Annales d'Université Valahia Targoviste,
Section d'Archéologie et d'Histoire,
Tome XI, Numéro 2, 2009, p. 41-50
ISSN: 1584-1855

Management of archaeological sites in Tulcea County using an integrated geospatial system for their positioning and protection

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Abstract: Management of archaeological sites in Tulcea County using an integrated geospatial system for their positioning and protection. While conservation is a key component of sustainable development, cultural landscapes preserve traditional interactions between nature and culture. Within the cultural landscapes, the protection of historical monuments presents an importance underlined by numerous international and European political documents. The importance increases when historical monuments receive additional educational and informational value through their inclusion in touristic circuits. Consequently, different institution started their involvement in historical conservation all over the world. New technologies, particularly the Geographical Information Systems (used to integrate spatially referenced data in a problem solving environment) and the Global Positioning Systems (used to accurately position and represent different objects in a geodatabase), had found applications in the conservation of historical monuments. Unfortunately, approaches differ by place, and no common methodology could be used for a joint management of the worldwide heritage. Two pieces of legislation tackle the issues related to the protection of historical monuments in Romania, and each of them introduces different classifications. This paper introduces a novel methodology that has a potential of integrating other approaches and databases, and also for being used in conjunction with other planning and research instruments. The methodology had been applied in Tulcea County, due to its richness in historical monuments, to build and query a geodatabase of all historical monuments, regardless of their inclusion in other databases. The database consists of the following elements: literature reviews, archeological database, digital elevation model, thematic maps, satellite imagery, digital maps, integrated maps, and WEB site. Results suggest that the methodology allows for integrating new elements to existing database, join databases owned by different agencies, easily update information and perform spatial queries for informative, research or planning purposes. Furthermore, the project leading to the creation of the PATRIMON database had proposed a lighting system used for the possible inclusion of identified monuments in touristic circuits.

Keywords: geodatabase, GIS, GPS, historical monument, cultural landscape

Introduction

The concept of sustainable development, defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (G. H. Brundtland, 1987) implies the conservation of biodiversity for future generations. The concept of biodiversity embeds both biological and ethno-cultural diversity (A.-I. Petrişor, 2008), since the environment could be seen as a system

composed out of four types of capital: natural, economic, social and cultural (BSRIA-1997). The connection between the two concepts is revealed especially when analyzed from a spatial perspective: landscapes, including cultural landscapes, are defined the Florence Convention (2000) and the Faro Convention (2005) as the result of a long term interaction between man and nature, including their perception by population (A.-I. Petrişor, L. E. Petrişor, 2008). The European Charter on the architectural heritage and resolution (76) 28 of the Council of Europe's Committee of Ministers defines integrated conservation as actions aiming to preserve the cultural heritage as part of the environment (natural on anthropic), use and adapt it to the needs of the society. Therefore, conservation implies the participation of population, and tourism enhances the increased awareness of population towards the value of the cultural heritage.

The importance of protecting the cultural heritage, including historical monuments, had been underlined by numerous political documents of the European Union, including without limiting to, the European Cultural Convention (Paris-1954), the Convention concerning the Protection of the World Cultural and Natural Heritage (Paris-1972), the Convention for the Protection of the Architectural Heritage of Europe (Granada-1985), the European Convention on Offences Relating to Cultural Property (Delphi-1985), the European Convention on the Protection of the Archaeological Heritage - revised (La Valetta-1992),.the European Landscape Convention (Florence-2003), and the Territorial Agenda of the European Union (Leipzig - 2007).

The United Nations Educational, Scientific and Cultural Organization (UNESCO) define three types of cultural landscapes: landscapes clearly designed and created by man, landscapes developed organically (including vestigial and continuous landscapes) and associative landscapes (UNESCO-2006).

UNESCO had elaborated based on inputs from experts of the 39 member states a list with 878 protected sites from all over the world. Seven sites are from Romania: the churches of Moldova, the monastery of Horezu, the villages with fortified churches in Transylvania, the Dacian fortresses of the Orăştie Mountains, the historic centre of Sighişoara, the wooden churches of Maramureş, and the Danube Delta Reserve of Biosphere (UNESCO-2009).

Two pieces of the Romanian legislation regulate historical monuments. The National Spatial Plan has a section on protected areas, defining 150 monuments and sites grouped in Paleolithic assemblies, Neolithic and Eneolithic settlements, settlements and necropolises of the bronze age, fortifications and settlements from the first iron age, Dacian fortifications, necropolises and sacred areas from the second iron age, casters and civilian settlements, antique cities, edifices, medieval monuments (archeologically identified), and archeological reserves. Law no. 5 of 2000 identifies historical monuments of national monuments (over 20.000), grouped in: archeological monuments, architectural monuments and assemblies, art monuments and assemblies, and memorial buildings and monuments.

New recommendations of the Ministry of Culture envisage the implementation of spatial technologies (Geographical Information Systems - GIS and Global Positioning Systems - GPS) in managing data on spatial monuments. GIS systems represent decision support systems involving the integration of spatially referenced data in a problem solving environment (D. J. Cowen, 1988) and can be used in conjunction with remote sensing methods, representing the acquisition of information about an object without being in direct contact with it (J. R. Jensen, 2007).

Even though some steps were taken (*e.g*, 10,326 monuments included in the Archeological Repertoire of Romania, started in 1949 by the Institute of History and Philosophy and continued by CIMEC Institute for Cultural Memory, available in GIS format at http://ran.cimec.ro/sel.asp?Lang=EN), there are no local resources and personnel to complete this work..

This paper proposes a geospatial methodology for marking and coding historical sites in order to preserve them and also introduce them in the touristic circuits. The methodology is applied to a case study - Tulcea County. Benefits include a better management by spatial and urban planning authorities, as well as a better knowledge of the sites, avoiding their deterioration and allowing for a better management of archeological activities. Tulcea County possesses most archeological sites (488 are enlisted as historical monuments and data are available for other 40). However, not all sites were included due to the lack of topographical documents, resulting into an increased risk for their deterioration. Furthermore, only 2% have GPS/GIS based topographic documents, mostly based on obsolete and imprecise data. Upon the creation of the PATRIMON geodatabase for Tulcea, spatial queries are used to answer specific questions.

1. Code in the National Archeological Repertoire (NAR)
2. Code in the List of Historical Monuments (LHM)
3. Unique local identifier
4. Identifier of the site (usual name or reference name)
5. Category of the site, according to NAR
6. NAR shape or function (amphitheatre, rupestral assembly etc.)
7. Period / Age (precise, interval, period)
8. Century
9. Date when filed
10. Last update
11. Name of county
12. Name of administrative-territorial unit (ATU)
13. Name of commune or village
14. SIRUTA Code
15. Postal code
16. Name of street, if applicable (urban areas)
17. Street number
18. Street milestone
19. Water course milestone
20. Cadastre parcel
21. Type of property
22. Name of owner
23. Cartographic localization procedures
24. Reference system (WGS84, Stereo70)
25. Type of file containing topographic reference (DXF, DWG, TIFF, JPG, shape)
26. Topology (point, line, polygon)
27. Precision of cartographic coordinates
28. X coordinate (center of the site - E-W)
29. Y coordinate (center of the site - N-S)
30. Z coordinate (center of the site - altitude)
31. Land use
32. General conservation status
33. Threats
34. Judicial protection
35. Urbanistic regulations
36. Valorization (arrangements, lighting, other accessories, signaling)
37. Position, images, archeological remarks (attached text file)
38. Images
39. Remarks (includes name of person recording information in the database)
40. Code in the National Archeological Repertoire (NAR)
41. Code in the List of Historical Monuments (LHM)
42. Unique local identifier
43. Identifier of the site (usual name or reference name)
44. Category of the site, according to NAR
45. NAR shape or function (amphitheatre, rupestral assembly etc.)
46. Period / Age (precise, interval, period)
47. Century
48. Date when filed
49. Last update
50. Name of county

51. Name of administrative-territorial unit (ATU)
52. Name of commune or village
53. SIRUTA Code
54. Postal code
55. Name of street, if applicable (urban areas)
56. Street number
57. Street milestone
58. Water course milestone
59. Cadastre parcel
60. Type of property
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72. Threats
73. Judicial protection
74. Urbanistic regulations
75. Valorization (arrangements, lighting, other accessories, signaling)
76. Position, images, archeological remarks (attached text file)
77. Images
78. Remarks (includes name of person recording information in the database)

Table 1 - Information recorded in the study for each historical monument. Each line corresponds to a field contained by the database, and filled in for each monument.

Name	*Cetatea Dinogetia*	*Cetatea Argamum (Origame)*	*Enisala Palanca*	*Babadag-Dealul Cetatuia*	*Enisala Cetate*	*Enisala - zid exterior*	*Cetate Halmyris*	*Turnul cet. bizantine Proslavita*	*Port antic*	*Basilica Niculitel*
NAR Code	160635.03	160653.03	161197.01	159669.01	161197.04	161197.04	160920.02	161062.12	161062.09	161044.07
LHM Code	TL-I-s-A-05795	TL-I-s-A-05808	TL-I-s-B-05780	TL-I-s-A-05734	TL-I-s-A-05785	TL-I-s-A-05785	TL-I-s-A-05844	TL-I-s-A-05864	-	TL-I-m-A-05862
Data filed	23.04.08	10.07.08	10.07.08	10.07.08	10.07.08	10.07.08	10.07.08	10.07.08	10.07.08	10.07.08
Last update	03.05.09	03.05.09	03.05.09	03.05.09	03.05.09	03.05.09	03.05.09	03.05.09	03.05.09	03.05.09
County	Tulcea	Tulcea	Tulcea	Tulcea	Tulcea	Tulcea	Tulcea	Tulcea	Tulcea	Tulcea
ATU	Jijila	Jurilovca	Sarichioi	Babadag	Sarichioi	Sarichioi	Murighiol	Nufaru	Nufaru	Niculitel
Place	Garvan	Jurilovca	Enisala	Babadag	Enisala	Enisala	Murighiol	Nufaru	Nufaru	Niculitel
SIRUTA	160217	11679	11657	11622	11657	11657	11697	11703	11703	11701
Water milestone	Garla Mare	L. Razelm, L. Golovita	Canalul Enisala, L. Razelm, L. Babadag	L. Babadag	L. Razelm, L. Babadag	L. Razelm, L. Babadag	L. Saratura Mica, Sf. Gheorghe	Danube, Sf. Gheorghe	Danube, Sf. Gheorghe	Valea lui Iancu
# Parcel	0	0	0	0	0	0	0	0	0	0
Property	0	0	0	0	0	0	0	0	0	0
Positioning	GPS	GPS	GPS	GPS	GPS	GPS	GPS	GPS	GPS	GPS
Reference system	STEREO 70	STEREO 70	STEREO 70	STEREO 70	STEREO 70	STEREO 70	STEREO 70	STEREO 70	STEREO 70	STEREO 70
File	shape	shape	shape	shape	shape	shape	shape	shape	shape	shape
Topology	L	L	L	L	L	L	L	L	L	L
Precision	3	3	3	3	3	3	3	3	3	3
X	75000000	830837,8	802425,5	795407,2	803026,9	803026,9	830834,7	808354,3	808290	773864,1
Y	44000000	400282,8	383493,7	385980,7	383272,9	383272,9	400274,1	413212,4	413362,5	415598,8
Z	44	48	51	50	135	135	38	36	32	103
Regime	Civil housing	Housing	Civil housing	Civil housing	Civil housing	Civil housing	Civil housing	Civil housing	Civil housing	Religious
Type	Citadel	Fortified settlement	Settlement	Fortified settlement	Citadel	Citadel	Citadel	Citadel	Citadel	Basilica
Age	Eneolithic, Roman, Roman-Byzantine	Greek, Roman, medieval	Medieval, Roman, Hallstatt, La Tène	Hallstatt, La Tène, Hellenistic, medieval, Roman	Medieval	Medieval	Roman	Byzantine, medieval	Byzantine	Roman-Byzantine
Century	II, IV-VI, X-XII	V-IV, II-VI, X-XII	XIV-XV, IV-II, X-XI	XI-VII, V-IV, IV-III, X	XV-XVII	XV-XVII	II-VII	X-XI, XII-XIII	X-XIII	IV-VI
Judicial protection	true	true	true	true	true	true	true	true	true	true
Length	666,0443	1394,282	485,4246	632,4555	269,4147	204,9537	597,776	2,670215	164,8261	120,2198
Postal code	827110	827115	827191	825100	827191	827191	827150	827170	827170	827165
Street milestone	DN22E (E87), DJ222M	DJ222, dirt road	DJ222	E87 (DN22), railroad	Dc81	Dc81	Dc9	Dc2, DJ222C	Dc2, DJ222C	DJ229, Dc84, Dc62
Land use	Non-arable agricultural	Non-arable agricultural	Pastures	Non-arable agricultural	Pastures	Pastures	Non-arable agricultural	Housing (urban tissue)	Housing (urban tissue)	Housing (urban tissue)
Conservation	Advanced degradation	Gradual degradation, covered by vegetation	Deplorable, partially destroyed	Severely affected	Restoration, consolidation	Restoration, consolidation	Included in National Restoration Plan	Protected by built body	Dig for protection	Restoration, consolidation, protective building

Name	*Cetatea Dinogetia*	*Cetatea Argamum (Origame)*	*Enisala - Palanca*	*Babadag-Dealul Cetatuia*	*Enisala Cetate*	*Enisala - zid exterior*	*Cetate Halmyris*	*Turnul cet. bizantine Proslavita*	*Port antic*	*Basilica Niculitel*
Threats	Vegeta-tion, falling stones	Vegeta-tion, clime	Mud ex-traction, landslide	Falling due to high level of water (Ba-badag)	Insuffi-ciently conserved foundation	Insuffi-ciently conserved foundation	Vegetation	Houses with deep foundation built	Walls de-stroyed deliber-ately by owner	Slope, dwelled area, crossroad
Urban regulations	Protected area	Protected area	Protected area	Protected area	Protected area	Protected area	Protected area	Protected area	Protected area	Protected area
Valoriza-tion	Restora-tion	Conserva-tion, cleaning, restoration	Delinea-tion, research	Conserva-tion	Uncover-ing, re-search	Uncover-ing, re-search	Protection, restora-tion, consoli-dation	Building, sign	Conserva-tion, val-orization, delineation	Museum, already in touristic circuit
Remarks	UP, Pope-scu, Tache	UP, Pope-scu, Tache	UP, Pope-scu, Tache	UP, Pope-scu, Tache	UP, Pope-scu, Tache	UP, Pope-scu, Tache	UP, Pope-scu, Tache	UP, Pope-scu, Tache	UP, Pope-scu, Tache	UP, Pope-scu, Tache
Images files	poze_dino getia	poze_arga mum	poze_enisa la	poze_Baba dag	poze_enisa la	poze_enisa la	poze_halm yris	poze_nufar u	poze_nufa ru	poze_nicul itel
Description file	dinogetia.d oc	argamum. doc	Enisala_bu n.doc	Babadag, Dealul Cetatuia	Enisala_bu n.doc	Enisala_bu n.doc	halmyris_ bun	proslavita-nufaru	proslavita-nufaru	bazilica_ni culitel_bun

Table 2 - Sample results of the study. The first column includes fields present in Table 1, and the next columns indicate how columns are filled in for sample locations. Fields that had not been filled in for most selected records are not shown.

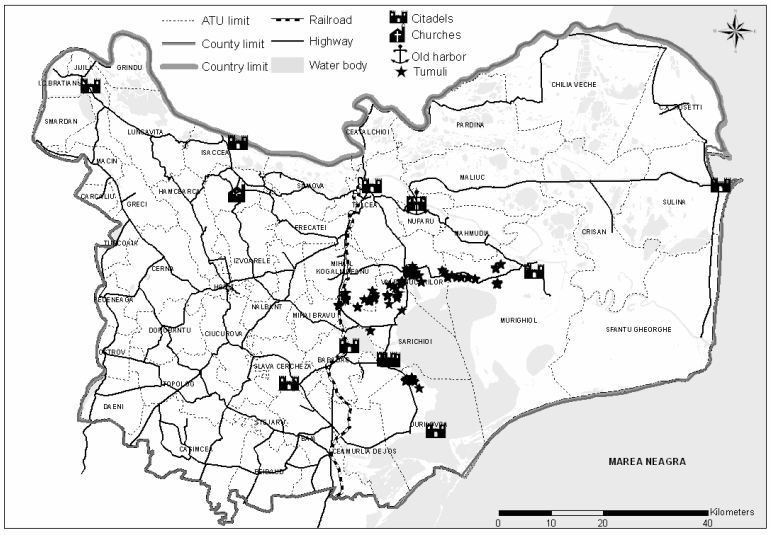

Fig. 1 - Graphical representation of the PATRIMON database. The image displays the main objectives, classified by type (citadel, church, old harbor or tumulus), as well as the milestones (main roads, railroads and water bodies), and the limits of administrative-territorial units, county, and country. Some of these elements are not contained in existing databases of the Ministry of Culture

Methods

Several papers presented in a UNESCO 2002 conference (A. Del, 2002; L. Bianchini, 2002; J. Counsell, 2002; C. Diekmann, 2002; R. El Hassan, 2002) had showed that worldwide few institutions are in charge with documents related to the cultural heritage and use different methodologies, and proposed a unique model for all data bases. This study had recorded the

following information, presented in detail in Tab. 1: name of the site, local administrative-territorial unit, archeological methods, names of researchers, period, extension area of the site, chronology of occupation and/or use, type of site by chronological period, general remarks from the review of literature, and references.

GIS archeological maps are produced taking the following steps: (1) literature review based on publications or maps referring to a specific period; (2) build archeological database, allowing for updating and queries; (3) build a digital elevation model (DEM) based on satellite imagery; (4) create geological, land use and other thematic maps of the area of interest; (5) derive site information from satellite imagery at different resolution; (6) build digital maps representing the sites using points, lines, and polygons; (7) create integrated maps for all sites (1:50,000), adding ancillary information in the same coordinate system; (8) create a WEB site with maps and metadata.

Upon the construction of geodatabases, GIS could answer specific research and/or management questions, using specific spatial analysis procedures. However, geodatabases include two types of information. Spatial information (based on the GIS/GPS technology) allows for precise drawing and positioning of each objective and is used to create maps. Ancillary data are included in the table of attributes and could be displayed on larger maps using different symbols based on the spatial data. The objective of the project was to create a geodatabase of historical monuments in Tulcea. However, this paper presents several analyses based upon the geodatabase in order to underline its utility.

In order to identify monuments on site for the inclusion in touristic circuits, a lighting system was proposed through this study, consisting of a photovoltaic panel IS75P 75Wp 12V, a controller Rigel 12, a led lamp, an acid battery 55Ah, and a metallic arm with the inner diameter 6.5 cm and adjustable angle (10-30°-45°).

Results and discussion

This paper presents two types of results. The first ones present the geodatabase created through the project, while the second type consists of GIS-based analyses answering specific research questions using the spatial database, in order to show its utility. Sample results of the first type are presented in Tab. 2. The table displays 10 sample records, indicating how the fields that could be filled in with information for most of these records appear in the database. In addition, Fig. 1 displays the main objectives contained by the PATRIMON database, classified as either citadel, church, old harbor or tumulus, as well as the milestones (roads, railroads and water bodies) used to identify each of them, and the limits of administrative-territorial units containing these monuments. Some of these records represented in the figure are not contained in existing databases of the Ministry of Culture. In the particular case of the citadels, their contour was digitized using the GPS and GIS technology. An example is provided in Fig. 2, showing Citadels Enisala and Enisala-Palanca. The image also includes the limits of protected areas and land use, classified according to the third level of the CORINE scheme (N. de Lima, 2005).

The second type of results relate to the particular usefulness of the PATRIMON geodatabase. Querying a geodatabase is different from the classical example operating with tables through the facility of performing spatial queries, *i.e.*, obtain information about a specific objective by simply selecting the objective from a digital map. Such an example is presented in Fig. 3, where information on the Halmyris Citadel is made available in an opening window following the selection of the objective from the digital map displayed in Fig. 1. Moreover, the complexity of performing such queries exceeds in GIS the simple level of selecting individual objects. Fig. 4 displays a map derived from the map displayed in Fig. 1, where different symbols indicate the period (group of centuries) when first dwelling of each citadel occurred. Such analyses allow for mapping the age of monuments and could find particular relevance to archeologists.

In conclusion, the flexibility of the GIS technology and the scientific value added by the ability to perform spatial analyses represent an important research tool for archeologists, but could find application in integrated urban management (if such information is used in conjunction with planning tools), conservation of monuments and other areas as well.

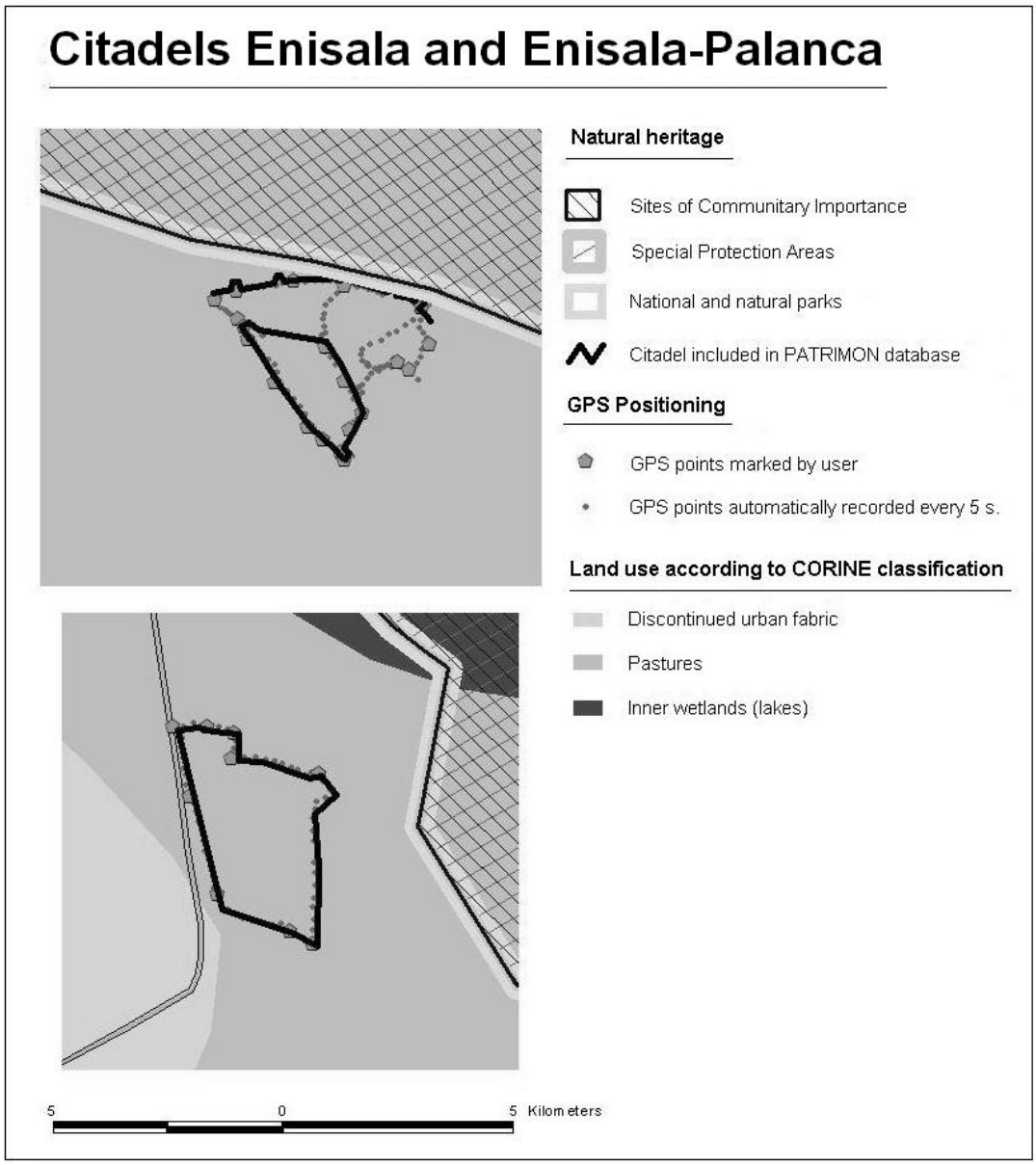

Fig. 2 - Details on the exact mapping of Citadels Enisala and Enisala-Palanca, including the use of GPS technology. The image also displays the limits of protected areas and land use, classified according to the CORINE scheme

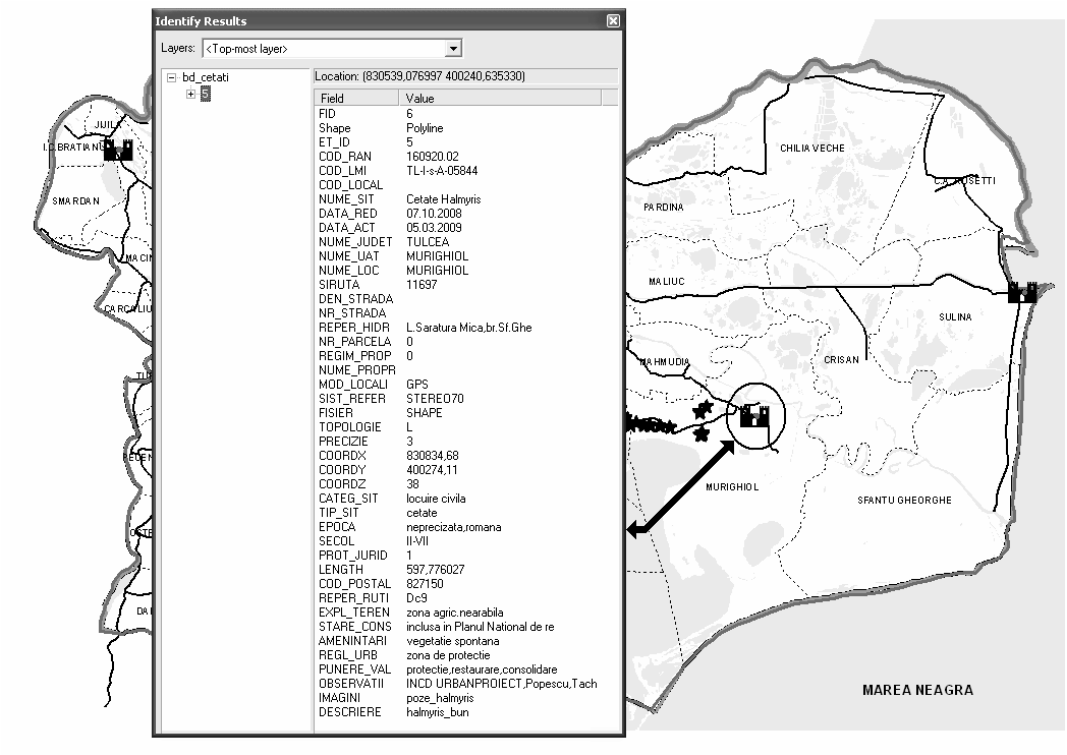

Fig. 3 - Use of the digital database. GIS technology allows for visualizing ancillary information in a separate window upon the selection of a specific objective from the digital map.

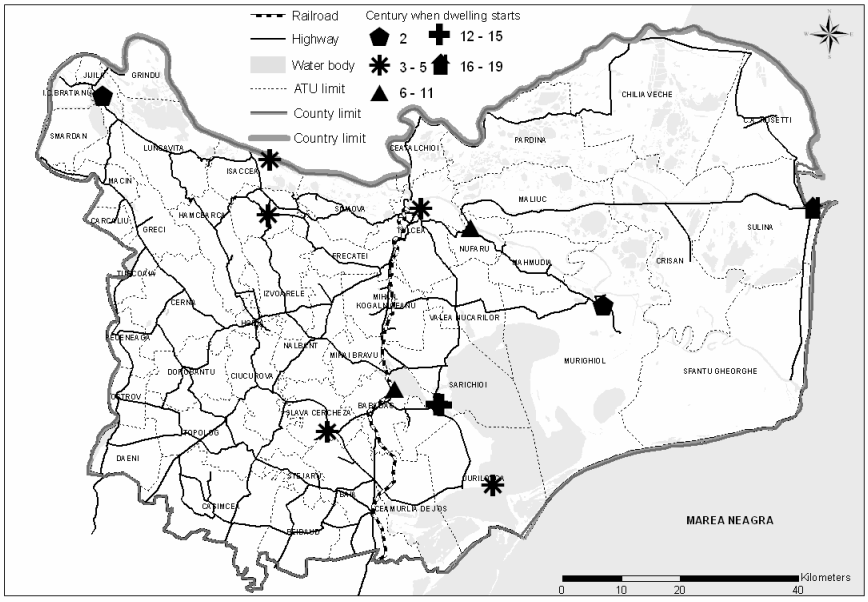

Fig. 4 - Spatial analyses involving the PATRIMON database. The image displays the citadels classified based upon the century when first dwelling of the citadel occurred, using different symbols for each group of centuries.

Acknowledgement

This work was supported by National Center for Program Management at the Ministry of Education and Research grant #2930/2007, "*Integrated Geospatial System for the Localization and Protection of Archeological Sites. Pilot Project: Tulcea County – GISTEREG*", coordinated by SC Crescendo International SRL, Bucharest, with the following partners: National Institute of Research and Development in Urban and Spatial Planning URBANPROIECT, Bucharest, the Institute for Eco-Museal Research, Tulcea, and SC Electrovâlcea SRL, Râmnicu Vâlcea.

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