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A Web-GIS Approach to Cultural Resources Management in Crete: the Digital Archaeological Atlas of Crete

Abstract: The Digital Archaeological Atlas of Crete, part of a larger campaign (Digital Crete: Mediterranean Itineraries), was implemented under the framework of the Greek Operational Program “Information Society”, part of the “eEurope” initiative of the European Union which is funded by the 3rd European Community Support Framework. A program module was constructed in order to create a database warehouse for cultural heritage sites on the island of Crete in the South Aegean Sea. A combination of internet-accessible databases, web-GIS techniques and multimedia, provides for the integrated and wide dissemination of cultural information, while contributing to a better understanding of the cultural environment and the influence of the natural environment on the history of the settlement of Crete.

Introduction

The growing number of cultural resource databanks created recently is a testament to the increasing importance of the accessibility of cultural information to researchers and the wider public. Many of these databanks are also enriched with a geographical component through the use of Geographical Information Systems (GIS) (MAGIS 2007; BEVAN / CONOLLY 2002; JOHNSON / WILSON 2003; SARRIS et al. 2002). This movement is manifested in the development of easily accessible web-based information systems, such as Google Earth, NASA’s World Wind and Microsoft’s Virtual Earth platform. Though the above systems capture the attention of the wider public, however, they are insufficient for heavy-duty spatial analyses and large amounts of diverse information on the archaeological and environmental context of the cultural resources.

The construction of Cultural Geographic Information Systems (CGIS) requires a very different approach than usual GIS applications, in terms of the quality of the data provided, the kind of information that is made available to the public and the synthesis of the thematic layers that are needed for mapping the cultural monuments and sites. To a considerable extent, the above tasks are controlled by the GIS application’s core database. On the other hand, the geographic information which is incorporated into the GIS platform depends on the specific application, the scale of detail, the availability of the data and the target audience. A much more integrat-

ed approach is needed if a corresponding application is to be used for purposes that go beyond the static dissemination of cultural data. According to the operational guidelines of UNESCO’s World Heritage Committee, reactive monitoring of the sites is needed to ensure their protection from human and natural damage. However, the above directives are mainly limited to the sites that have been included in the World Heritage List.

Taking this into account, the efforts of this project were focused on creating an infrastructure which could offer a multi-parametric cultural resource tool not only capable of providing general information related to the archaeological sites of Crete and their spatial distribution on the island over time, but also able to retrieve data related to the risk imposed by a set of diverse human activities (tourism, population increase, settlement establishments, etc.) and environmental factors (seismic activity, agricultural fires, geomorphic change, etc.). In this way, a more integrated inventory related to both cultural and natural resources has been formed, which can then be used by researchers, managers, developers and the wider public.

The Archaeological Inventory

Past archaeological research on excavations, surface surveys, independent studies, joint analytical procedures or field campaigns and thematic studies has been collated from numerous sources including

books, journals, monographs, technical reports, conference proceedings, review volumes, newspapers, and PhD and MA theses. Each source was carefully selected to provide the broadest, most accurate and up-to-date spectrum of information regarding the archaeological sites, with an emphasis on the periods from pre-history until the Roman Empire. Indexing and retrieval of archaeological objects and information was accomplished by constructing a relational database designed to guarantee compatibility with the GIS platform.

The database was designed with MySQL 4.1, while PHP 4.4.1 was used to communicate with the HTTP Web Server (Fig. 1). A special version of Imagemagick compatible with PHP, Magickwand, handles images and photographic material. The main database tables contain the chief geographic attributes like toponym, territory name, province and geographic context, as well as a short description of the site concerning the architectural monuments, main finds, surrounding landscape, locality and other environmental aspects. The database also includes information on past investigations (type of excavation or surface survey, the methods of geophysical prospection and archaeo-environmental analysis used, supervising institute and researchers, research period and related references), and sites that are currently under study have been also entered to the database. However, since data from a number of archaeological sites remains unpublished, external users (those outside the IMS-FORTH facilities) cannot view the data and photos from these sites – a precautionary measure for the protection of sites. The environmental surroundings and landscape conditions are also entered into the database, together with the corresponding digital photographs which are saved in three different formats (.jpeg, .tiff and .bmp) with a minimum resolution of 600 dpi. Because photographic material of archaeological sites is protected under Greek Archaeological Law, all images are displayed with a watermark symbol of the IMS-FORTH logo and are only available to an external user as thumbnail images.

Due to the changing use of the landscape over time, the relationship between a site's category or type and its corresponding chronological phase does not follow simplistic rules. In order to avoid fuzziness or misfit in defining these attributes, a hierarchy of both chronological and typological categories has been set up, consisting of parent categories and more detailed classes, allowing both multiple entries, generalizations and more detailed information



Fig. 1. Diagram indicating the main modules of the database connections with the GIS server.

to be entered. This proved to be extremely helpful in counterbalancing problems that arose when classifying sites from past archaeological research which used different methodological approaches.

Information on georeferencing of the archaeological sites has been also entered in the database, together with the method used to define the location of the sites. Relocation of the archaeological sites proved to be one of the hardest tasks of the project, since many of them have either been destroyed by development or natural processes or inaccurately located on maps, especially those recorded by old surveys which lacked appropriate instruments. In order to satisfy the needs of the project, a systematic GPS survey, aerial orthophotos from the Ministry of Agriculture (scale 1:5000) and various satellite images (mainly SPOT and Quickbird), together with a systematic digitization of archaeological maps and plans, were utilized to locate the sites. In addition to the available data, a systematic GPS survey was carried out with various mobile GPS units (Leica GS20, Thales Mobile Mapper CE, Garmin 12XL, Trimble and two double frequency Ashtech Z-12 units) and

static or Stop & Go configurations of mapping. Corrections carried out through EGNOS or a differential secondary GPS base station increased the accuracy of the available measurements to less than 1 m. In many cases, delineation of archaeological features required more than a single GPS measurement per site. In total, more than 4000 GPS points have been collected corresponding to about 3000 archaeological sites.

By the end of 2006, more than 5500 archaeological sites, accompanied by 2600 photographs and almost 4000 bibliographic references, had been entered in the database, more than 60 % of them positioned in a geographical context through surface surveys or digitization processes. Information can be retrieved in both Greek and English in two different ways according to the user's needs. In cases where the user has a general knowledge of a site or its category, synthetic key-words can be used and the search engine returns all related information within all the fields of the database. A more sophisticated method of data retrieval involves a filter-based search which allows categories to be specified in the fields of chronological period, geographic region, type of site, name of researcher, type of archaeological investigation, etc. The result of the query is a list of sites matching the specific criteria and the user can view the stored data for each one (Fig. 2).

External users of the system have access via the project's website. There is also provision for two categories of users depending on their access requirements: creating new entries and updating existing data, or searching the database. Password protection has been provided for intranet users, and internet users require a similar password for registration purposes only (Fig. 1).

The Web- and Web-GIS-Based Portal: a Geographic Reference Tool for the Archaeological Atlas of Crete

A specially-designed web portal currently hosts the "Digital Crete" data (http://www.ims.forth.gr/ims/external_projects/digital_crete/digital_crete-gr.html). The module dealing with the digital Archaeological Atlas of Crete has several different access points. On the home page, users find general information about the project's goals and methodology, the kinds of data available through the database, their documentation and treatment, abbreviations used in the hierarchy of typological or chronological

ARCHAEOLOGICAL ATLAS OF CRETE - ARCHAEOLOGICAL SITES
View Site in Digital Map

Site Information

SITE NAME :	Itanos
CLOSEST VILLAGE :	Palaikastro
PREFECTURE :	LASITHIOU
MUNICIPALITY :	ITANOU
PROVINCE :	Sitia

Conservation Status

DECLARED SITE :	✓
ZONE A :	-
ZONE B :	-
CONSERVATION :	well preserved
FENCED SITE :	-

Ministry of Culture - Declarations

Code	Declaration Decisions
1. 899/Β/26.5.1976 (4)	ΥΠΠΟ/ΑΡΧ/Α1/931/24456/1834 n.t.
2. 666/Β/23.9.1970 (1)	Αρ.Α. 9597
3. 822/Β/6.7.2000 (1)	ΥΠΠΟ/ΑΡΧ/Α1/943/21086/1004
4. 278/Β/31.3.1999 (1)	ΥΠΠΟ/ΑΡΧ/Α1/943/46515/2763 n.t.

Time-line of Usage

Time Period	Place name	Secondary names	Dating Verification	Category	Category Verification
1.	LM IA		Sure	Town	
2.	LM IB		Sure	Town	
3.	Dark Ages/Protogeometric	Itanos	Sure	Town	
4.	Geometric	Itanos	Sure	Town	
5.	Archaic	Itanos	Sure	Town	
6.	Hellenistic	Itanos	Sure	Town	
7.	Roman	Itanos	Sure	Town	
8.	1st Byzantine		Sure	Town	

Geophysical Prospection

Researcher/s	Research Institute	Beginning of Research	Completion of Research	Geophysical Prospection Method	
1.	APOSTOLOS SARRIS	Institute of Mediterranean Studies- Foundation for Research & Technology, Hellas (F.O.R.T.H.)	1996	2001	Ground Penetrating Radar Magnetic Gradient Seismic Refraction Soil Resistivity Mapping Soil Resistivity Tomography Soil Conductivity-EM
2.	VAFIDIS ANTONIS	Department of Mineral Resources Engineering Technical University of Crete (TUC)	1996	2001	Ground Penetrating Radar Magnetic Gradient Seismic Refraction Soil Resistivity Mapping Soil Resistivity Tomography Soil Conductivity-EM

Bibliography Reference of Geophysical Prospection

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- SARRIS A., VAFIDIS A., Technical Report on the Geophysical Survey in the Archaeological Site of Itanos (Erimoupolis, Lassithi, Lassithi) - 1997 Field Season. Institute of Mediterranean Studies, 1998

Archaeo-Environmental Studies

Researcher/s	Research Institute	Beginning of Research	Completion of Research	Archaeo-Environmental Method
1.	MYLONA D.			

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Photos
NATURAL SETTINGS PHOTOS

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Fig. 2. A sample result of a query from the archaeological inventory.

categories of the archaeological sites, explanatory notes about the origin and coding of the cartographic layers, as well as statistical information and other

background information on the metadata found in the cartographic framework of the project.

Cartographic layers consist of topographic maps supplied by the Hellenic Military Geographic Service (scale 1 : 50,000, main and secondary road network, villages, towns, contour lines, datum points, mountains), land use and land capability maps from the Ministry of Agriculture (scale 1 : 50,000, forests, artificial vegetation, erosion, aspect, soil depth, geology), hydrolithological maps of the Region of Crete (scale 1 : 50,000, type of soils, water permeability) and geological maps from the Institute of Geological and Mineral Exploration (scale 1 : 50,000, geological formations, faults, geological periods, etc.). The above maps were rectified in a common geodetic projection (EGSA'87 or HGSR'87) and digitized thematically. In some instances, more detailed topographic maps at a scale of 1 : 5000 or generalized geological maps (SARRIS et al. 2006) were used to achieve a more accurate representation of the environmental features.

As mentioned above, the project goal was not merely the static presentation of the archaeological sites' distribution within their topographic context, but also a more sophisticated integration of the geo-environmental data to facilitate the management of the archaeological sites in a wider perspective. To do this, geo-information from a number of sources has been collected, processed and mapped via different interpolation algorithms (Fig. 3). Time series maps were created from monthly data from the National Meteorological Service on the average rainfall for the periods of 1990–2000 and 2000–2005, along with the mean monthly temperature for 2000. Historic seismic data from the Geodynamic Institute of the National Observatory of Athens and the Aristotle University of Thessaloniki was used to map the epicenters of earthquakes and the density surface of historical seismic activity for earthquakes measuring over 4 units on the Richter scale, a level expected to cause some degree of damage to ancient and historical monuments. Maps indicating repeated occurrences of fire and the size of the burnt surface in each case were charted based on the archives of the Ministry of Agriculture and the Fire Department. Multivariate spatial analysis of vegetation classification, reflectivity of satellite imagery, population data, and geological, meteorological and topographic factors, produced further environmental layers showing risk models for fires and landslides. Census data from the National Statistical Service was processed to provide population maps within municipalities

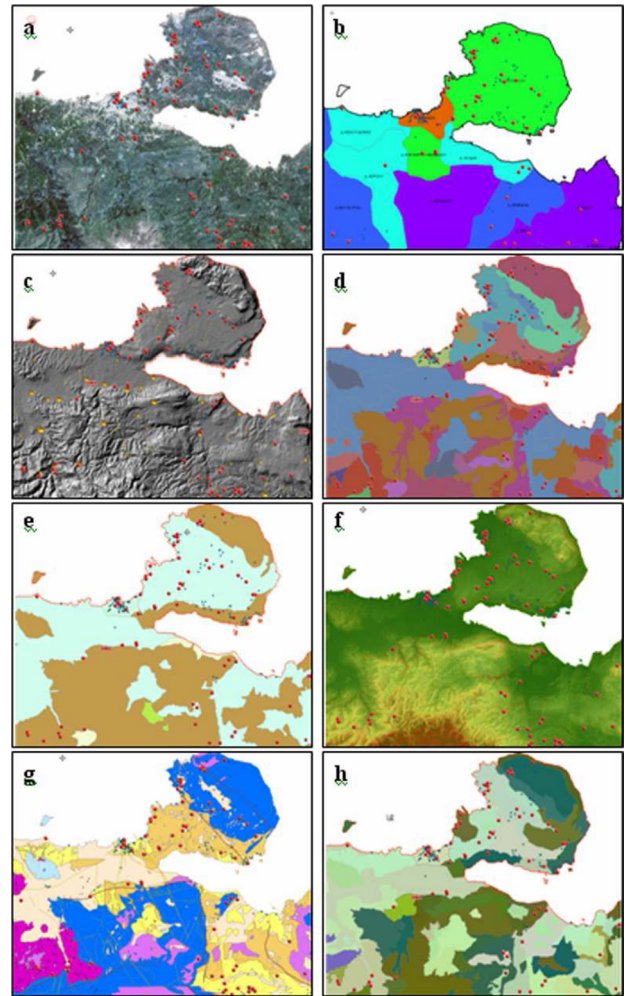


Fig. 3. Samples of cartographic syntheses available from the web-GIS of the Archaeological Atlas of Crete. Images show the Chania region, red dots represent archaeological sites. a) Landsat Image, b) population per municipality, c) hillshading and agricultural fire frequency, d) soil depth, e) soil erosion, f) DEM, g) unified geological map, h) land use types.

for the years 1913, 1920, 1928, 1940, 1951, 1961, 1971, 1981, 1991 and 2001. It should be mentioned that many of the aforementioned layers were produced in the course of the EMERIC I project, a natural risk assessment of Crete's natural resources (SARRIS et al. 2006).

Aerial photos, along with SPOT and Landsat ETM satellite images, were used to locate the archaeological sites and as background reference layers for mapping the size and layout of the sites. The satellite images were rectified with a combination of GCPs and the coastal line resulting from an ortho-rectified panchromatic SPOT image. Stereoscopic SPOT satellite images were used to create a 20 m DEM, which

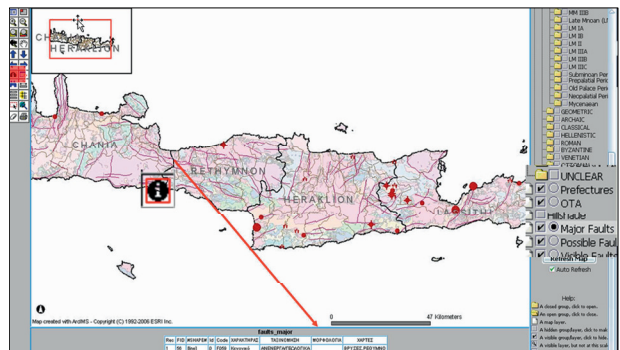
was further processed to obtain raster images of the aspect, slope and hillshading. The monuments within the four major cities of Crete (Herakleion, Chania, Rethymno and Agios Nikolaos) were located precisely with the help of Quickbird-2 images (IOANNIDOU / KARATHANASI / SARRIS 2005). All of the satellite images and some of the bulky raster data were compressed with the MrSid encoder down to 75–90 % of their original size. The Quickbird images were also compressed after being partitioned to a series of tiles covering the whole urban area (Fig. 4a).

Initially, the data was published and disseminated on the Internet using ArcIMS (ESRI) software (Fig. 4b). An HTML browser was preferred since it did not require any additional modules to be downloaded by the external user. Data entry and navigation of the maps (including identification of attributes, pan and zoom functions, selection of elements, printing, etc.) are carried out via special tools determined by the web administrator. In order to better manage the available information, groups of map layers representing a common topic (such as geology, topography or environmental risk) were created, accompanied by the relevant subset of archaeological data concerning the published, geo-referenced sites. The user can interact with the cartographic material by viewing detailed information about each site and by searching based on site attributes. Furthermore, the archaeological data was grouped on the basis of chronology and type. Thus, the archaeological information can be shown as a hierarchical tree diagram of thematic classes. Due to the large amount of detail contained in the groups of map layers, certain filters were applied to each layer concerning the scale, so that only certain information is viewable at a particular view scale. In the end, all the individual projects were upgraded to the ArcGIS Server 9.2 platform (Fig. 4c). The advantages of the upgrade include better web-mapping tools, faster map display exploiting Ajax, dockable elements and collapsible panels that create a much more user-friendly interface, and enhanced map feature search tools using maptips.

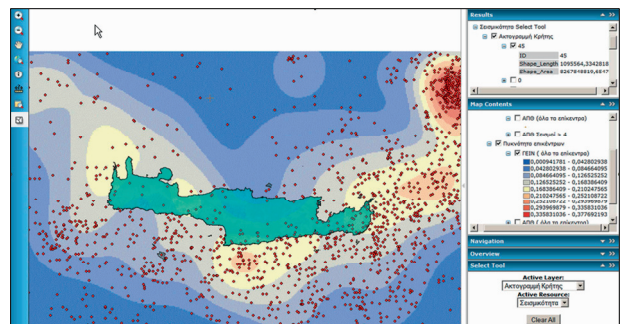
In addition, the web portal exports updated statistical information from the database in the form of piecharts. The statistics that the user is able to access include the percentage of declared sites, the type of mapping or archaeological methods used, the number of sites belonging to different typological or chronological classes, and the type of analytical methods used.



a)



b)



c)

Fig. 4. a) Quickbird image of Chania and sample archaeological sites within the city, b) ArcIMS view of the geotectonic attributes of the island of Crete and their correlation to specific archeological categories, c) ArcGIS server view of the historical seismic activity on the island of Crete. The correlation of the above geo-information with the archaeological data is of vital importance for the conservation of cultural monuments.

Finally, an initiative aimed at recording interviews with living archaeologists active in the region of Crete has been launched. A small number of videos documenting the current views of active archaeologists and presenting their anecdotes is also avail-

able, creating an innovative multimedia archive. The videos are accessible in .wmv format with two levels of compression, one for a dialup connection and the other for a high-speed connection.

Building a Cultural-Environmental Geographic Inventory of Crete

The Archaeological Atlas of Crete has changed the way we search for spatial information in an archaeological context. The archaeological inventory, integrated with a wealth of geo-information and other statistical data, constitutes a reference point for researchers and the wider public. Moving away from the myth of the danger presented by the wide dissemination of archaeological information, the archaeological atlas of Crete accomplishes multiple tasks: it raises awareness of cultural heritage in the wider public by providing a full record of the antiquities in a geographic region; it is a nodal point of reference for researchers who want to pursue basic research on settlement patterns and communication networks; it is a tool for managers and developers who need to incorporate multiple parameters in conservation or development plans; it hosts information that can be used to create tourist guides.

In short, Digital Crete is intended to take a role in the future promotion and conservation of the cultural heritage of Crete by archaeological researchers, site managers and private or public developers. It is hoped that its impact will change the philosophy and design of other cultural web-GIS inventories which are solely used either as static information databanks or as distribution maps.

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