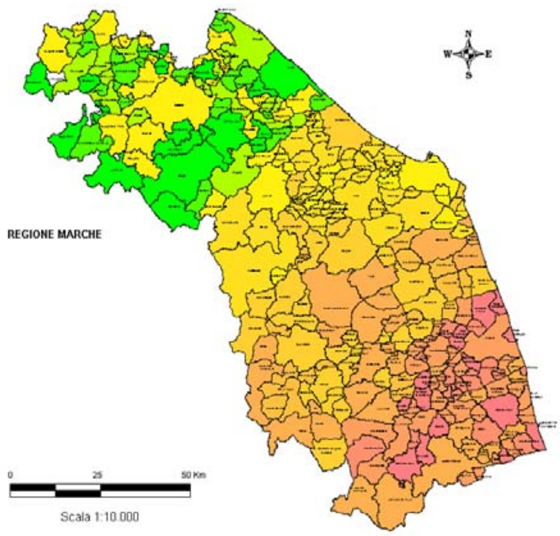

Figure 2. The representation of the Regional Technical Map of the Marche in correspondence with the table above

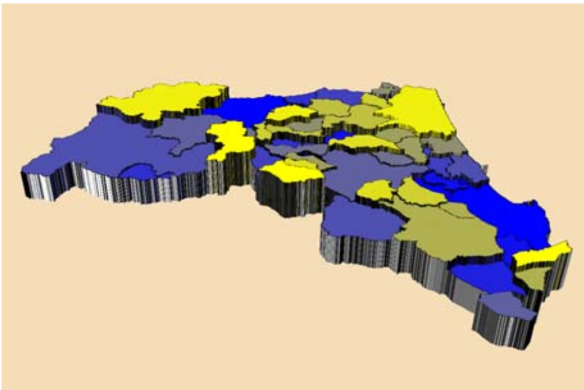

Figure 3. The prism map of the Province of Ancona

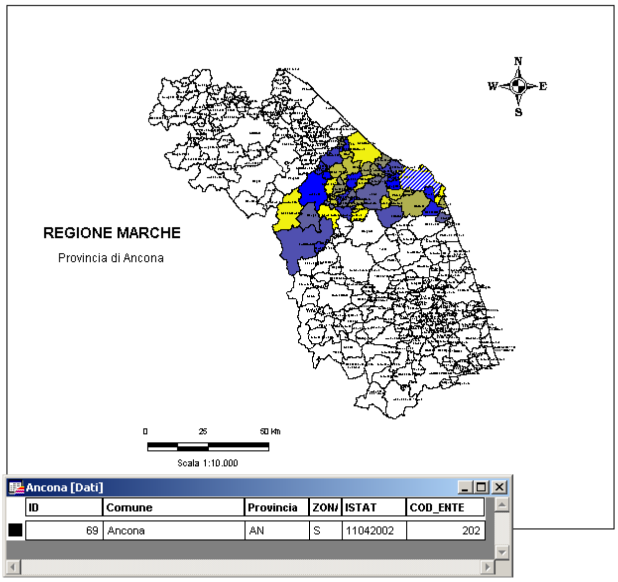

Figure 4. The town of Ancona selected by a query in the map of Province of Ancona

Then we have put in the GIS the six sites, which are the object of the geological-environmental study. These zones, inside the town of Ancona called *Saline*, *Barcaglione*, *Monte Rosato*, *San Bartolomeo*, *Aspio* e *Piantate Lunghe* are visible in the representation of the *Land Uses Map* of town of Ancona on the scale 1:5.000 (Figure 5).

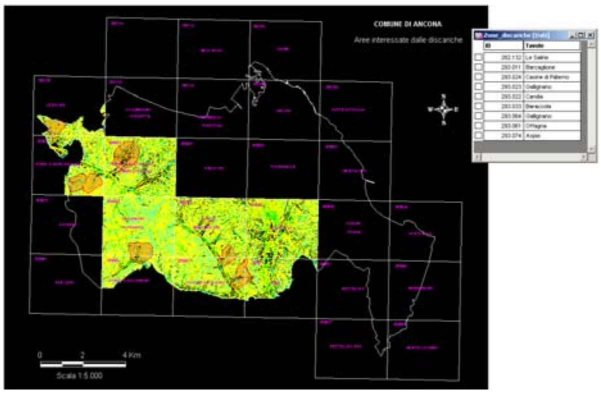

Figure 5. The sites localized in the Land Uses Map of Ancona

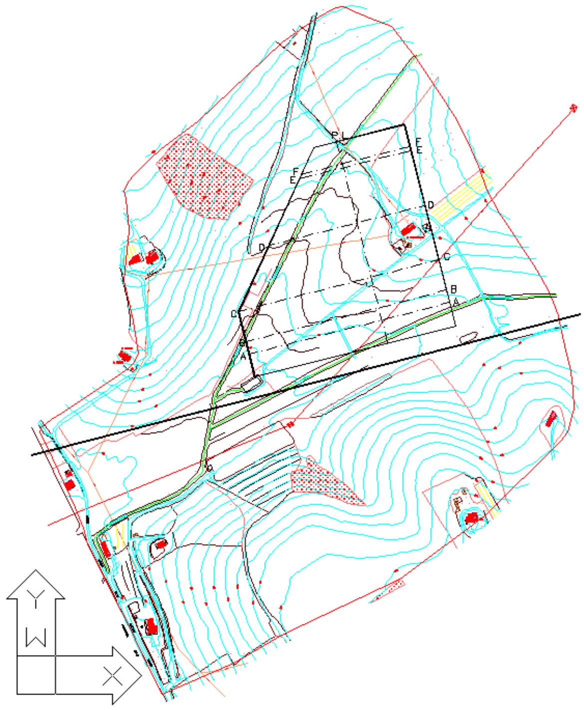

Figure 6. The vector representation of Piantate Lunghe

We have acquired some maps of each site on the scale 1:1.000 in vector format (Figure 6). It brings information about contour lines, quoted points, vegetation, anthropological elements obtained by a photogrammetric survey. Other collected data have been the limits about roads and urban areas derived by a map on the scale 1:10.000. After having geographically localized the sites, we had to acquire geological-environmental analysis. Infact the choice of sites where to collocate the dumps it is a big problem. We had to avoid the environmental and social impact to maintain the more objectivity is possible too. We have found 22 characteristics to which we have assigned a numbers from 0 to 10. These data in the GIS were expressed through a *magnitudo* string on an electronic sheet of Excel and then referred to the areas studied, to create a biunivocal and fundamental correspondence between maps and data. To compare all these sites, we have made a classification by means a matricial product of the 22 *magnitudo* strings. Then, by a query, we have individuated, inside the sites, the four potential areas, characterized by maximum value of *magnitudo* (Figure 7, Figure 8).

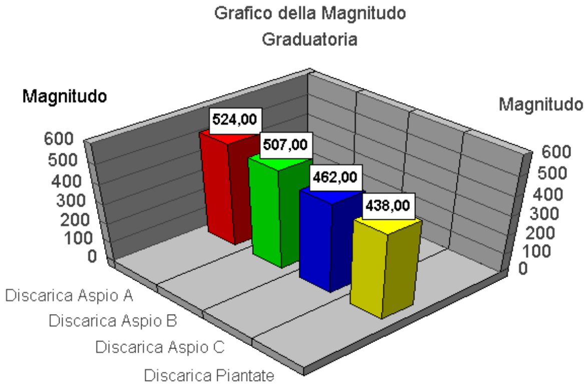

Figure 7. The graphic representation of the *magnitudo* string

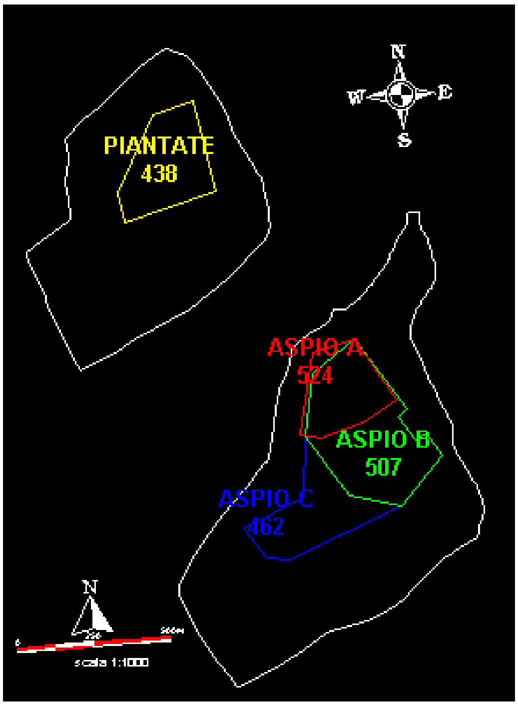

Figure 8. The four potential areas, characterized by maximum value of *magnitudo*

3. GENERATION OF THREE-DIMENSIONAL CARTOGRAPHIC DATABASE

Till now we have worked with bidimensional map. But the data available could let us a three-dimensional study too. So the development of research has experimented the possibility to process and represent the altimetric information too, on the analysed cartographic basis. Using the quoted points and different interpolation techniques we have reached a Digital Elevation Model both as a GRID and contour lines (Baiocchi et al., 2001). By means Surfer, Er-Mapper and MapInfo, we have realized a DEM with 1 meter of gridding interval of Piantate Lunghe and Aspio sites (Figure 9).

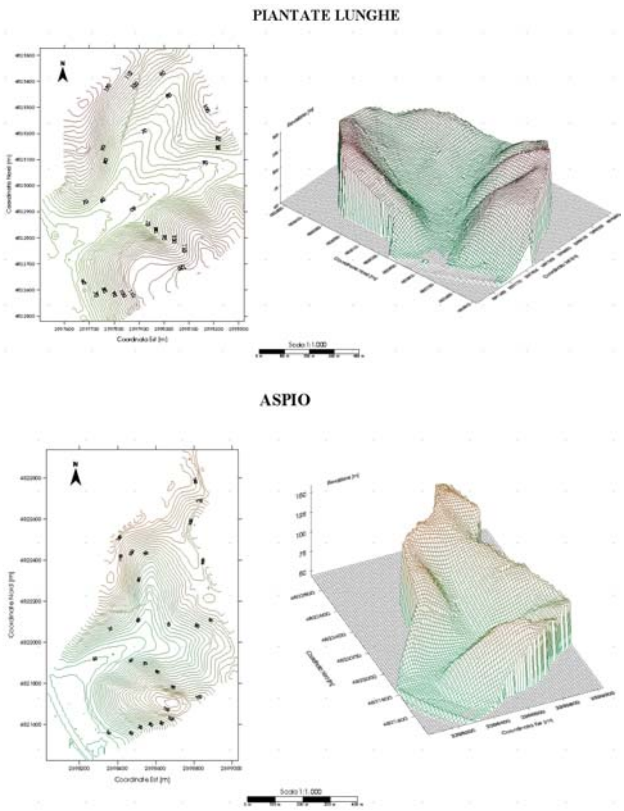

Figure 9. DEM representations by wireframe and contour lines

Wireframe DEM is a representation, although very descriptive, without realistic contents. To improve this representation it is possible to use the details offered by the aerial photos. To this point we have taken into account 10 photos (4 about Piantate Lunghe and 6 about Aspio) on the medium scale 1:7.000 realized in the photogrammetric campaigns of the 1996 (Figure 10).

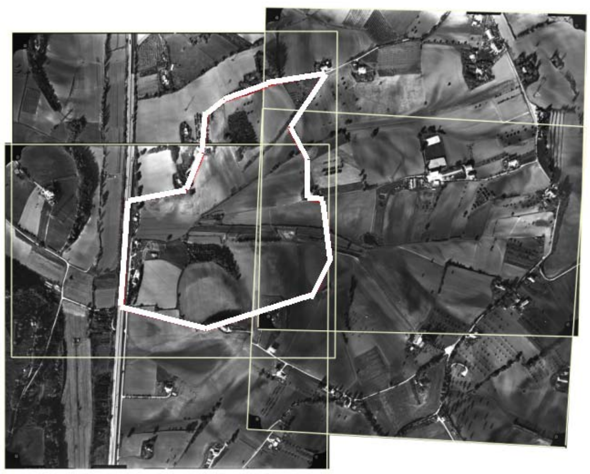

Figure 10. The strips of the photogrammetric survey

Transferred in digital format the aerial photos it was possible to correct geometrically and to geocode them by Ground Control Points (GCP) using Er-Mapper. The more delicate phase of this process has just been to localize correctly the GCP both inside the images and into the vector map. We had to underline the necessity to maintain the accuracy less than one meter, to obtain a correct result at the final orthoimage's scale (1:1.000).

Successively the single orthoimages have been composed in an orthomosaic that has been balanced on clip regions to completely reduce the zones of overlap (Figure 11, Figure 12).

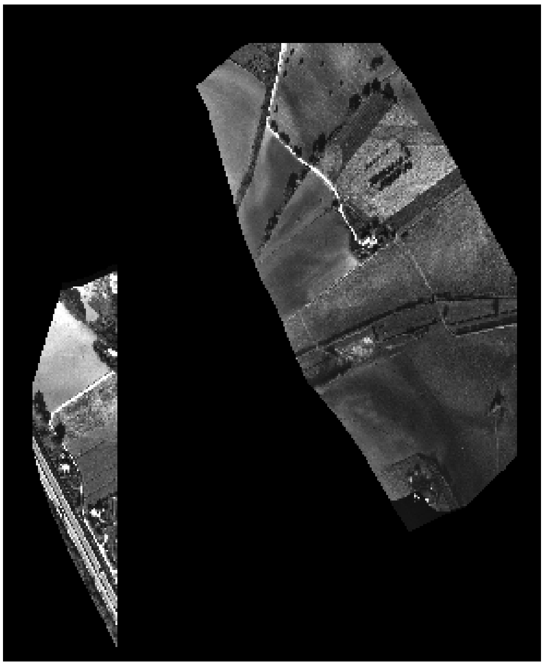

Figure 11. The orthomosaic without balancing process

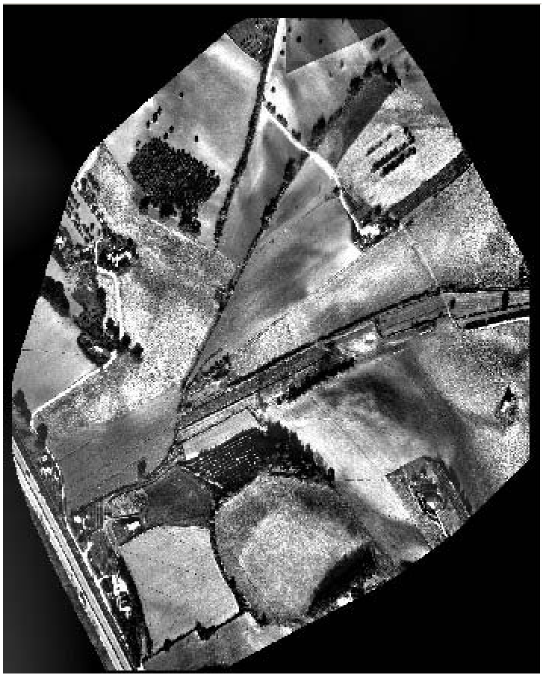

Figure 12. The orthomosaic after balancing process

Digital orthoimage is a photographic map very rich in information but it must yet be completed by the cartographic elements (administrative limits, toponymy, altimetry, and so on). So these characteristic elements and the DEM, like contour lines, have been superimposed like vector on the raster map (Figure 13).

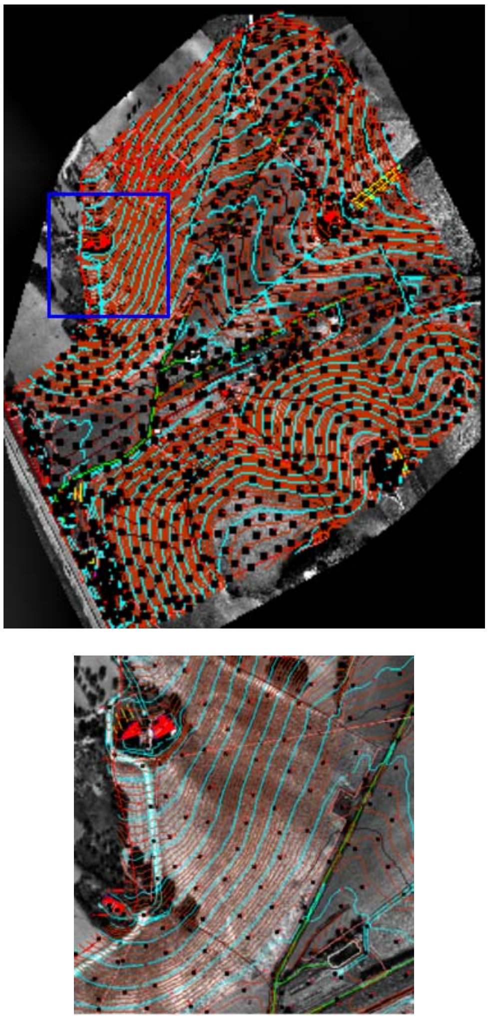

Figure 13. The digital orthoimage with the overlap of some cartographic elements

At last the orthomosaic has been photo-textured on a 3D wireframe, generated again in a GIS by TIN method (Figure 14), giving a three-dimensional representation, which is very realistic and of great impact for the environmental analysis (AA.VV., 2001). In the Figure 15 we can see and evaluate the dynamic 3D representation of the orthomosaic.

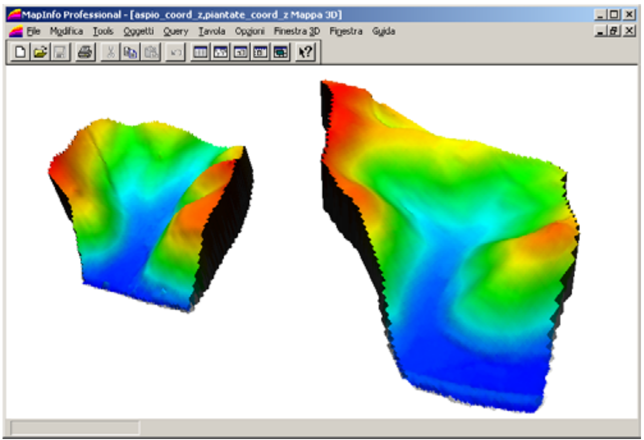

Figure 14. The shaded images of the TIN generated in MapInfo

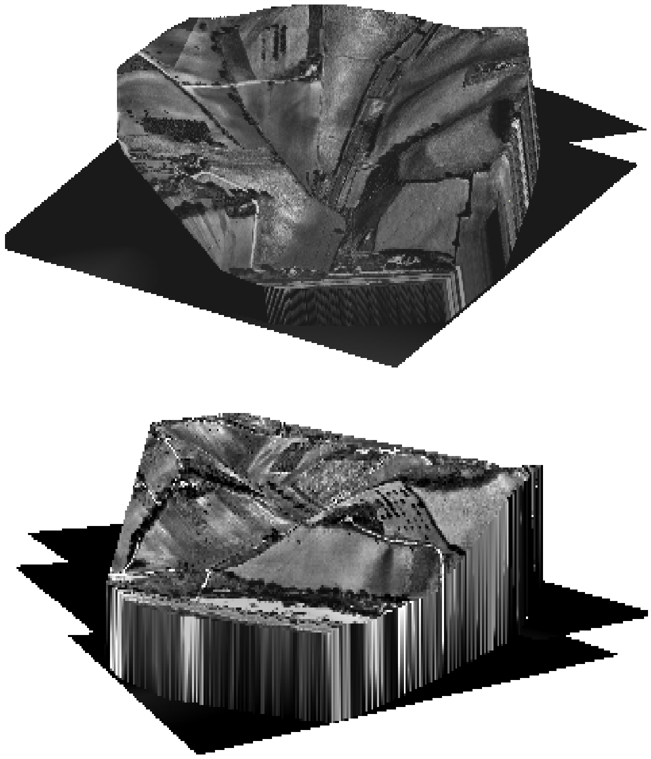

Figure 15. The 3D representation of the orthoimages superimposed on the DEM

4. A 3D GIS FOR A THEMATIC ANALYSIS

In this moment GIS must take into account the new cartographic products already explained. The possibility to create directly these products inside GIS now it is possible. Infact, MapInfo 6.5, let us create a 3D visualization importing directly the DEM externally generated, and overlaying an orthomosaic on 3D surface. In conclusion these procedures we allow to overcome the bidimensional contest for the best three-dimensional one in the generation of a thematic map. DEM give us some morphological information about territory, the overlay of orthomosaic let us localize the interested areas. These advantages pay a price in term of procedures and time during the phase of data processing, even if we have to underline that the three-dimensional result uses products (DEM, orthoimages), which should be the standard in the cartographic production. To show this potentiality we have realized a 3D thematic map in a GIS. In the work-area each parameter, related to the geological-environmental analysis, has been overlapped on the orthomosaic of the sites, selected for dumps, not only in a bidimensional way but also in a three-dimensional one. Choosing a thematic sampling, based on the min and max value of *magnitudo*, it was possible to have some detailed information about each parameter in the investigated areas. We report, to give an example, some 2D and 3D maps referred only to few parameters. Note please the chance to have correlated information: capacity of the area, distance from interested points like drain well and the distance from the urban centre (Figure 16, Figure 17, Figure 18, Figure 19, Figure 20, Figure 21).

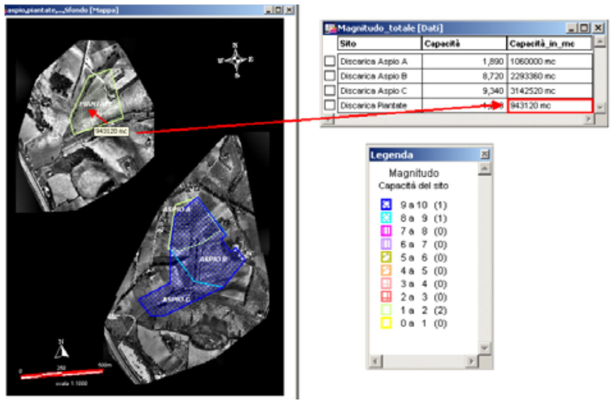

Figure 16. 2D Thematic Map of the parameter “capacity of the area”

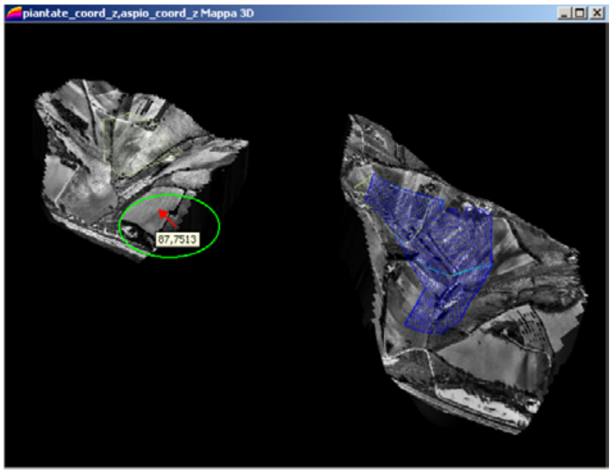

Figure 17. 3D Thematic Map of the parameter “capacity of the area”

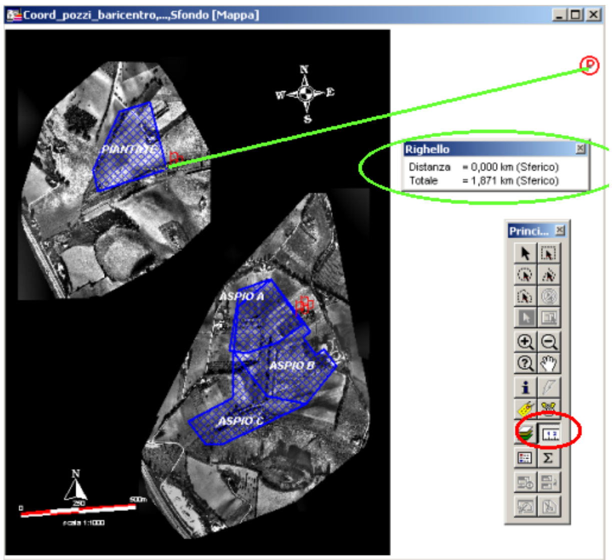

Figure 18. 2D Thematic Map of parameter “distance from drain well”

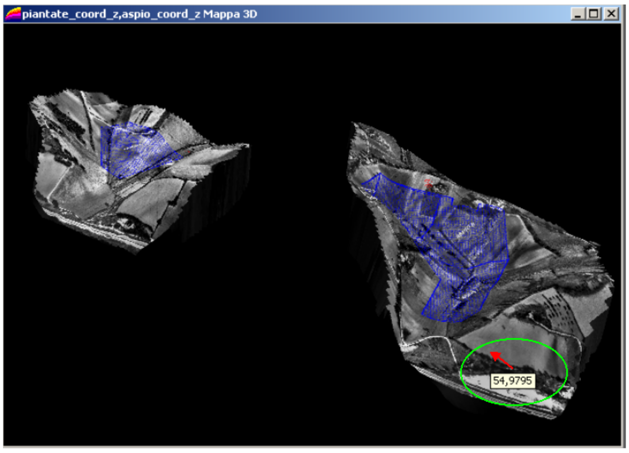

Figure 19. 3D Thematic Map of parameter “distance from drain well”

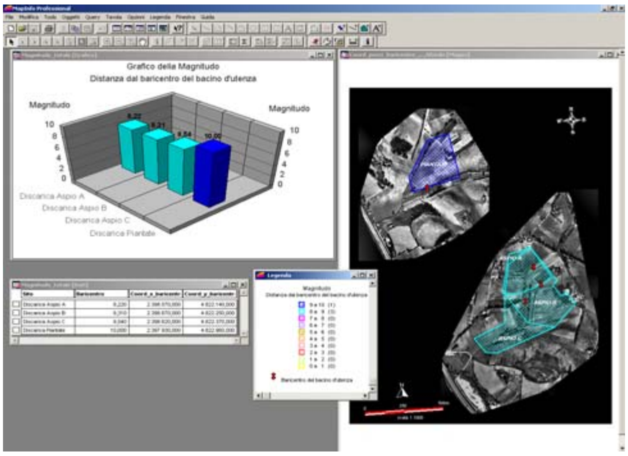

Figure 20. 2D Thematic Map of parameter “distance from the urban centre”

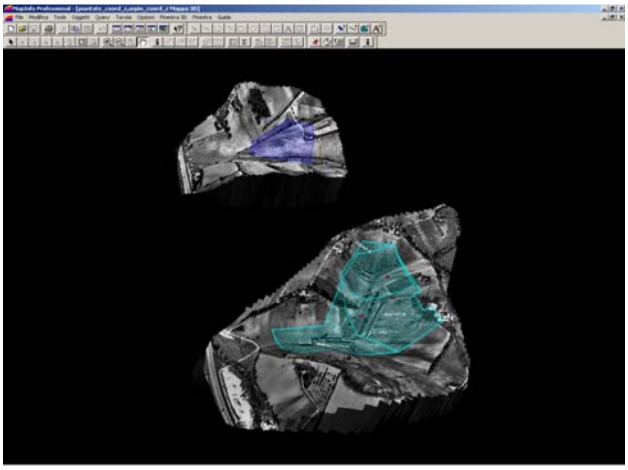

Figure 21. 3D Thematic Map of parameter “distance from the urban centre”

5. CONCLUSIONS

The use of Geographical Information System cannot be underestimated. By this instrument a different kind of information can be acquired, processed and updated. This experimentation would realize a complete three-dimensional database, from a cartographic point of view inside GIS. So, images deriving from digital sensors, as other qualitative and quantitative data, in a spatial reference, become the database for the application of innovative procedures in the elaboration and representation of the cartography. GIS can manage in a very simple way all these products. A lot of disciplines are involved in this process, for example civil, environmental and territorial engineering. The use of software avoids the operator to do some repetitive and slow operations but it is suitable to work in an interactive way for the necessity of a results’ supervision and to obtain a good product.

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