Environmental Monitoring of spatial data for the application of NATURA 2000 network in Cyprus using Remote Sensing and GIS

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ABSTRACT

In Cyprus, the landscape is continually changing under the influence of several factors (e.g., forest fires, urbanization, building development); this situation contributes to a need for updated, consistent and accurate intermediate-scale land cover information. Production of these maps usually requires mapping for the whole area, in a process that usually constitute major undertakings implying major investments when in fact updated maps can be obtained by detecting, interpreting and inserting areas of change in existing maps. Analysis of multi-spectral satellite imagery for accurate land cover mapping and change detection, combining with Geographic Information Systems (GIS) provide an adequate environment to address the problem of land cover change detection. Indeed, this paper presents a case study for the application of integrated remote sensing and GIS data for the classification and monitoring of the land-use changes to support the application on the NATURA 2000 network in some small villages in Cyprus. The study was conducted in Mammari/Denia area in Nicosia. Data analysis was conducted using GIS software.

1. INTRODUCTION

Natura 2000 is a coherent ecological network of special areas selected to assist in the maintenance of biodiversity in the European territory. It is composed of two different kinds of sites: firstly, the special areas of conservation (SAC) designated under the Habitats Directive (Council Directive 92/43/EEC) on the conservation of natural habitats and of wild fauna and flora, and secondly the special protection areas (SPA) designated under the Birds Directive (Council Directive 79/409/EEC) for the conservation of wild birds. These two EEC directives define an integrated framework to identify, to maintain and to protect natural sites as a whole; they represent the European Union's most concrete act towards the achievement of international biodiversity policy commitments, such as the Bern Convention82/72/EEC and the Biodiversity Convention 93/626/EEC (Barbati et al. 2002). According to the Habitats Directive, Natura 2000 "shall enable the natural habitat types and the species habitats listed in Annex I and Annex II to be maintained or, where appropriate, restored to a favourable conservation status in their natural range" (Article 3). The conservation status will be taken as "favourable" when:

• the natural range and areas the natural habitat types cover are stable or increasing;
• the specific structure and functions which are necessary for the natural habitat types long-term maintenance exist and are likely to continue to exist for the foreseeable future;
• the population dynamics data on the species concerned indicate that they are maintaining themselves on a long term basis as viable components of their natural habitats;

• the natural ranges of the species are neither being reduced nor are likely to be reduced for the foreseeable future;
• there is, and will probably continue to be, a sufficiently large habitat to maintain its population on a long term basis (Article 1).

To achieve the aim of the Habitat Directive, *i.e.*,to contribute towards ensuring biodiversity, it is reported the Member State shall:
• establish the necessary conservation measures involving appropriate management plans specifically designed for the sites or integrated into other development plans, and appropriate statutory, administrative or contractual measures which correspond to the ecological requirements of the natural habitat types and the species present on the sites;
• take appropriate steps to avoid, in the special areas of conservation, the deterioration of natural habitats as well as disturbance of the species for which the areas have been designated (Article 6). Therefore, when management of a Natura 2000 site is required, it is fundamental to identify, evaluate and monitor the site over time, to ensure that natural habitat and species are being maintained in a favourable conservation status.

In Cyprus, the initial list of sites, identified through a LIFE project according to the scientific criteria of the Habitats and Birds Directives, covered 26 % of the island’s territory, but was cut down to 14 % by various ministries; it is now being further whittled by a stakeholder body.

Remote Sensing and GIS has been used in different kinds of studies connected to conservation and protected areas management. Land cover classification based on satellite images is one of the most popular methods. In the past, the classifications of remote sensing images have been criticized to be too general and inaccurate. In most cases they have been based on field measurements and visual interpretation of the images, whereby image characteristics like resolution (pixel size), spatial coverage and spectral channel effects can limit the usability of the images in vegetation classification (Kumpula et all, 2005). There are new, Very High Resolution (VHR) satellite systems like IKONOS-2 and Quickbird-2, which provide pixel size of less than 5m. They are significantly more detailed than the older ones like Landsat and SPOT. However the high price still limits their use in more scientific investigation.

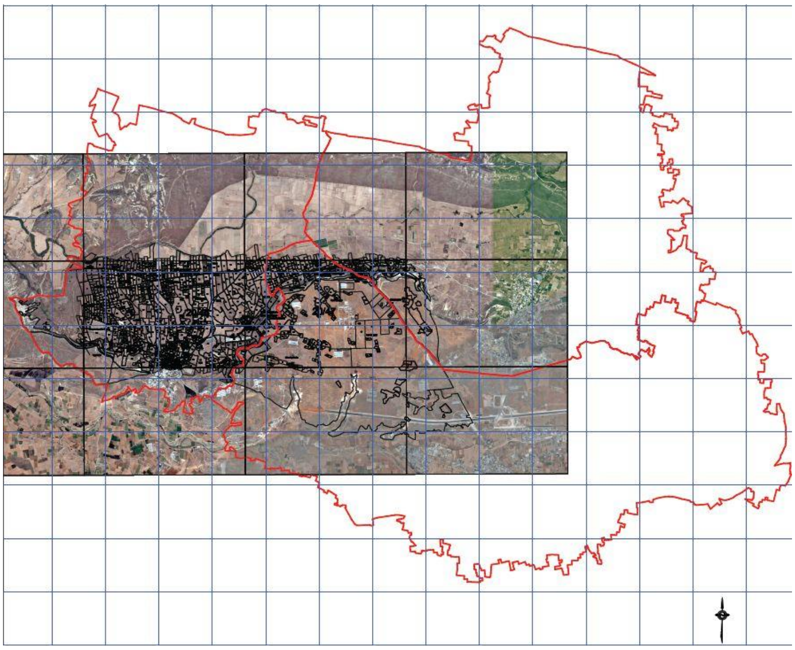


Figure 1: Mammari – Deneia satellite image with overlay with property data

2. Study Area

The site is located in the Mesaoria plain, about 12 km west of Nicosia. The habitats of the area are well conserved and most of the site preserves its natural characters. A total of more than 250 plant taxa are found within the site including nine endemics. The calcareous steep cliffs are favourable nesting places for many fauna species including the fox, around 60 bird species and a number of reptiles. is of great importance. Remote Sensing and GIS were use to assist such task.

3. METHODOLOGY

Maps and photographic documentation were collected as needed. Assessment of Natura 2000 habitat classes is based upon experts 'best' knowledge on distribution, extent and quality. On the entire surface of Cyprus, assessment of certain habitat classes can be quite difficult - there will be no statistics to lean on, and assessment can easily be related to 'intelligent guessing'.

By the use of digital remote sensing and GIS techniques, it is possible to provide decision support to experts to locate new potential habitat areas as well as establishing an objective basis for judgment of the national extent. In Cyprus many of Natura 2000 habitat classes can be sub-divided into classes related to the level of CORINE which in many cases gives a better representation of eco-environment driven by geo-botanical relation.

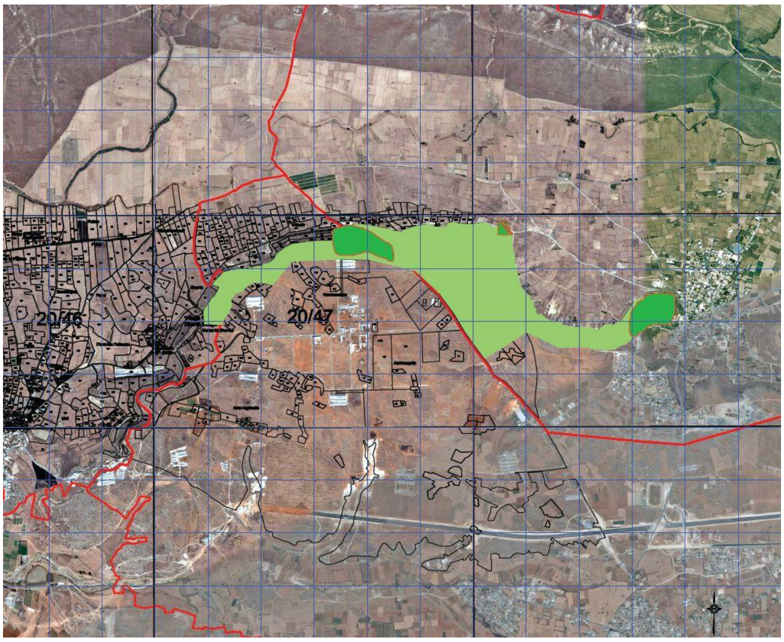
In Cyprus the use of digital remote sensing and GIS techniques has so far made it possible to estimate the extent of more habitat classes. Habitat specialists have been involved in the classification procedures by visual interpretation of classes, digitalization of specific habitat areas, delivery of field data and further in the discussion on criteria's for habitats that should be analysed in GIS. The analysis and simulation of habitats include the use of national vector layers on forest, water courses, land use and Digital Elevation Models.

The most important part of GIS is data. The environmental GIS data we had collected for the study area were included of raster and vector data, which has been stored in an oracle database. The database cover the whole study area. Scale varies from 1: 5 000 to 1: 1 million or pixel size from 1 to 500 metres. When there was a need for data, which was not in digital form, we had to scan the data and vectorise or input and producing the data for our database. Land-use classification from Landsat TM images is an example of producing such data. The NATURA 2000 protection plan for Cyprus was reproduced with AutoCAD Map 3D and ArcView software. The digitizing was done on-screen using numerical base maps and real estate boarders as background data.

Data used for the classification process includes Landsat image, field data collected on the terrain and different additional spatial data for comparison and correction like CORINE land cover data, topographical, vegetation maps etc. Field data consists on known site locations for the classification and rectification points for the image georectification. Site location points were selected randomly to represent the main vegetation types of Mammari – Deneia Area. From sites main tree species, field layer vegetation and mineral ground coverage were inventoried and locations were marked with GPS. For the georectification of the satellite image clearly visible crossing from different parts of the satellite image were marked with GPS

Image interpretation was done using ERDAS imagine software. According to the field data and interpretations the satellite image was first classified into the main landuse classes and subclasses.

The classification scheme used was supervised maximum likelihood classifier. Image classification was imported to grid format in ArcGIS software. Fragmentary of the classification map was reduced by using smooth 2x2 gridmajority filter.



Goedetic Reference System - LTM - CGRS93
(Local Transverse Mercator)

Point 01	X = 218361.971904	Y = 393787.391895
Point 02	X = 218361.971904	Y = 393787.391895
Point 03	X = 218110.368377	Y = 393683.358261
Point 04	X = 218132.580561	Y = 393902.037527
Point 05	X = 217173.167543	Y = 394452.231356
Point 06	X = 217147.726926	Y = 394484.153032
Point 07	X = 217120.160111	Y = 394519.017041
Point 08	X = 217090.850513	Y = 394448.690893
Point 08	X = 217090.850513	Y = 394448.690893
Point 09	X = 217078.557114	Y = 394518.33511
Point 10	X = 216260.533370	Y = 394249.992823
Point 11	X = 216014.997372	Y = 394306.313466
Point 12	X = 215841.222251	Y = 394353.787238
Point 13	X = 215845.782643	Y = 394468.284441
Point 14	X = 216105.918751	Y = 394447.265046

Figure 2: Mammari – Deneia satellite image with overlay with Natura 2000 protected areas

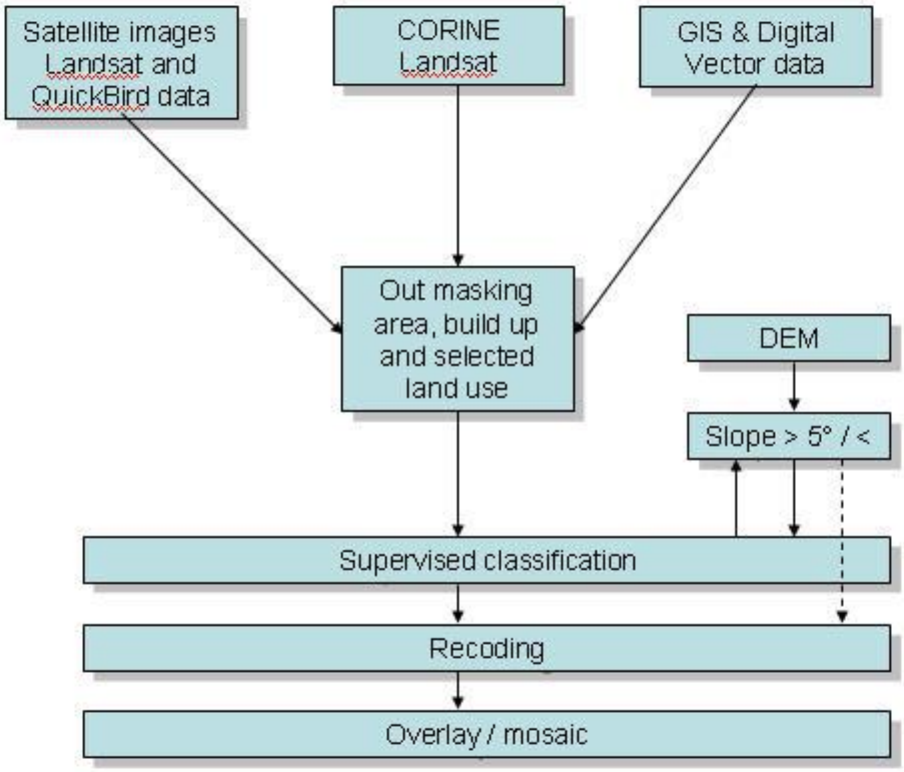


Figure 2: classification process of images and GIS data

Satellite Data

For the presented investigation QuickBird data were used. The QuickBird sensor is the first commercial satellite that provides submeter resolution. Its panchromatic band collects data with a

60 cm resolution at nadir while the multispectral (visible and near infrared) ground sampling distance is 2.4 m at nadir. In advance of the forest classification non forest land-uses, such as agriculture or urban area were masked, based on thresholds for shape, texture and spectral mean value of these classes. The classification of forest types was performed on single tree small tree group level as nearest neighbour classification of the mean spectral values of the segments. The trainings areas for the process were taken from field work, silvicultural maps and aerial photographs. The results of level 1 were aggregated to tree group patch level, where a threshold of 70 per cent had to be achieved to be assigned to a single species. Mixed stands were assigned to a new introduced group "Mixed deciduous" and "Mixed". The third level was used to improve the classifications of the sub-levels and to derive potential NATURA 2000 habitat types. Shadowed areas were separately masked and classified, using the NDVI and relations to neighbour objects ("Border to" and "distance to").

The products (satellite classification maps, vegetation change maps, land cover maps, habitat maps) are generated using a combination of historic and recent satellite imagery, fieldwork results and ancillary data. Shape, fragmentation, location, connectivity and heterogeneity of habitat objects are detected and monitored, which represent recognised parameters for the definition of ecological quality of protection sites.

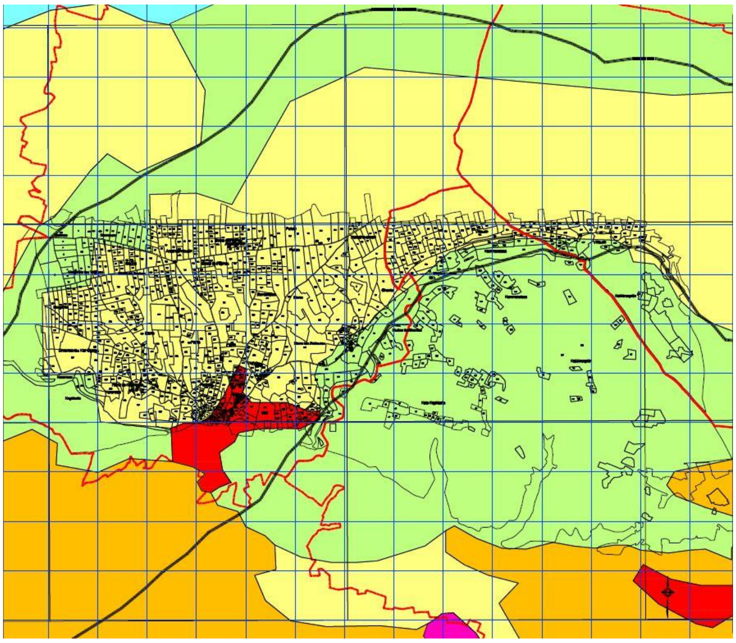


Figure 1: Corinne Land use areas

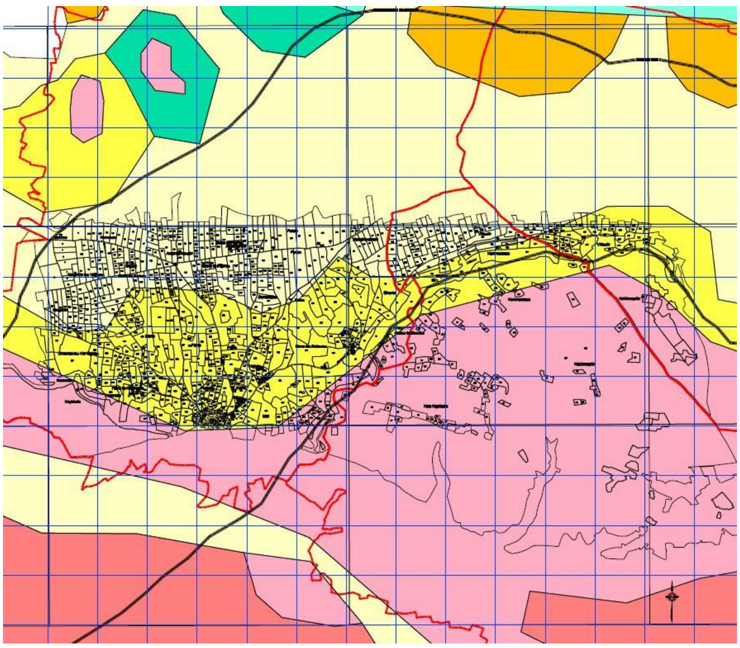
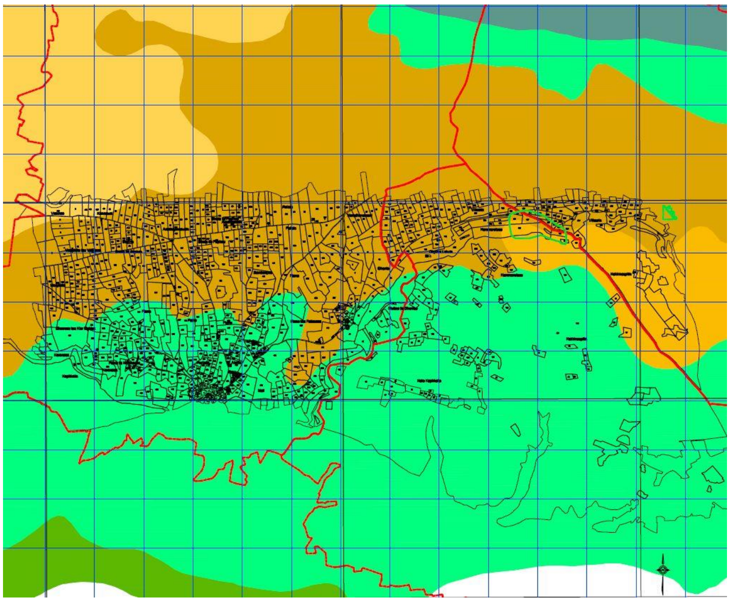


Figure 1: Geological classifications of the area



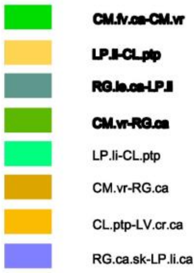


Figure 1: Soil classifications of the area

Figure 2: (a) Landsat TM image of Cyprus (11/9/98)

4. CONCLUSIONS

Performing a classification using additional GIS-data provokes the question for consistent availability of these data. In Cyprus a very good satellite data-basis is existent. However, the coverage and quality of geo-data will rise. Therefore, the development of integrating techniques of these data into classification processes is of importance. This study shows that for some types the classification accuracy can be higher with ancillary information integrated by GIS. It is indicated, that natural site-conditions are more relevant for classification success. However, further improvements can be made by analysing which kind of ancillary geo-information is most effectual in classification enhancement. Moreover, a comparison of different techniques of integrating geo-data into classifications, such as neural networks or multi-agent modelling, could be useful for a quality assessment of integration techniques. For different reasons, the scale levels are helpful, e.g. for improvement of classification quality via sub-level and super level. However, the results vary with scale altering. Not always supplies the finest scale and classification the sufficient information. One way would be the introduction of upper limit sizes of biotopes. Another approach could be found again in the utilisation of available GIS-data. The polygons of an existent biotope map are certainly useful for biotope quality assessments or monitoring purposes (Frick et al., 2005).

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