# Temporal Land Cover Analysis of a NATURA 2000 Wetland. The Case Study of Megalo Livari (GR 2420004) in Northern Evia, Greece

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**Abstract.** Natural environment has been degraded both qualitative and quantitative due to human activities over the last century. The European Ecological network NATURA 2000 has been created to preserve the biodiversity in SCI and SPA areas. The selected study area of Megalo Livari in Northern Evia, a part of the NATURA 2000 network, is one of the most important wetlands for migratory birds in Greece with rich riparian forest vegetation. The aim of this work is to record the temporal land cover changes, nearly the last 50 years, by means of remote sensing and GIS analysis. The proposed methodology presents a cost effective solution for an accurate assessment of the land cover changes in the study area. An old and a recent orthoimage of the area of interest are used and the land cover changes are assessed by photo-interpretation in combination with field work. The land cover changes, largely affected by human activities (agriculture, tourism, fishery), is the main reason of the degradation of the natural environment, more particularly of the riparian forest and vegetation the last 50 years in the area of Megalo Livari in Greece.

**Keywords.** Wetland, NATURA 2000, Megalo Livari (GR 2420004), riparian forest, riparian vegetation, orthoimages, remote sensing, GIS.

## 1. Introduction

Over the last century, human interference has lead to the degradation of the natural environment. Land cover change detection has been one of the most important applications of remote sensing for the detection and protection of the natural environment [1]. Therefore, it offers great potential not only to the management of the natural environment but also to the management of the social and economical consequences to the human environment. Some of the methodologies for such applications can be categorized as: delineation of changes, multivariate temporal resolution in feature space, image rationing and subtraction, image regression, post-classification comparison and multi-temporal linear data transformation [2], [3], [4], [5]. This study presents a cost-effective conventional technique for the assessment of land cover changes of one of the few wetlands in eastern continental Greece. The European Ecological network NATURA 2000 has been created to preserve the biodiversity in SCI and SPA areas. The selected study area of Megalo Livari in Northern Evia, Greece, a part of the NATURA 2000 network, is one of the most important wetlands for migratory birds. It also constitutes both a Special Protection Area (SPA) (GR2420007) and a Site of Community Importance (SCI) (GR2420004) [6].

The aim of this work is to record the land cover changes the last fifty years, by means of orthoimages using standard remote sensing and GIS techniques. An orthoimage has been created from a stereopair of aerial photographs using ground control points and a recent one has been provided by the e-Ktimatologio digital services of the Hellenic Cadastre (KTIMATOLOGIO S.A.)

[7]. A visual and statistical assessment has been made using the two georeferenced orthoimages, of the main land cover changes in the study area combined with field work. The human interference (agriculture, tourism, fishery) seems to be the main reason of the degradation of the Megalo Livari wetland in Greece during the last five decades. This cost-effective, simple and quick assessment is proposed to identify and analyse such phenomena, towards the management and the protection of the natural environment. Moreover, the study of the structure of the riparian vegetation in a wetland is crucial for its management and its natural preservation supports the rich biodiversity in the study area [8], [9], [10], [11].

## 2. Study area

The study area is located at the northern edge of Evia island in Greece (Figure 1). Megalo Livari is one of the few wetlands of eastern continental Greece (Figure 2) of outstanding importance with a great variety of existing habitat types and the migration of wintering birds. It is also a part of the NATURA 2000 network as Site of Community Importance (SCI), (GR2420004). It has also been considered as a Special Protection Area (SPA), (GR2420007) and Important Bird Areas (IBA), with old code GR69 [12] and new code GR109 [13].

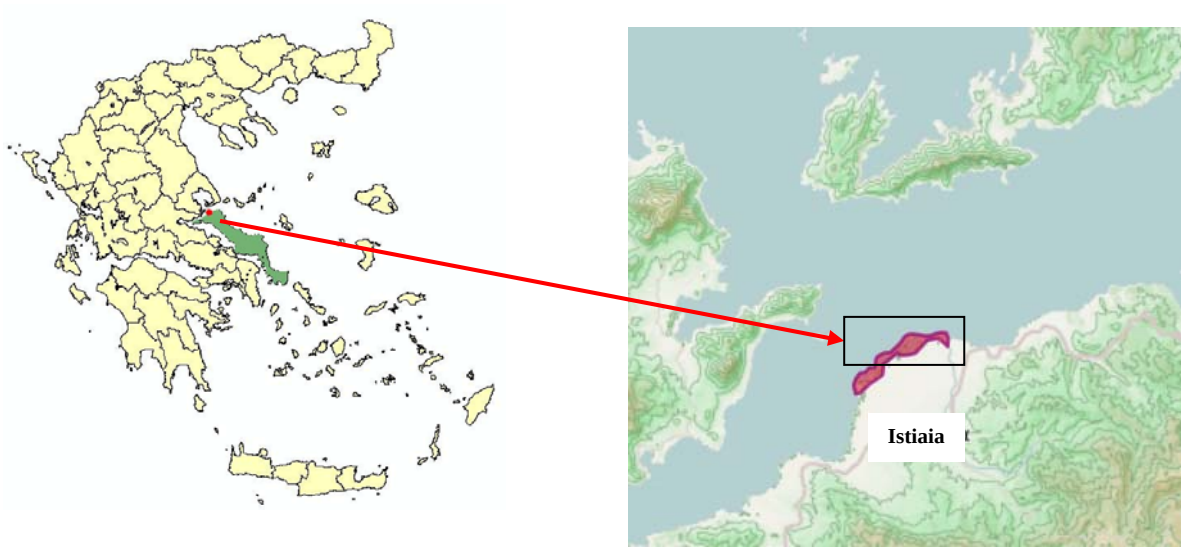


Figure 1: The study area of Megalo Livari highlighted in the map of Greece (http://filotis.itia.ntua.gr) [14].

Figure 2: An image of the Legalo Livari wetland taken during the field work.

The fauna of the wetland of Megalo Livari is very rich. Some of the most often occurring species of fauna are the following: *Lutra lutra, Testudo hermanni, Testudo graeca, Emys orbicularis, Mauremys caspica, Elaphe quatuorlineata, Elaphe situla., Lepus europaeus, Martes foina, Mustela nivalis, Cisticola juncidis* [6]. Moreover, the wetland of Megalo Livari is used for fish culture, while in its perimeter, intense agriculture and livestock is observed [15].

According to Sfougaris, 1993 [16]: *"Megalo Livari was extensively exploited in the past for fish production, but digging, landfilling, and changes of the orifice have been conducted for the intensification of fish culture. Road construction, habitation and tourism activities are extended towards the lagoon. In addition, a fish hatchery was constructed at the northern edge of the lagoon. The conservation status of the wetland vegetation around the lagoon, of the reedbeds and the riverine forest has seriously deteriorated".*

## 3. Materials and methods

Large scale aerial photographs have been used to analyse the land cover changes of the Megalo Livari wetland in Greece. A stereopair of aerial photographs dated back to 1960 at a scale of 1:15.000, provided by the Hellenic Military Geographical Service [17] as well as an orthoimage of 2008 by the e-Ktimatologio digital services of the Hellenic Cadastre (KTIMATOLOGIO S.A.) [7], available at not cost for educational purposes, have been used. Due to the lack of aerial imagery from 1960 and on, of similar scale, resulted in using the one from 1960 and the recent orthoimage of 2008. An orthoimage of 1960 has been created from the old aerial imagery stereopair, using six ground control points, in remote sensing environment, to be compared to the recent orthoimage of 2008.

The relief displacement has been removed on the photographs of 1960, thus creating the respective orthoimage. This process involved the following steps:

1. Aerial photographs stereopair
2. Inner orientation of the images: reconstruction of the geometry of the camera
3. Outer orientation of the images
    i. Relative orientation: the relative position of the two photographs during the photo acquisition-photogrammetric resection)
    ii. Absolute orientation: reference of the relative model at the Hellenic Geodetic Reference System 1987 (HGRS 87), calculation of the coordinates for each point on the photograph (photogrammetric intersection)
4. Digital terrain model: a 3D model surface
5. Orthoimage: image after removing the relief displacement

After the orthoimage generation, the two orthoimages were compatible to each other to the Hellenic Geodetic Reference System 1987 (HGRS 87).

Figure 3: The orthoimages of 1960 (left) and 2008 (right) of the study area.

The old and the recent orthoimages were used to interpret, digitize and therefore create nine land cover classes in the study area in GIS environment. Some further details on some of the classes have been digitized by applying, among other, specific methodology of different steps in CAD environment, using applications, specific interfaces and techniques such as transformations application, normals orientation, automation of area calculation etc [18]. The classes that have been digitized were the following: canals, roads, sand, dunes, agriculture, anthropogenic features, water, riparian vegetation and riparian forest. Two linear vector files represented the canals and the roads of the study area whereas seven polygonal vector files represented the sand, dunes, agriculture, urban, water, riparian vegetation and riparian forest. The two output thematic maps of 1960 and 2008 (Figure 4) show the distribution of the above nine classes in the area of Megalo Livari.

More particularly, the photointerpretation of the three classes of riparian vegetation, riparian forest and dunes has been combined by field work and the main species that were recorded are the following:

- the dominant species of Riparian vegetation : *Phragmites australis, Typha angustifolia, Arundo donax*, *Juncus acutus*, *J. maritimus, Tamarix sp. hampeana, Vitex agnus-castus., Salicornia sp., Polygonon maritimus*

- the dominant species of Riparian forest : *Salix alba, Populus alba, Ulmus minor, Alnus glutinosa, Platanus orientalis*

- Dunes : *Elymus farctus, Eryngium maritimum, Euphorbia paralia, Cacile maritime, Asphodelus fistulosus, Cyperus capitatus, Anthemis tomentosa*

In the wider region of Megalo Livari, apart from the remaining natural riparian vegetation, some individual forest trees (*Pinus pinea, Eucalyptus sp. Populus sp*.) were planted.

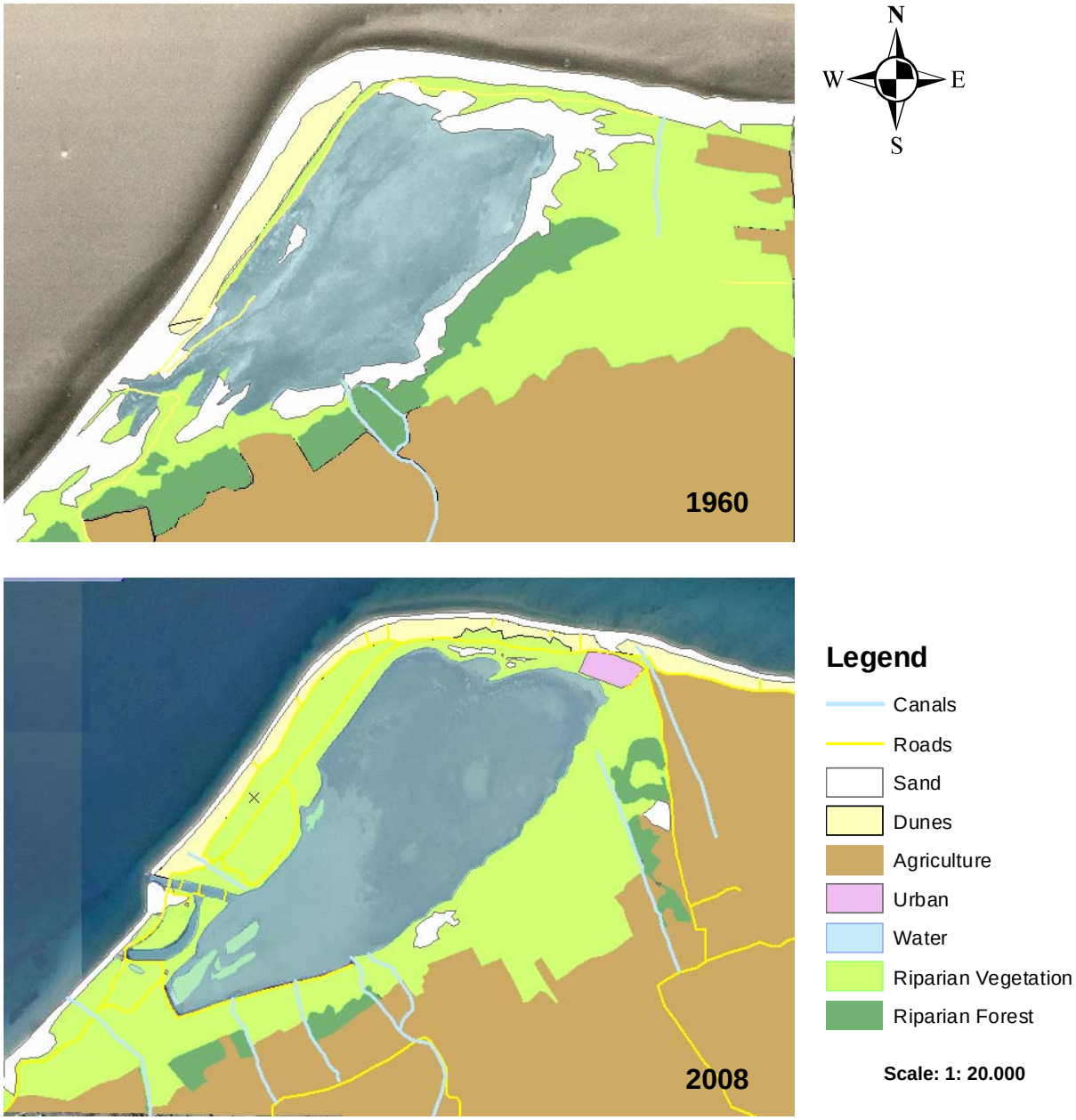


Figure 4: The thematic maps of the area of Megalo Livari of 1960 and 2008.

## 4. Results

The gains and losses for the two orthoimages of 1960 and 2008 have been computed. The next table shows the area and the percentage for each of the seven classes of the aforementioned dates, the last 50 years. The area of water in 2008 has slightly increased compared to the riparian forest which has decreased from 18631 sq. m. to 7238 sq. m. in 1960 and 2008 respectively. On the contrary, a 7% increase in agriculture has been noticed through the years whereas the riparian vegetation in 2008 has been evenly distributed around the water area. A visual interpretation of the thematic maps from 1960 to 2008 (Figure 4) shows a change in the shape of the north side of the coastline, probably due to sea currents and at the south west part of the wetland where an artificial canal has been formed to provide a communication between the sea and the lagoon. The human interference has been made

known in the recent orthoimage at the north east of the wetland through the construction of a private industry for the production of fish fry.

**Table 1.** Assessment of the land cover changes between 1960 and 2008.

| Land Cover | Year | | | |
|---|---|---|---|---|
| | 1960 | | 2008 | |
| | **Area** (sq. meters) | **Percentage** (%) | **Area** (sq. meters) | **Percentage** (%) |
| Sand | 43490 | 15.77 | 8659 | 3.16 |
| Riparian Vegetation | 63848 | 23.15 | 76065 | 27.73 |
| Riparian Forest | 18631 | 6.75 | 7238 | 2.64 |
| Dunes | 7913 | 2.87 | 9449 | 3.45 |
| Agriculture | 88604 | 32.12 | 107340 | 39.14 |
| Water | 57709 | 20.92 | 64985 | 23.69 |
| Urban | - | - | 1324 | 0.48 |

## 5. Conclusions

Both a qualitative and quantitative comparative evaluation between an old and a recent orthoimage allows us to easily monitor the land cover changes over the years using conventional remote sensing and GIS techniques in combination with field work. A cost-effective and fairly rapid assessment of the land cover changes, through thematic maps, originated from old and recent orthoimages of the Megalo Livari wetland in Greece, part of the NATURA 2000 network, reveals the degradation of the natural environment and the changes due to human interference the last 50 years. Future perspectives should include a more detailed temporal change detection of different habitat types (types of biotopes) of the study area in combination with field work. This would be a step further towards a more accurate assessment of monitoring and the protection of the wetland of Megalo Livari.

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