SUSTAINABLE MANAGEMENT OF INSULAR ENVIRONMENT USING GIS AND REMOTE SENSING TECHNOLOGIES

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ABSTRACT

Insular environment is characterized by a series of particularities which have been given a special attention in the past years at international level. This work investigates and describes the most important elements of these particularities in an effort to develop models of sustainable management. Such elements affect: (a) The natural environment and the landscape due to insular vulnerability on natural hazards, climate change, etc. (b) The cultural environment due to population problems such as: small size of permanent inhabitants, fluctuations of seasonal population size and population aging. (c) The economic development due to problems such as: small size economy, limited public works infrastructure, small size of private investments for development, weakness of local private and public administration ability, transportation costs due to large distances and dependence on other markets, limited variety in producing and exporting goods. Sustainable management models are proposed by adapting to the insular environment GIS and remote sensing technologies.

INTRODUCTION

This is a preliminary work for a Ph. D. research project which deals with the Greek island environment.

The island environment and particularly the environmentally sensitive areas on the islands are characterized by a number of features, which in recent years have been recognized worldwide. These features cover both the natural environment and landscape (fragility, vulnerability to natural disasters and climate change), the human environment (small population size, seasonal variations and aging population) and economic development (small economy , public infrastructure deficiencies and limited number of private investment, weakness of administrative capacity in both public and private sectors, distance and dependence on global markets, high transport costs, pressure from tourism, limited diversification in production and exports).

The importance of an integrated approach for the development and management of natural resources have been emphasised in many international forums on sustainable development In modern management of the island environment, geographic information systems and remote sensing can be used as tools of the utmost value. They can help establish cross-sectoral communication - by providing not only very powerful tools for storage and analysis of multisectoral spatial and statistical data, but also by integrating databases of different sectors in the same format, structure and map projection in the GIS system.

DESCRIPTION OF THE RESEARCH PROJECT

As a first step, GIS and remote sensing will be applied to create a **database on environmentally sensitive areas and basic infrastructure** on an island region of the Cyclades, including three islands of different sizes. The environmentally sensitive areas are to be classified, mapped in detail and assessed, in three different-sized islands (Naxos, Ios, Koufonisi). In Figure 1 is shown a Landsat-TM (yr. 2000) image with land cover classification of the island of Naxos and some other smaller islands.These areas include important ecosystems and land-sea-areas classified as Natura 2000 areas, but also areas classified or candidate as of outstanding natural beauty and geological

interest, as well as areas of particular landscape like mountain valleys with terraces. The evaluation will cover both the risks faced and the possibility of protection / promotion.

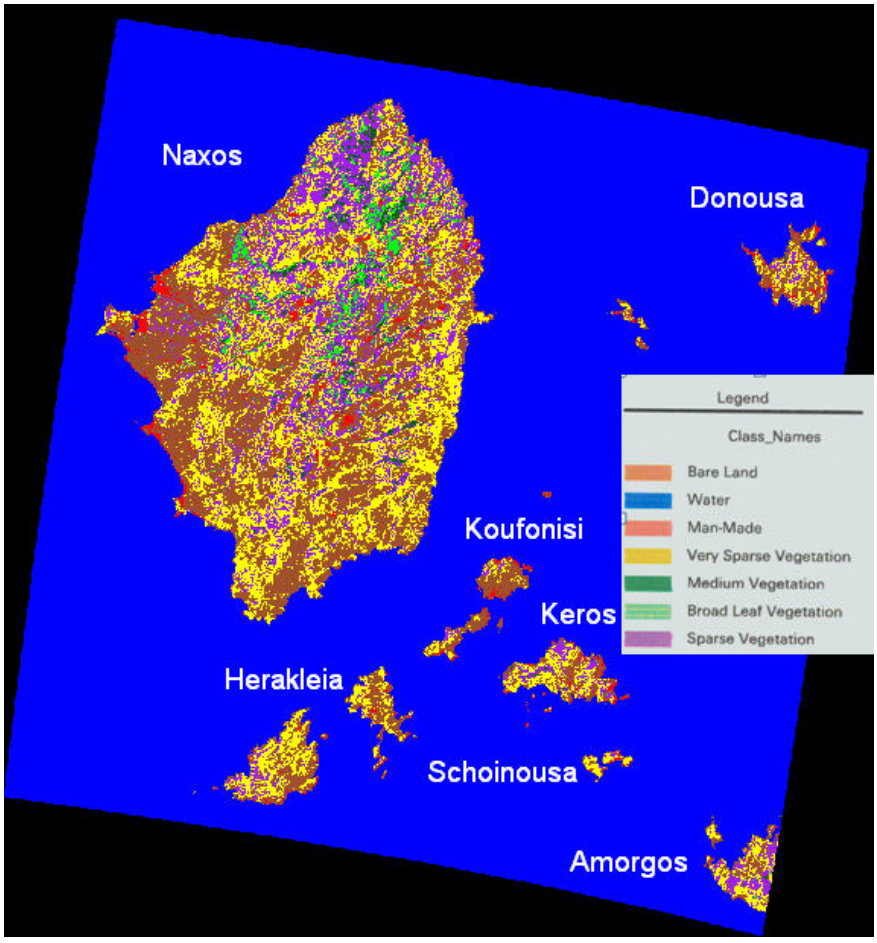

Figure 1. A Landsat-TM (yr. 2000) image with land cover classification of the island of Naxos and some other smaller islands (Kantzas E. P., 2002).

The GIS database will contain layers, like:

- roads
- utility lines
- physiography lines
- sea feature lines
- cultural landmark lines
- populated places
- contour lines
- drainage lines
- drainage points
- Terraces
- Stone walls

In Figure 2 is shown some vectorized features including terraces, drainage lines, protected areas (Natura 2000) using maps 1:5000.

A second step will be the **Identification and evaluation of existing or proposed projects or actions or policies** for the protection and promotion of environmentally sensitive areas in the three islands of different sizes will follow. The identification will include both traditional uses of species and techniques, as well as modern methods or policies, which have been applied in or around environmental sensitive areas of the islands, in different

sectors as: agriculture and livestock, use of indigenous medicinal plants, forest protection and the soil erosion prevention, supply and distribution of water, energy, tourism. For each project, action or policy the following will be collected and evaluated: specific actions and their budget, groups of interest -individuals / businesses, public agencies, NGOs, etc., and funding. A list of sustainable projects /actions or policies will be selected and proposed after the evaluation.

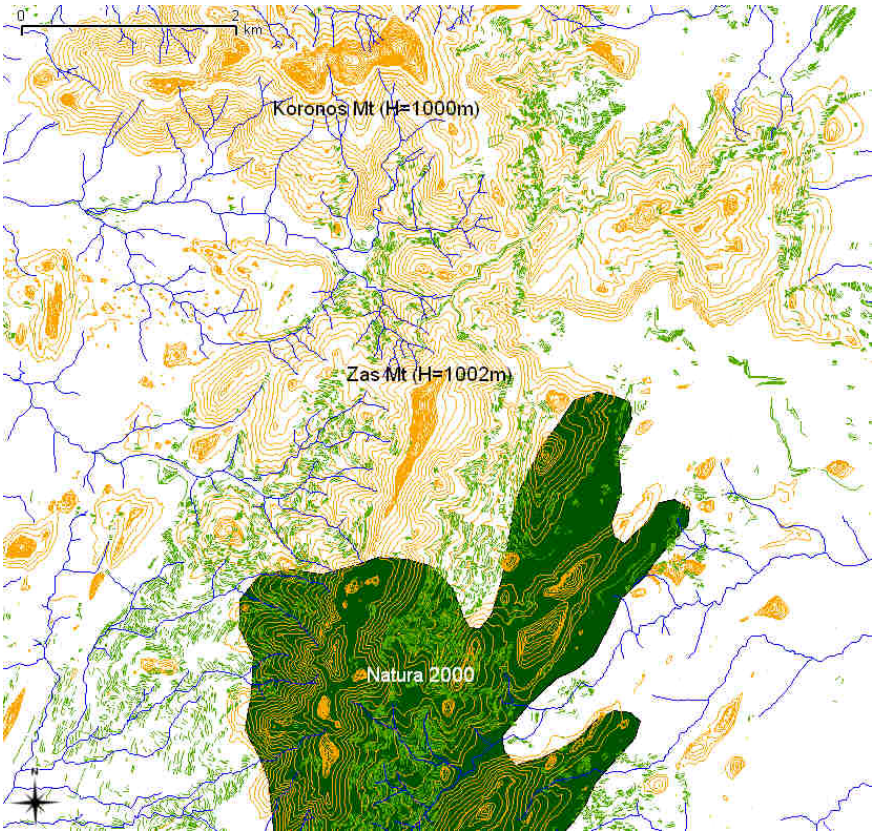

Figure 2. The mountainous part of the island of Naxos with two mountain tops rising over 1000 meters. Terraces are shown by green lines.

A third step will be the **Identification and assessment of expected threats and risks** for environmentally sensitive areas in the three islands. The identification will cover both physical hazards (natural disasters) and man-made hazards from development projects, public infrastructure, and climate change.

Final stage and basic outcome of the research project will be the **development of pilot applications for the management of environmentally sensitive areas of the islands** with the help of GIS and remote sensing. The development of pilot applications will cover ten topics to be determined in cooperation with the local public and local authorities. The pilot applications will be designed to provide evidence base and tools for sustainable management of areas by local populations and authorities.

The ultimate use of GIS lies in its capability for modelling: constructing models of the real world from digital data bases, and using these models to simulate the effect of a specific process over time for a given scenario. Modelling is a powerful tool for analysing trends and identifying factors that affect them, or for displaying the possible consequences of planning decisions or projects that affect resource use and management.

TOPICS OF INTEREST FOR THE RESEARCH PROJECT AND THE PILOT APPLICATIONS TO BE DEVELOPED

They will be selected among important issues for islands environment and will be related to sustainable agriculture, climate change, water management, renewable energy and biodiversity.

Islands are more than the collection of their inhabitants and their resources. They are living ecosystems and we are now beginning to realize that there are many interdependencies and interwoven systems that come together to form the whole, especially between agricultural areas and natural areas. Economical, social and environmental programs need to protect and restore habitat, and not simply protect individual species or solve individual problems. Problems generated by humans in many islands are increasing in number and complexity and are now demanding more of our attention. There is evidence to suggest that changes in the environment and culture of the islands, which was mostly based in traditional agriculture, are significantly enough to endanger and threaten a healthy future for humans and many other life forms. These alterations not only degrade the environment but they also alter the social fabric and the culture of the islands which took aeons to develop. In Figure 3 is showing the degradation of natural environment in the island of Naxos because of heavy grazing after a fire. In Figure 4 is shown a goat three meters over the ground grazing whatever is left from a fig tree.

Climate change is a serious threat especially for the insular regions, with sea level rising. Like other sectors, farmers on islands must help to cut the European Union's overall greenhouse gas emissions and they must also adapt to the climate change which is already coming. It is important to prepare policies and tools to face possible changes in climatic zones in islands, and take measures to balance negative effects that come from tourism, agriculture, fisheries as well as in economy and social structures. The present model of development (massive tourism, extensive construction, abandonment of agriculture etc.) combined with the scarcity of resources (energy, water, human capital) is seriously threatening their fragile ecosystems and social cohesion.

The Aegean islands are by far the most oil dependent economies with, at the same time, the worst rate CO2 /habitant (due to the size of plants, the fluctuation of the demand and the quality of energy distribution nets). Changes in the energy pattern with the development of Renewable Energy projects will affect other aspects of life (e.g. desalination, transportation, energy for isolated sites, agriculture etc) and contribute significantly to national environmental goals. There are two main problems in this sector:

Figure 3. Degraded natural environment because of heavy grazing after fire, (left) before land slide, (right) after land slide.

Figure 4. A goat three meters over the ground grazing whatever is left from a fig tree.

- To identify technologies and/or infrastructures permitting the increase of renewables sharing in insular autonomous systems (non connected with the mainland) as well as in interconnected electrical networks. Besides the actual problems related to the grid capacity, the fluctuation of the primary energy production and the fluctuation of the demand (the influence of tourism) should be taken into account. This could be possible by elaborating storage technologies (hybrid, H2, coupling RES and desalination etc.), energy exportation and/or by improving existing electricity networks.
- The opposition against renewables of a certain size – especial wind and geothermal. This opposition is related to environmental concerns and aesthetic approaches. Sometimes, this attitude is the result of a misinformation and/or of a lack of appropriate discussion between investors and local population. The main challenge is to "find a balance between the local dimension and the national or global (climate change) priorities".

One important issue related to climate change is directly related to quality farming, quality food products and biodiversity which give high added value to farmers and to the islands. This is turn contributes to the food supply of the islands and as a result transportation of food products is minimized. This is very important for minimizing CO2 emissions and contributes to the climate protection.

Good Agricultural and environment condition referred to in Article 5 of Reg. (EC) No 1782 / 2003 are especially important for the islands, where inter /alia soil erosion, abandoned land and destruction of terraces constitute a major danger for sustainability.

AN EXAMPLE:ISLAND TERRACES AND MOUNTAINOUS LANDSCAPE MANAGEMENT USING GIS AND REMOTE SENSING

The main causes of deterioration of the mountainous landscape characterised by the dry stone terraces (see Figures 5 and 6) are:

- Abandonment: The abandonment of agricultural activity affects very negatively the state of the terraces. The most common causes are:
    a) The lack of maintenance.
    b) The hardening of the earth, causing rainwater to run faster and cause severe erosion damage.
    c) The death of some trees or plants that fix the soil. The disappearance of this function weakens the stability of the terraces or balconies.
    d) The colonization of terraced areas with new grass species, shrubs or trees.

Figure 5. Terraces near the village of Komiaki of Naxos.

Figure 6. Detail showing abandoned agriculture with terraces.
In the middle is showing a small opening in the wall to protect people from the rain.

- Climate Causes: The terraces and dry stone walls form a water regulation system truly effective that works perfectly when the rate of dry seasons and rainy seasons is regular and balanced. Heavy droughts or heavy water are the main enemies of stability margins. Torrential rains are relatively common, the term "down valley" refers to the fact that the drainage and insufficient water retention and water overflow over the edges of the terraces and fields become real rivers.
- Fires have affected very negatively the status of the terraced systems. Abandoned terraced land, are badly damaged when burned for two main reasons:
    a. The fire itself damages the stones.
    b. The land, depleted of the plant protection is very vulnerable to erosion by water. These, not finding any resistance, moves the lighter soil and gains speed.
- Manmade Risks: there are also man made risks from poor management of the terraces and the dry stone walls:

c. The construction of public infrastructure of major environmental impacts, like new roads, wind farms, irrigation facilities or drainage pipelines. The construction of such works and the machinery of considerable size required, damage many terraces and other dry stone structures

A GIS Database on the terraces system will be developed as follows:

1) First demarcation by means of stereoscopic photo interpreting of past and present air images will be undertaken.

2) Construction, environmental, functional and conservation description of the dry-stone walling heritage. In order to define and analyse the current state of the agricultural terraces different variables will be mapped at a 1:5000 scale. The variables refer to conservation, agricultural use, pastures and plant physiognomy and each of them generates a thematic map:

- Area location: name, geographic location, borders.
- Environmental data: minimum and maximum height, minimum and maximum gradients, exposure, rock type and predominant formations, surface water courses, existence of fountains or important water springs, rainfall and temperature data, physical risk factors, fires, tree and shrub covering percentage, presence of soil in the wall joints, surface area percentage of wall covered by wild shrubs and flora species and community listings both of the wall and the field.
- Data originated from human activities: property type, presence or absence of habitable constructions, residence type, external access, internal access, past and current uses, presence of leisure or walking activities and farming type.
- Building and conservation data of the dry-stone walling heritage: walled surface area in square kilometres, state of conservation, arrangement type, wall rock composition, wall layout –height and width, coping type, other building elements, access to and from other walled banks, hydraulic systems for water collection, hydraulic systems for flooding control and other related dry-stone structures. In Figure 7 is shown a part of the island environment which includes sea and urban areas together with mountain areas.

Figure 7. The village Apollon of Naxos by the seaside. In the mountain environment is shown some terraces and stone walls which divide properties.

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