UTILIZING GEOGRAPHICAL INFORMATION SYSTEMS (GIS) & SATELLITE REMOTE SENSING ANALYSIS FOR INTEGRATED PLANNING: A CASE STUDY OF PAPHOS DISTRICT AREA - UNESCO WORLD HERITAGE TOWN (PAPHOS, CYPRUS)

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ABSTRACT:

Preservation of the World Heritage Site and historic district in Paphos will ultimately depend upon understanding the interrelationship among a variety of cultural and natural parameters. Indeed, for tracing such a situation, a landscape analysis utilizing remote sensing and GIS technology is being conducted at the Paphos District area in Cyprus in the service of planning for a revitalized town that will preserve not only historic sites, but traditional cultural forms as well. A successful plan and implementation will provide an opportunity to local decision makers to provide a synoptic and detailed planning of the town. Indeed, high resolution (QUICKBIRD, IKONOS) and medium resolution (Landsat ETM+, SPOT) satellite images have been used in conjunction with topographical and other auxiliary data in this study. The GIS will serve as an "intelligent" database, which will provide a compact space where all sorts of data relevant to Paphos cultural sites can be stored in digital format, including images, maps, documents, photographs, and even audio recordings. More importantly, data will be arranged so that it can be incorporated into displays like maps, charts, and tables, and can be queried in the service of sophisticated analytical procedures. Future analyses can be the basis for future planning, design, and site management decisions. This study shows only the methodology proposed by the authors in this project and the first results obtained from its application.

1. INTRODUCTION

Satellite remote sensing has become a common tool of investigation, prediction and forecast of environmental change and scenarios through the development of GIS-based models and decision-support instruments that have further enhanced and considerably supported decision-making (Ayad, 2005; Douglas, 2005; Hadjimitsis *et al*., 2005 and 2006). With the advent of new high spatial and spectral resolution satellite, new applications for precision mapping and accurate monitoring have become feasible. The integration of multi-source geo-referenced spatial data within a real spatial database, which allows a synergistic processing of a considerable amount of information, the standardization of data and the elaboration of digital maps that are the basis of decision-making. GIS-based decision-support systems strongly sustain a single decision-maker, or a group of decision-makers, in evaluating alternatives to enhance decisions and to achieve specific objectives (Looney, 2001). It is, however, the decision-maker who determines the criteria, factors and constraints that may reduce uncertainty in the decision rules, and, in the end, makes the decisions. Therefore decisions for resolving unstructured problems should be based on preliminary simulation on a computer-based systems, thus necessitating the use of GIS technology.

2. METHODOLOGY

2.1 The idea

The authors presents their proposed methodology in which GIS, satellite remote sensing and topographic mapping tools are basically used in order to develop a system that can be used for the integrated planning of the Paphos District area as shown in Figure 1.

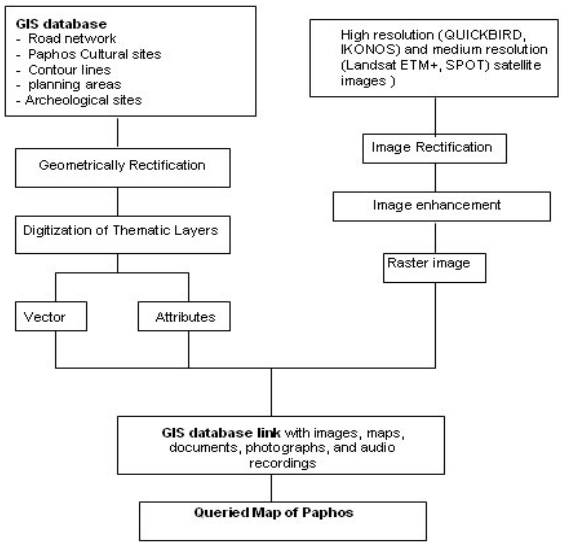

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Figure 1. Proposed Methodology

The GIS database will consist the following: road network, cultural sites of the district area, archaeological areas and details on the planning considerations. Digitization of the GIS data will be taken place. Satellite imagery must be pre-processed (geometric and radiometric correction) and then must be post-processed using the image enhancement method. Finally a GIS database link with the image data will be applied for developing a queried map of Paphos District area.

2.2 The method

In this study, all of the GIS implementation phases were applied. In addition to this, current state and necessities were fixed on feasibility phase. Data design, process design and physical design phases were carried out on design phase. Finally, Paphos was selected as the working area as it contained many World Heritage Sites.

District boundary maps, survey maps, high resolution (QUICKBIRD, IKONOS) and medium resolution (Landsat ETM+, SPOT) satellite images, vector polygons such as geographical areas of archaeological and historic sites were graphical components of GIS Design and Application. In addition, non-graphical components consisted of attributes of designed layers. As well, detailed information related to photos, images, documents and even audio recordings were available for better recognition of query objects. In this study, middle lines of roads which had vector and graphical characteristic for network analysis, and historical and tourism places and all of the geographical objects considered as necessary items were designed as point layer. Building layers were designed as polygon geometry with attributes. By clicking on a site, sample pictures of how the area appears could be obtained, viewed and printed on request. Table 1 shows the layers and its attributes produced in this project.

Name of Layer	Attribute
Hotel	ID,Name,TEL,Servises
Church	ID,Name,Image,Doc
Restaurant	ID,Name,TEL,Address
Park	ID,Name,Services
Museum	ID,Name,TEL,Image
Police	ID,Name,TEL
Archeological area	ID,Name,Image
Public Building	ID,Name,TEL
Way	ID,Name,Type
Historical Building	ID,Name,Image

Table 1. Layers and its attributes

A GIS application provided a structure for presenting data in the form of maps for visual analysis, as points, lines and areas, but the power of GIS goes far beyond maps. In fact, mapping is a minor part of GIS application. The databases associated with GIS and the tools to manipulate those data sets are powerful tools for organizing, analyzing and interpreting data. Data are stored in a GIS in two main formats—vector and raster. *Vector* representation of data is probably more familiar and more precise, defining objects as points, connected points (lines) or areas enclosed by lines (polygons). *Raster* representation has advantages, but is somewhat less precise because the entire cell has to be identified with the same representation. Precision depends upon the relative size of the grid cells.

2.3 Database

The database of this study is constructed of three type of data. Firstly satellite remotely sensed data such as Landsat TM (acquired on May 2000, January 2001), IKONOS (March, 2000) and Quickbird (December 2003, 2006) were imported and processed to provide valuable information about the spatial patterns of the Paphos District area. Secondly auxiliary data such as documents and photographs have been used. Thirdly, topographic maps of the Paphos District area were scanned and digitised to formulate a digital base map of study.

2.4 Pre-processing of satellite images

All images were ortho-rectified to a Universal Transverse Mercator grid using the nearest neighbour resampling method. Geometric correction was carried out using standard techniques with ground control points and a first order polynomial fit. A Digital Elevation Model (DEM) was also used. Then, the ortho-images were radiometrically corrected by converting the entire dataset from digital number values into ground reflectance values (Mather, 2001). By using multi-temporal images, atmospheric effects are found to be very significant. Hence, it is therefore essential that atmospheric effects must be taken into account before attempts are made to estimate ground conditions. Hadjimitsis *et al.* (2003) found that that the darkest pixel atmospheric correction method was the most suitable technique for removing the atmospheric effects from satellite images. Indeed, the darkest pixel atmospheric correction technique was also applied in the satellite images.

2.5 Image enhancement and feature extraction

Image enhancement has been used to convert the image quality to a better and more understandable level for feature extraction or image interpretation. Feature extraction has been also used to quantify the image quality through various parameters or functions, which have been applied to the original images (Mather, 2001). These processes can be considered as conversion of the image data. Image enhancement has been applied mainly for image interpretation in the form of an image output, while feature extraction has been normally used for automated classification or analysis in a quantitative form

2.6 Study area

This study was carried out in Paphos, which contains a wealth of historical, archaeological and tourist sites. Paphos has an air of holiday charm combined with history, and older-day elegance is lent to the town by its classical style buildings in the upper part of town, which leads to the shopping area. The lower part of the town - known as Kato Paphos has a life of its own albeit so close by, down near the sea -home of the harbor, the fish taverns, souvenir shops and several beautiful hotels with important archaeological sites around them.

Paphos has been inhabited since the Neolithic period. It was a centre of the cult of Aphrodite and of pre-Hellenic fertility deities. Aphrodite's legendary birthplace was on this island, where her temple was erected by the Myceneans in the 12th century B.C. The remains of villas, palaces, theatres, fortresses

and tombs mean that the site is of exceptional architectural and historic value. The mosaics of Nea Paphos are among the most beautiful in the world. The legacy from its remarkable history adds up to nothing less than an open museum, so much so that UNESCO simply added the whole town to its World Cultural Heritage List. Among the treasures unearthed, are the remarkable mosaics in the Houses of Dionysos, Theseus and Aion, beautifully preserved after 16 centuries under the soil. Then there are the mysterious vaults and caves, the Tombs of the Kings, the Pillar to which Saint Paul was allegedly tied and whipped, the ancient Odeon Theatre and other places of interest including the Byzantine Museum and the District Archaeological Museum.

3. APPLICATION & RESULTS

3.1 Application

These results can be achieved by queries in GIS Design and Application:

- Determination of important and necessary places for tourism.
- Determination for future town planning.
- Determination of preservation of historic sites.
- Determination of the optimum plan for urban tree canopy and vegetation coverage.
- Determination of the shortest distance between the selected places
- Determination for storm water runoff and sewerage.
- Determination for air pollution.

Queries can be made on historic sites concerning their accessibility from the nearest distance and mode of transport. Services provided at each site can be obtained from the tables. By clicking on several points in each site, information on the geology, flora and fauna, population, planning and zoning, utility infrastructure, and other information can be obtained. This list of queries is endless, and unique to every potential user. For the system to be more effective, it can also be made available on the Internet for access by potential users. The use of GIS design is not limited to planners but as well as to tourism. Also a successful plan and implementation will provide an opportunity to local decision makers to provide a synoptic and detailed planning of the town.

Figure 2 shows how query data are used in the form of maps for visual analysis. Indeed, Figure 2 shows also an overview of the Archaeological and cultural sites in the Paphos District area based on the application of the proposed methodology shown in Figure1. Figures 3 and 4 show how the GIS data have been used in conjunction with high and medium-resolution satellite images and other auxiliary data (e.g. maps) for further planning analysis.

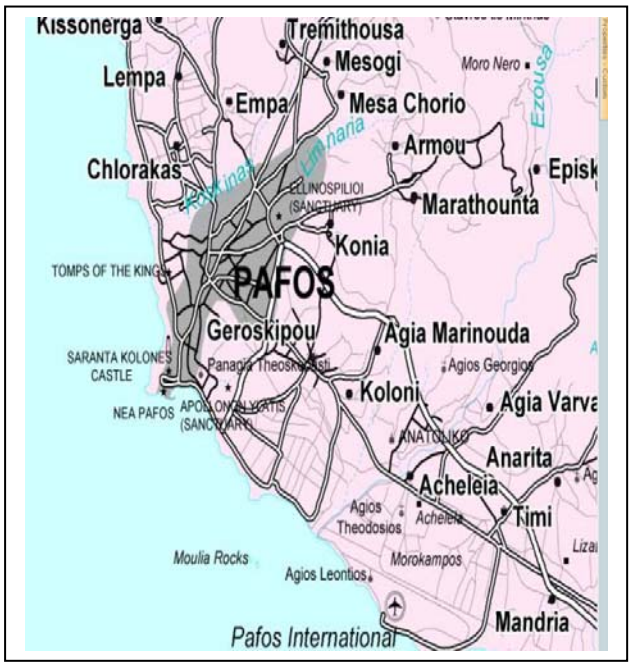

Figure 2: Query data in the form of maps for visual analysis. Archaeological and cultural sites are presented.

Figure 3: GIS data in conjunction with Quickbird satellite image data acquired on 23/12/2003: 'House of Theseous in Paphos'.

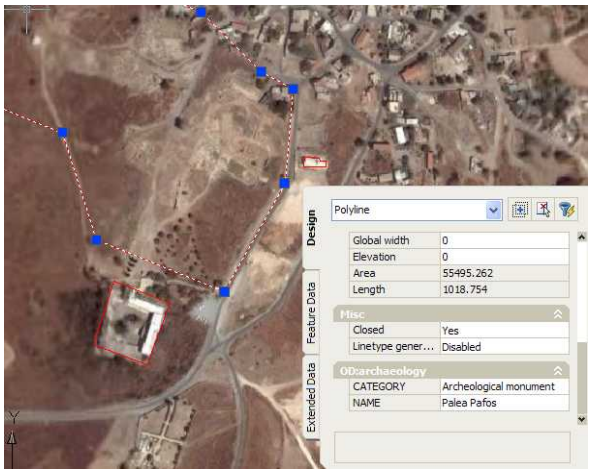

Figure 4. Sample snap-shot showing the use of GIS in conjunction with satellite image (Quickbird) acquired on 23/12/2003 for the Aphrodite Temple at Kouklia in Paphos

In this study, there were no standards among the data during the system creating process and some problems occurred during transferring the graphical data to the GIS. Afterwards, the standards were formed between graphical and non graphical data.

4. CONCLUSIONS & FUTURE RECOMMENDATIONS

In this study, optimum planning for site management decisions, query of geographical data, obtaining the visual and detailed information about the geographical data and network analysis applications were carried out. However, this study on GIS design and application for cultural heritage sites and network analysis reveals important considerations to help users make decisions for future town planning. This GIS database could be expanded to analyze urban tree canopy and vegetation coverage, storm water runoff reduction potential, and air pollution mitigation. The database can also help to identify neighbourhoods in greatest need of trees, and allowed for trees to be accounted for in GIS alongside other forms of infrastructure. The advantage for making decisions based on the overall data from this system could provide spur economic revitalization, enhanced city planning, economic development, and preserve important cultural and heritage sites and buildings. Moreover, users appear to save time via GIS design and enhance decision making. The applicability of the GIS database has far-reaching potential in making effective decisions in town planning.

The GIS is served in this study as an "intelligent" database. GIS is used to provide a compact space where all sorts of data relevant to Paphos District Area can be stored in digital format, including images, maps, documents, photographs, and even audio recordings. Data have been already arranged so that it can be incorporated into displays like maps, charts, and tables, and can be queried in the service of sophisticated analytical procedures. Future analyses can be the basis for future planning, design, and site management decisions.

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