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THE GOULANDRIS NATURAL HISTORY MUSEUM
GREEK BIOTOPE/WETLAND CENTRE

Lake Doiran

Functional analysis and proposed restoration measures





Thessaloniki, 2005

SOCIETY FOR THE INVESTIGATION AND CONSERVATION OF BIODIVERSITY AND THE SUSTAINABLE DEVELOPMENT OF NATURAL ECOSYSTEMS - BIOECO

HELLENIC AID
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PROJECT TEAM
(alphabetical order)

EKBY

Manolis Anastasiadis, MSc

Charalambos Doulgeris, MSc

Maria Katsakiori, MSc

Dimitris Papadimos, MSc

Miltiadis Seferlis, MSc

Vasiliki Tsiaousi, MSc

BIOECO

Ordan Cukaliev, Dr

Svetozar Petkovski, Dr

Vesna Sidorovska, Dr

Darrell Smith, Dr

Vladimir Stavric, MSc

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INTRODUCTION

Lake Doiran straddles the border of Greece and FYROM, being a relic of the large ancient lake Paionia. Two thirds of the open waters are in FYROM, whereas 2/3 of its catchment area are in Hellenic territory.

Lake Doiran is a significant natural asset and a valuable resource for communities around the lake.

The objective of the present study is to evaluate the state of Lake Doiran (in terms of functions and values) using innovative tools and to propose restoration measures. The restoration measures were discussed and concluded between the members of the project team.

The report contains two chapters. The evaluation of the functions and values performed by Lake Doiran, are presented in the first chapter. Proposed restoration measures are described in the second chapter.

The report is prepared in the frame of the project "Assessment of the degree of expression of the functions and values of the tranboundary Lake Doiran". The project is funded by the Hellenic Ministry of Foreign Affairs – HELLENIC AID and carried out by The Goulandris Natural History Museum – Greek Biotope/Wetland Centre (Greece) and the "Society for the Investigation and Conservation of Biodiversity and the Sustainable Development of Natural Ecosystems (BIOECO)" (FYROM).

CHAPTER 1. GENERAL DESCRIPTION

Scientific research has shown that wetland ecosystems can perform a range of functions which result from interactions between wetland processes and ecosystem structure. Wetland functions result in the provision of important goods, services (including direct or indirect human use) and attributes, which collectively are termed *values* (Simpson 1999).

Hence, *functions* relate to the processes of wetlands, while from a socio-economic perspective, the term relates to the provision of goods and services (*values*).

Several techniques have been developed which can be used to assess the functions that are being performed by wetland ecosystems.

Earliest techniques which were developed were rapid assessment procedures most often used to assess single sites and to provide project-oriented results. The Wetland Evaluation Technique (WET) (US Army Corps of Engineers) considered broad groups of functions (physical, chemical and biological characteristics of a wetland) and values (fish and wildlife habitat value, flood control, groundwater recharge/discharge, recreation and education). More recent techniques such as the Hydrogeomorphic Method are based on peer-viewed and data-based models.

The method used in this project to evaluate wetland functions is the result of a research project EVALUWET. EVALUWET was established under the auspices of EU FP5 programme to develop amongst others the *Functional Analysis Procedures* (FAPs) for evaluating functional characteristics of wetland ecosystems in Europe (Contract number EVKI-2000-00772). The project involved a pan-European collaboration of scientists from nine leading Institutes and was co-ordinated by the Royal Holloway Institute for Environmental Research, Univ. of London (www.rhul.ac.uk/Environmental-Research/evaluweb).

The FAPs have been developed to provide an assessment tool to assist planners and wetland managers to resolve decision-making dilemmas with regard to catchment planning and management. In doing so they provide guidance on the optimum conditions necessary to support wetland functions, and also identify levels of environmental impacts which alter wetland functions. In summary:

The FAPs of EVALUWET can be used to:

1. assess the performance of one particular function

2. assess the performance of a selection of functions;
3. assess the performance of all functions;
4. assess the performance of particular processes that occur as parts of certain functions.

and it is essentially the evolution of a previous project Functional Analysis of European Wetland Ecosystems (FAEWE) (Maltby et al 1996).

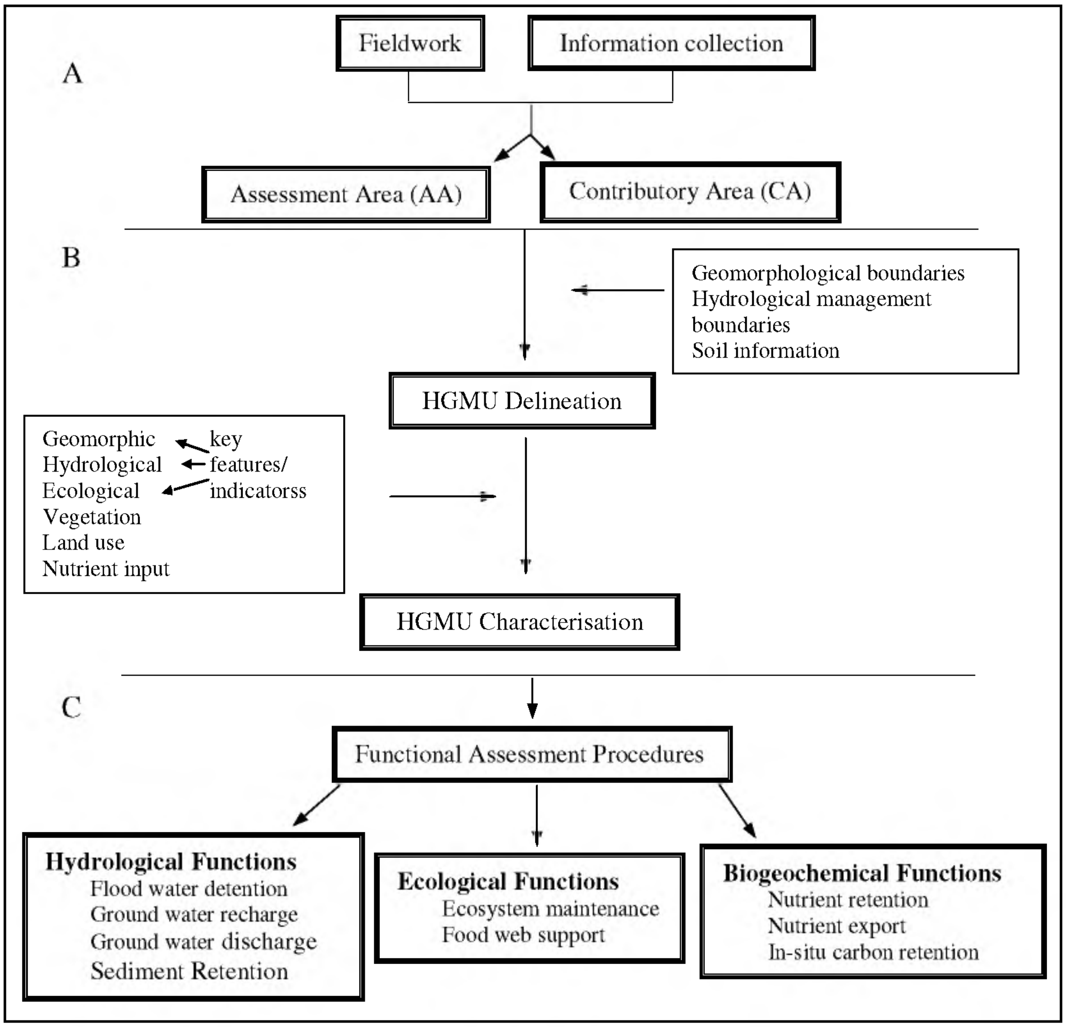

Figure 1. Conceptual diagram of the three steps of the Functional Assessment Procedures (FAPs).

Functional Assessment Procedures (FAPs) adopted the hydrogeomorphic approach which identifies the geomorphic location within the assessment area (wetland area of interest), and the hydrological inflows, outflows and management. The approach does not aim to classify the wetland into a specific hydrogeomorphic category, rather it seeks to identify areas (HGMUs) i.e Hydrogeomorphologic Units within the wetland that exhibit hydrogeomorphic homogeneity. Thus it provides an objective means by which functional performance can be measured, objectively compared across geographic areas and evaluated. One of its greatest advantages is that it allows for refinement and validation based on data and expert judgment. The assessment is relatively rapid, consistent and reproducible (Brinson 1993).

According to the FAPs key features or "indicators" are used in combination with the hydroperiod of a wetland. These features (Table 1) can indicate to what extent a function is being performed in each HGMU (HGMU characterisation). They may vary according to the function being assessed and they are related to hydrological, biological and geomorhological characteristics of the wetland. Each indicator has a different impact on the extent at which a function is performed.

Table 1. Wetland features affecting the potential functions and extent to which these factors may affect respective functions (H: High, M: Medium, L: Low (EVALUWET, unpublished report).

Wetland Functions / *Wetland Features*	*Floodwater attenuation*	*Groundwater recharge*	*Water storage*	*Sediment & toxicant trapping*	*Nutrient removal & transformation*	*Food web support*
Wetland-watershed ratio	✓ (M)		✓ (L)		✓ (M)	
Wetland position	✓ (H)					
Water chemistry						✓ (H)
Hydroperiod					✓ (H)	✓ (H)
Bottom slope/water velocity				✓ (M)		✓ (M)
Outlet characteristics	✓ (H)	✓ (M)	✓ (M)	✓ (M)	✓ (H)	
Water movement	✓ (L)				✓ (M)	
Water depth			✓ (H)	✓ (M)		✓ (M)
Vegetated area	✓ (H)				✓ (M)	
Soil		✓ (H)	✓ (M)	✓ (H)	✓ (H)	
Wetland type				✓ (H)		
Vegetation	✓ (M)			✓ (H)	✓ (M)	✓ (H)
Origin of water		✓ (H)	✓ (L)			
Artificial features		✓(M)	✓(M)			
Land uses			✓ (M/H)			
Habitat variation						✓ (H)
Exposure to wind				✓ (M)		

In the case of Doirani/Dojran Lake we selected those functions/processes of the wetland ecosystems which are of special interest for the area and assess only those ones. The rationale of the selected functions is analysed in other chapters.

Some of the functions emerge from physical processes which are described by identical terms, however they should be considered as separate stages of the wetland physical processes. The following are these we considered of high priority for the area and could be assessed according to data available:

HYDROLOGICAL FUNCTIONS (*Water quantity functions)*

Functions	**Processes**
Flood water detention	Flood water retention
Groundwater recharge	Groundwater recharge
Groundwater discharge	Groundwater discharge
Sediment retention	Sediment retention

ECOLOGICAL FUNCTIONS

Function	**Processes**
Ecosystem maintenance	Provision of overall habitat structural diversity
	Provision of microsites for:
	macro-invertebrates
	fish
	herpetiles
	birds
	mammals
	provision of plant and habitat diversity

In the following sections we describe how the method was applied in the Doiran Lake. Section B outlines data collection and field work for the delineation of the Assessment Area (AA) and Contributory Area (CA).

Section C illustrates the delineation of hydrogeomorphic units in the AA and finally in Section D the functional assessment is presented.

CHAPTER 2. FIELDWORK PREPARATION

2.1. Description

Fieldwork preparation has several purposes. One of the key aims is to produce maps to be used in the field which will illustrate the wetland area of interest called the **Assessment Area** (**AA**) and the wider area which can influence its functioning, called the **Contributory Area** (**CA**).

Additional information that assists the researcher in the field can be gathered in this stage. This information may relate to climate, land-use, management, conservation status and history of flooding. Local experts, landowners, environmental agencies and conservation bodies can be useful sources of such information.

2.2. Assessment Area (AA) delineation & map preparation

At this early stage of the procedure, it is necessary that we consider the exact purpose of the functional assessment, and therefore which precise area we should be looking at for future planning of restoration actions in the area. The HGMU approach allows the assessment of both wetlands and associated areas (frequently areas of special economic interest) including those that may possess non-wetland characteristics.

The FAPs indicates that the AA should fall into one or more of the following categories in which delineation is described by:

1. Field boundaries
2. Administrative boundaries
3. Ownership boundaries
4. Wetland extent

For categories 1-3 delineation was relatively straightforward and was easily transferred to a map. In category 4 it was up to the worker to set the boundary according to a personal and institutional definition of a wetland. In the case of Doiran Lake we selected the AA based on the shoreline of the lake about 20 years ago and permanent geomorphological and hydrological features on both sides of the national boundaries. Hence, on the Greek part the road next to the former shore of the lake which separates the wetland area from the present agricultural land was selected as boundary of the AA. In FYROM we followed the national road to the north and then to the north-east a secondary road until the boarder with Greece.

All potentially valuable archived information about the site was collected and the following list provides suitable sources.

* Detailed up-to-date topographic maps of the site and surrounding area and satellite images to improve a less recent or less detailed map.
* Older maps and image satellite/aerial photographs were useful for identifying changes in land cover and management.
* Geological maps, land-use maps and soil maps.
* Vegetation maps.
* Records of site management.
* Records of site flooding regime.
* Records or maps of land cover in the catchment.
* Details of land owners at and around the site, land managers, persons and institutions that have studied the site, persons or organisations that regularly use the site for recreational purposes such as bird watching, angling and hunting.

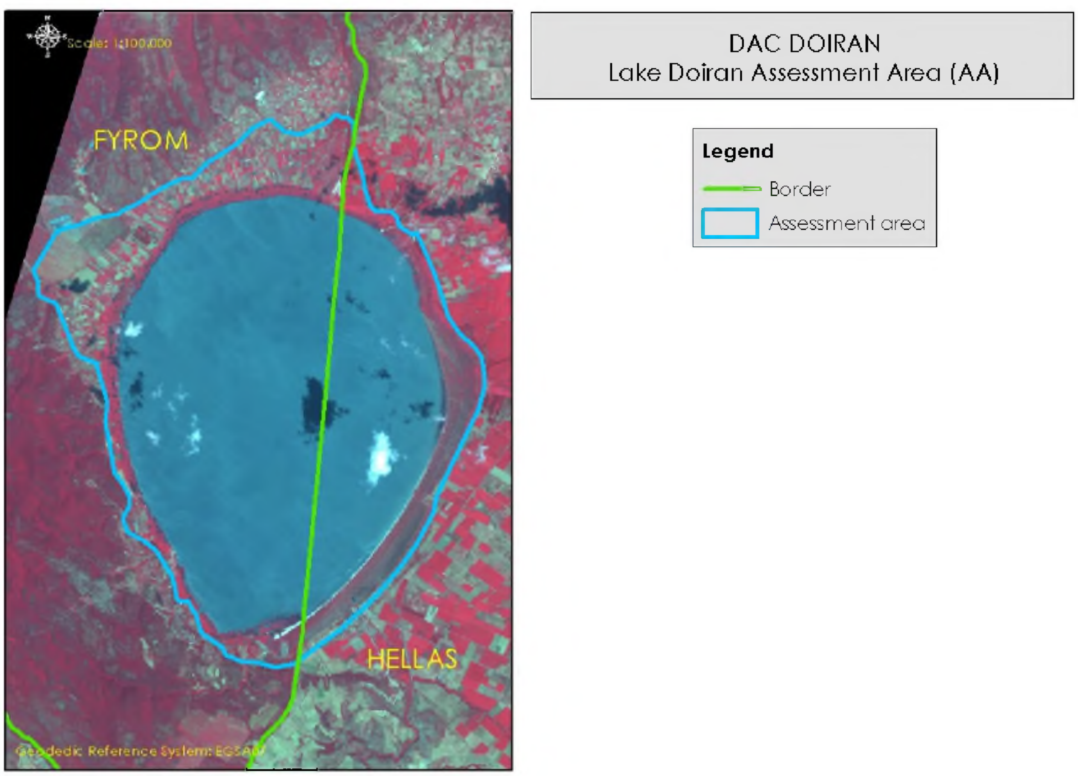

Figure 2. The Assessment Area of Lake Doiran

We selected a topographic map that details features such as watercourses, field boundaries, contours, and spot heights of the area in which the AA is located.

The defined Assessment Area (Figure 2) forms a practical unit on the map following topographic features such as roads and other permanent such features.

2.3. Contributory Area (CA) delineation & map preparation

The purpose of this section is to identify and delineate the area of land affecting the wetland under assessment (the Contributory Area (CA)).

The Contributory Area (CA) is the area that drains directly into the AA, either through surface, subsurface flow or through groundwater flow but not through direct flooding from waterways. The CA is therefore the area between the AA boundary (upslope from the water body) and the first topographic watershed division. This sets the AA into a wider landscape context, which is essential for certain functions as for example hydrological ones. The CA Map should cover the AA as well as the CA, including an adequate zone around the CA and AA. The CA boundary follows the watershed boundary and artificial structures that would intercept runoff from slopes (Figure 3). We defined as well as possible the expected location and limits of the CA from the Digital Elevation Model (DEM).

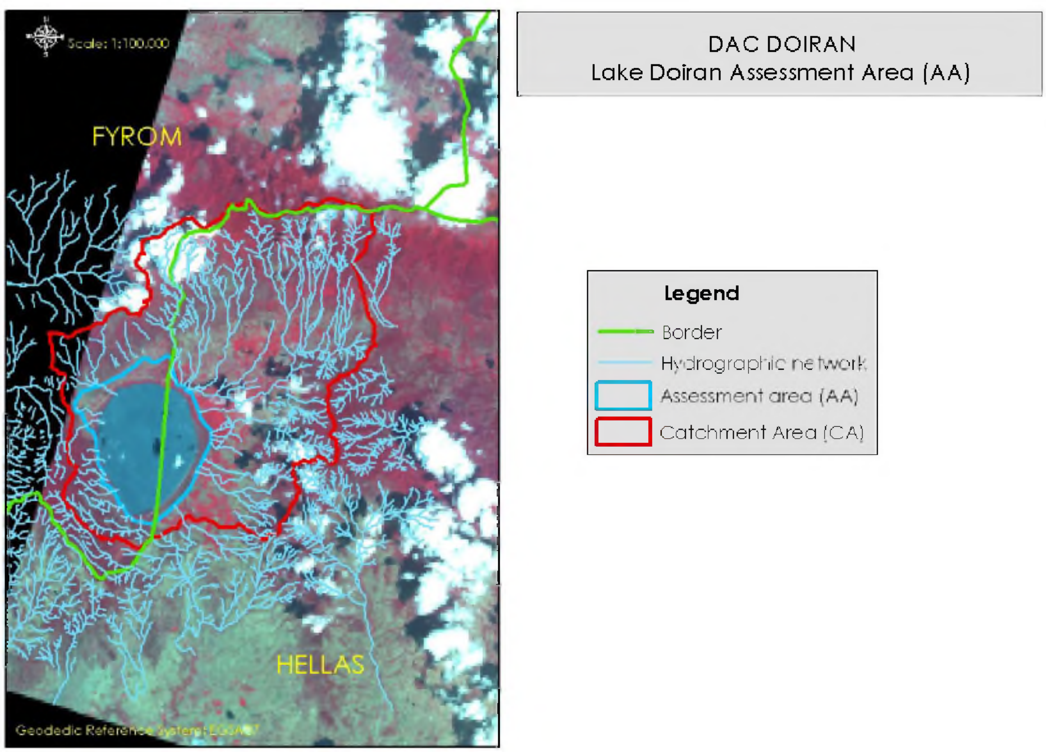

Figure 3. Catchment (Contributory Area CA) and hydrographical network of Lake Doiran

2.4. Collection of desk information on AA and CA

As much information about the site as possible was collected in advance of field visits. This information was used to help HGMU delineation and as a database for reference by the functional analysis procedures (Figure 1).

Key resource for the wetland database establishment was people with knowledge of the site e.g. farmers, fishermen etc. They provided information that is not available from maps, field surveys or archives. This is especially true for AA and CA management practices and determination of flooding regime.

Relatively recent and accurate land use data for the AA were available and they greatly assisted in orientation in the field. Sources of data were topographic maps, satellite images and information recorded about sites and properties.

The importance of land use practise in the areas adjacent to the AA is reflected in the potential influence on the functions of the site. Fishing, farming and mild recreation activities in Doiran catchement are the main uses which absolutely affect the wetland. Recreation practically only exists on the FYROM side whereas on the Greek side agriculture and stock farming are the main activities. Information on as many issues as possible about the site and its management was collected e.g. climatic conditions, application of fertilizers, ploughing, livestock, bird populations, conservation and protection status etc (Katsavouoni S. and S. Petkovski 2004).

CHAPTER 3. DELINEATION OF HYDRO-GEO-MORPHIC UNITS (HGMUs) IN LAKE DOIRAN

3.1. Catchment description

The catchment description includes physical, social and ecological characteristics (Katsavouni S. and S. Petkovski, 2004).

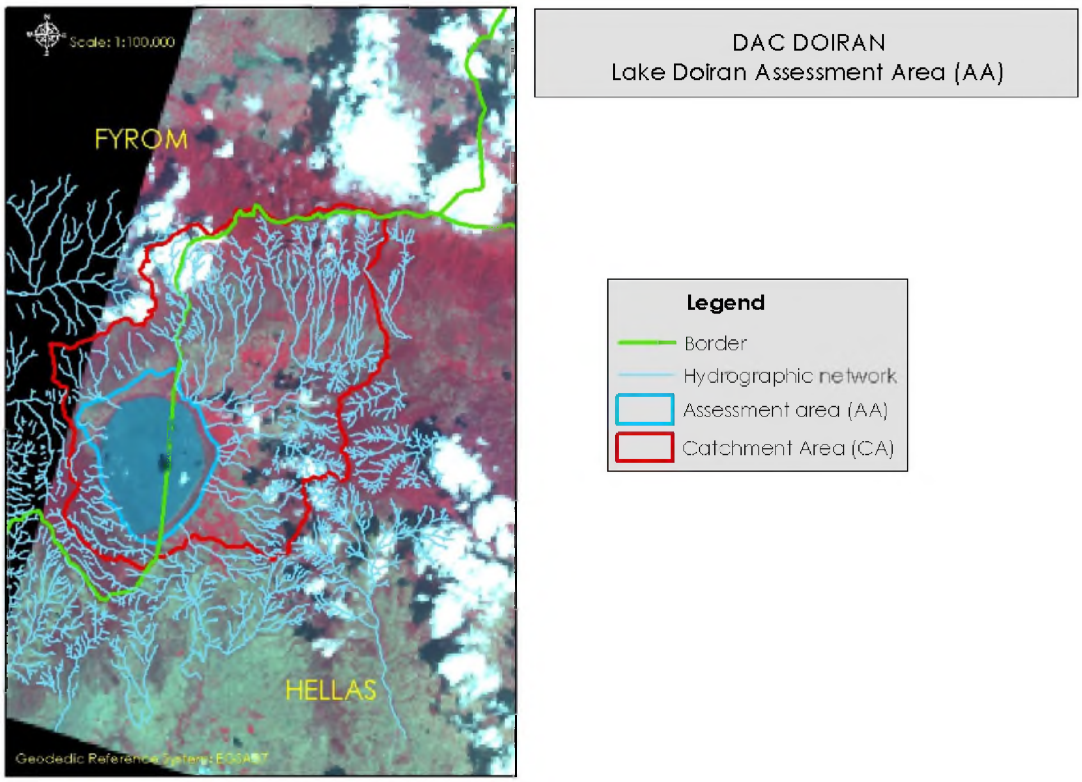

Figure 4. Almost 3/5 of Lake Doirani is in FYROM territory and more half of the catchment area is in Greek territory.

The total catchment area is approx. 276 km^2. The lake covers approx. 40 km^2 (or 42 km^2 according to FYROM) with a wide floodplain on the south and east side. Almost 3/5 of the lake area is in FYROM territory and the catchment is essentially an agricultural area (Figure 5). The surrounding hills and the mountain ranges of Belles and Krousia are densely vegetated. The highest altitude of mountain range Belles is close to 1874 m (Greek data) or 1820 m (FYROM data) and of mountain range Krousia 1474 m (Greek data) or 1447m (FYROM data).

A detailed description of the catchment can be found in the report by Katsavouni Sotiria and Svetozar Petkovski (2004).

There are three land types in the Doirani catchment area:

Hills

Local relief is between ~146 (close to lake surface) and 1874 m or 18720 m (Greek data or FUROM data respectively), containing a small proportion of steep slopes with shallow soils. Found in the west it contains deciduous forest and shrub woodland (Figure 5). Hilly area starts at approximately 500 m altitude.

Figure 5. Hill area around Lake Doiran

Open Water

It covers 12% of the catchment area. The bottom is smooth, silt-clay and depth ranges from 0.20m to 4.50 m (Figure 6).

Plains

With the exception of a small part which is forested the largest part of the plain area is mainly cultivated.

Figure 6. View of the open water area of the lake

3.2. Identification of HGMU boundaries

Hydrogeomorphology is the study of interactions between hydrology and geomorphology, and the associated landscape conditions that result (Maltby et al 1996). Based on this assumption the hydrogeomorphic approach to wetland classification and assessment has been developed in parallel by researchers in the United States of America and in Europe (Maltby et al 1996). The hydrogeomorphic classification of wetlands proposed by Brinson (1993) states that it should be possible to make reasonable judgements on how the physical properties (geomorphic setting, water source and hydrodynamics) can be translated into wetland functions. However, Brinson also elucidates that it is an inductive approach and as such it should remain open to testing and further development.

The approach does not aim to classify the wetland into a specific hydrogeomorphic category rather it seeks to identify areas within the wetland that exhibit hydrogeomorphic homogeneity. It is possible that a wetland may exhibit hydrogeomorphic homogeneity throughout, and thus represent a single HGMU. However, most wetlands comprise a mosaic of different HGMUs, each reflecting difference in the prevalent physical properties.

Thus for the identification of the HGMU boundaries, the geomorphology of the wetland is described in terms of slope (gradient), depressions and elevations.

The hydrology issue of the approach is characterised according to differences in surface and near surface inflows and outflows, and management. Soil type and vegetation covers are also recorded for each HGMU.

Finally, the components of the HGMU are utilised as direct inputs into the functional assessment procedures.

The division of the landscape into units, which have uniform functioning (Hydrogeomorphic Units, HGMUs) is conducted mainly in the field.

Assuming that each HGMU is a landscape unit of uniform geomorphology and hydrological regime; where soils must also be uniform in as far as they are a reflection of the hydrology and geomorphology the delineation of HGMUs within the floodplain was carried out according to the following criteria:

- **Management of hydrology**
- **Geomorphology**
- **Soil**

Initial HGMUs were mapped using criteria for Management of hydrology and for Geomorphology. These were amalgamated - but not usually divided - using soil information.

The Assessment Area is divided into its main landscape components which are then divided into HGMU. Potentially three main geographic components occur in it: *slopes*, *floodplains* and *open water* (Figure 7).

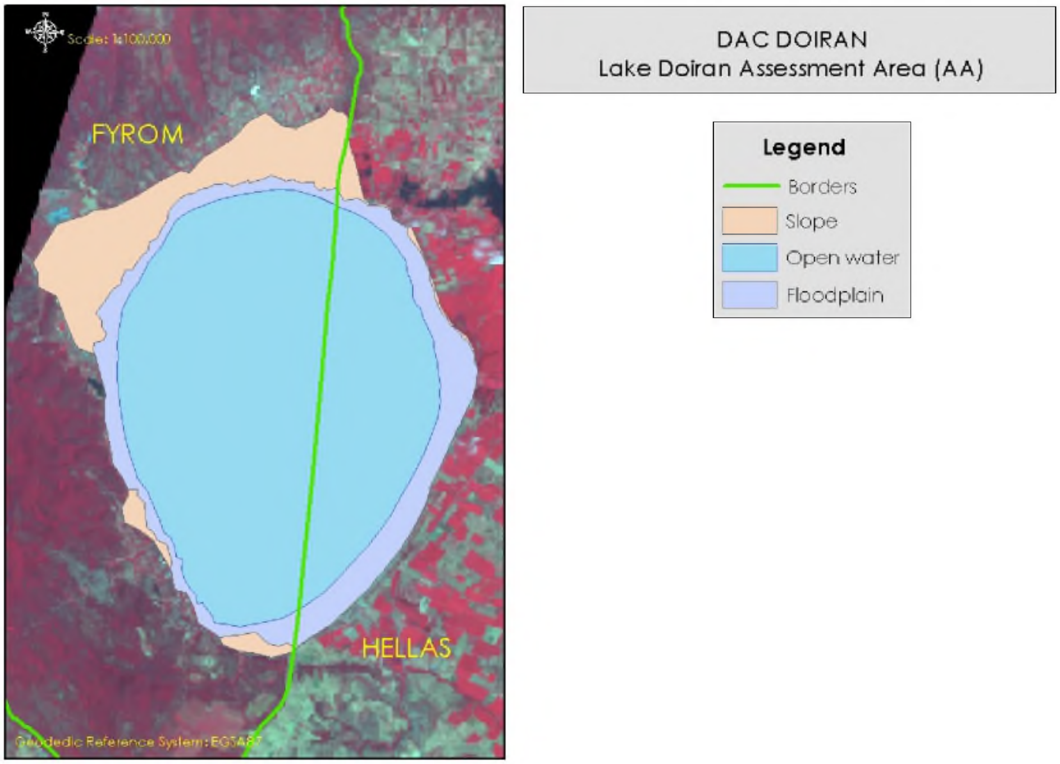

Figure 7. Subdivision of the AA into three main landscape components: slope, open water, floodplain

HGMUs boundaries were mapped in the field using a combination of information recorded on an AA map and observable **Hydrological Management boundaries** and **Geomorphological features** in the field. To do this several transects were identified from a nearby hill that allows a "bird's eye" view of the whole assessment area (Figure 8).

Transects cross most of the landscape units identified and they were not straight, but they met most of the following conditions (Figure 9):

- They were as evenly distributed through the AA as possible.
- Cover the main features and variation.
- Were identifiable in the field.
- Were possible to follow in the field (i.e. safe and physically manageable).
- Avoid following streams or artificial structures, which are likely to form HGMU boundaries.

Figure 8. "Bird's eye" view of Lake Doiran

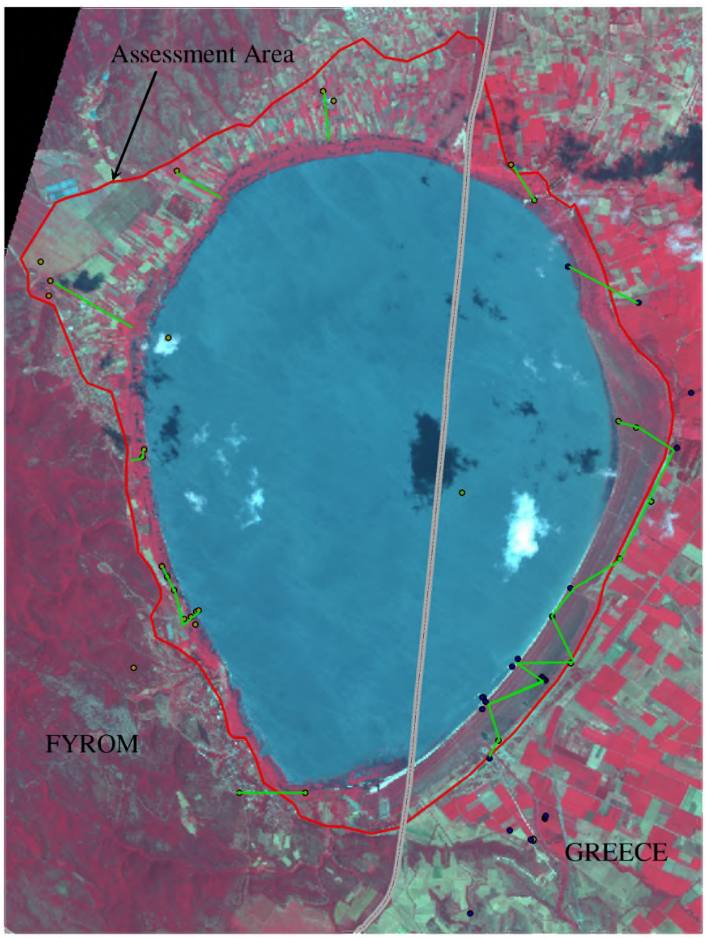

Figure 9. On filed trips we followed several transects (green line) through most of the landscape units taking waypoints with a portable GPS unit

3.2.1. Hydrological Management boundaries

- Embankments which may separate flooded from non-flooded units
- Streams and larger ditches which may separate areas with different inundation or groundwater regimes
- Other features separating intensively drained areas from non-drained areas.

3.2.2. Geomorphological boundaries

These can be identified as any significant change in the gradient of the land surface. When identifying geomorphological features the following were kept in mind:

- Sometimes the boundaries were not immediately apparent in the field, but they were often indicated by changes in 'wetness' of the wetland, as expressed by flooded or waterlogged soils associated with a specific vegetation type or structure.
- Soil wetness and - to a lesser extent - vegetation distribution could vary seasonally and with events.
- Vegetation characteristics were used as an indicator only if they were clearly not caused by management, i.e. they should not coincide with only a fence or a ditch.
- A code indicating inclination was attributed to each HGMU.

0-2°	**Flat/gentle** commonly describes floodplain components	G0
2°-5°	**Gentle** often describes flood slopes	G1
5°-15°	**Moderate**	G2
15°->	**Steep**	G3

This information is taken into consideration within several parts of the functional analysis procedures.

3.2.3. Soil information

Soil information was the final criterion for the subdivision of the AA into HGMUs. Soil information was used to check if the HGMU delineation based on hydrological management and geomorphology was correct. The information was collected during several field visits using a small shovel and it was of relatively simple level of detail i.e. colour, moisture status of the topsoil layer, colour of mottles.

The resulted HGMUs are:

Thirteen HGMUs of three types were identified and delineated in the AA (Fig 10):

1. **Elevated areas**: these are terraces (code ETC) and correspond to elevated shelf adjacent to the valley slopes at higher elevation than the floodplain and only inundated during exceptionally high flood events.

   ETC1: the area extends from the international road that passes through New Doiran village, on the FYROM side, towards the reed bed on the lake shore and covers mainly the village itself.

   ETC2: this is a relatively small area close to the boarder. Vegetation mainly consists of grassland and low shrubs.

   ETC3: this is the largest of all elevated areas extended on the northwest of the lake in the FYROM side mainly consisting of agricultural land.

   ETC4: this unit is at the north of the lake on the boarder line and it is also agricultural land.

2. **Intermediate areas:** these are flat areas (code **IFA**) and correspond to smooth plain lacking distinct micro-relief. Partly with dry soils, wet and water logged patches during the year.

   IFA1: this unit is located on the east shore of the lake in the Greek side and is covered with tall herbs and rush meadows.

   IFA2: reed bed, tall herbs and rush meadows Salix and Populous woods

   IFA3: reed bed, tall herbs and rush meadows

   IFA4: reed bed, tall herbs and rush meadows

   IFA5: reed bed, tall herbs and rush meadows

   IFA6: reed bed, tall herbs and rush meadows

   IFA7: reed bed

   IFA8: reed bed

3. **Depressional areas**: this is the open water area of the lake itself (code LDK)

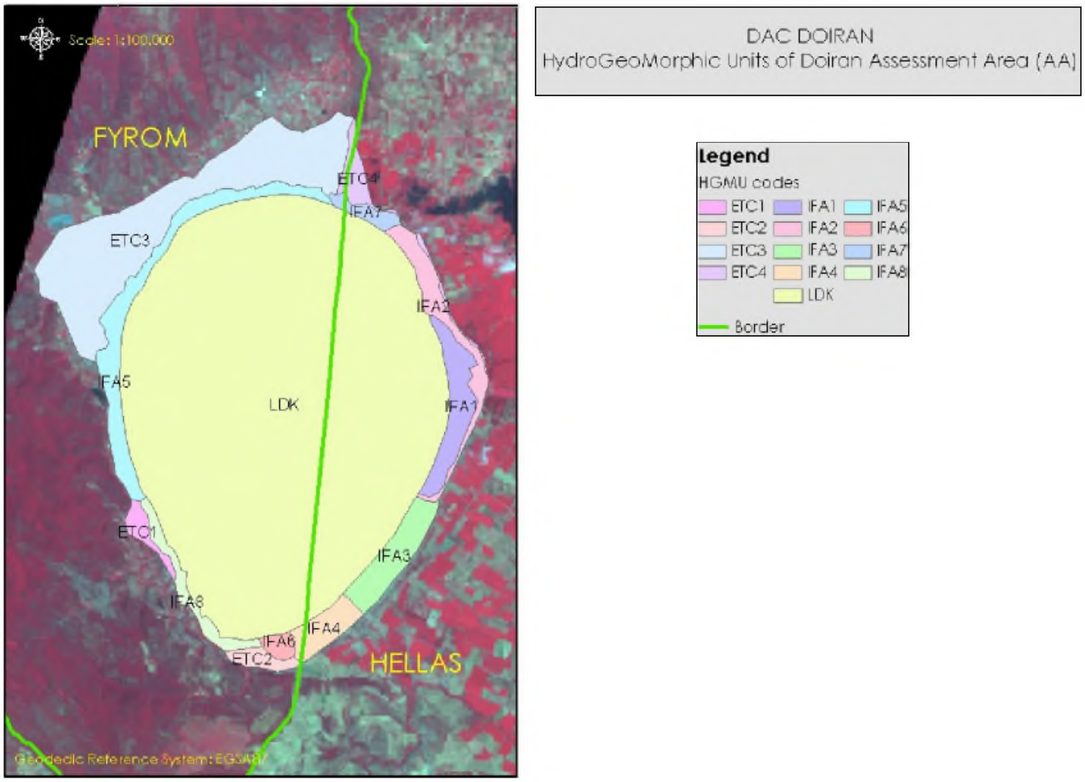

Figure 10. Division of the AA into 13 units with homogenous hydrology and geomorphology

3.3. HGMU Characterisation

Once the component HGMUs have been identified and their boundaries drawn, features ('indicators") of environmental and management importance found within each of them were recorded in order to determine what functions are being performed (EVALUWET):

3.3.1. <u>Recording gemorphological indicators</u>

Geomorphological indicators that were recorded were:

- Surface composition of the land
- Microtopography
- Topographical exposure to wind
- Presence of wind cropped trees

3.3.2. Hydrological indicators

The movement of water around and through a wetland is one of the primary determinants of how it functions hydrologically, ecologically and biochemically.

For the assessment of the hydrological functions the following indicators were recorded:

- HGMU elevation relative to a altitude reference level
- Characteristics of surface water flow direction
- Springs and seepage zones
- Inundation indicators
- Erosion and sediment indicators

3.3.3. Ecological indicators

During this activity ecological indicators were recorded. The identification of vegetation and habitat types in all HGMUs supplies important information for the natural conditions prevailing in the area, ecophysiological process and management practices occurring in the area. Natural and semi-natural communities predominate within the vegetation types as these less impacted habitats more accurately reflect the important environmental conditions that regulate wetland functions. Some broad categories, such as cropland, cover vast areas of the landscape but are poor bioindicators, whereas others of a restricted distribution are highly indicative of wetland functions.

3.3.4. Field indicators of land use and site management

Activities in the wetland such as grazing, ploughing, waste disposal, small constructions, hunting, fishing, and recreation were recorded in order to provide information on the uses occur or potentially occur in the AA. Thus it was found that:

- Cattle are frequently grazing in the AA
- Solid wastes is frequent on the lake shore (mainly wastes from fishers, farmers, hunters)
- The area is designated as game refuge however illegal hunting does occur in the area
- Recreation is mainly developed on the FYROM side (beach, hotel, casino) and only occasionally on the Greek side.

Assignment of a hydrological code to the HGMUs

During the HGMU delineation we determined which hydrological processes are very likely to occur in each HGMU. This results in a hydrological code, which is used as an input into several functional assessment procedures.

At this point it is important to stress the difference between the HGMU coding in this action and the outcome from the functional assessment. The coding determines whether selected hydrological processes are very likely to occur - *to any degree*, whereas the functional assessment determines whether hydrological functions definitely occur *to a significant degree*.

Groundwater Discharge

For those HGMUs coded as ETC (1-4) the following hold:

a. They are located in the slope component of the AA
b. The average groundwater table in the HGMU is at over 50 cm depth at any time of the year.

Considering these two conditions the process of groundwater discharge is unlikely to occur in ETC1, ETC2, ETC3, ETC4.

For those HGMUs coded as IFA (1-7) the following hold:

a. Abundant or lush vegetation e.g. trees, reed swamps, is found and the vegetation in nearby areas is sparse, with a large surface of exposed soil.
b. The area immediately upslope of the HGMU is located in a recharge area.

Considering these two conditions the process of groundwater discharge is likely to occur in IFA1, IFA2, IFA3, IFA4, IFA5, IFA6, IFA7.

Runoff Input

The process of runoff input into the HGMUs coded as ETC (1-4) is likely to occur since they are located directly downslope of an area larger than the HGMU itself and the area immediately upslope (inside or outside the AA or both) is very likely to produce runoff output.

In HGMUs IFA1, IFA3, IFA4, IFA8 the process of runoff input is unlikely to occur since they are separated from the upslope area by a feature that intercepts runoff e.g. a road.

In HGMUS IFA2, IFA5, IFA6, IFA7 the process of runoff input is likely to occur since they are located directly downslope of an area larger than themselves and the area upslope (inside or outside the AA, or both) is very likely to produce runoff output and there are drains originating in this area.

Runoff Output

The process is likely to occur in those HGMUs coded as ETCx since they are located on a slope and the soil is described as medium.

The soil in those HGMUs coded as IFAx is fine or medium and is either waterlogged or wet or flooded so the process of runoff output is likely to occur.

Albeit only hydrological and ecological functions were assessed it was considered as imperative demand to briefly commend on the water quality functions.

Nutrient input characterisation

Assessment of the water quality functions (Nutrient Retention and Nutrient Export) the nutrients entering or likely to enter an HGMU must be characterised according to the FAPs as formulated in EVALUWET.

A Nutrient Input is defined as a source of nutrient (e.g. nitrogen and/or phosphorus) that does not naturally occur in the wetland and is supplied to a site by one or more mechanisms: An HGMU may receive several different inputs. The following were considered as the principle mechanisms:

- Direct application
- Groundwater discharge
- Runoff input

Although lack of detailed data does not allow for an accurate biochemical functional assessment it is necessary to characterise each nutrient source and its mechanism(s) of supply.

This is achieved by identifying a type of nutrient source and where it is being received within the AA or CA and then what the mechanism of supply is for this source.

Determination of the presence of a nutrient source

Inorganic and/or organic loadings are applied into ETC1, ETC2, ETC3, ETC4.

In and/or close to IFA1, IFA3, IFA4 and IFA5 livestock is either kept or graze.

Determination of the mechanism of nutrient supply for each identified nutrient source

Runoff input is likely to occur in IFA5, ETC1, ETC2, ETC3, ETC4

CHAPTER 4. QUANTITATIVE FUNCTIONAL ASSESSMENT

Following the fieldwork, the delineation of the HGMUs the next step was the actual assessment of the pre-selected functions.

4.1. Hydrological Functions

Hydrological functions refer to functions that express the ability of the wetland to store floodwaters, interact with groundwater and store sediment (Floodwater retention, Groundwater recharge, Groundwater discharge and Sediment retention)

For floodwater retention to occur three conditions should be met:

1. The wetland must have significantly fluctuating water levels or - in some cases - adjoining higher areas must produce significant amounts of overland runoff.
2. The HGMU must be in open connection with the wetland during floods, or unimpeded overland flow into it must be possible.
3. For the flooding process to be described as a function of an HGMU, floods must have the potential to be damaging (economically or ecologically) downstream of the wetland ('flood control'), or flooding must have potential to provide hydrological favourable conditions, or floodwaters must have high suspended sediment loads.

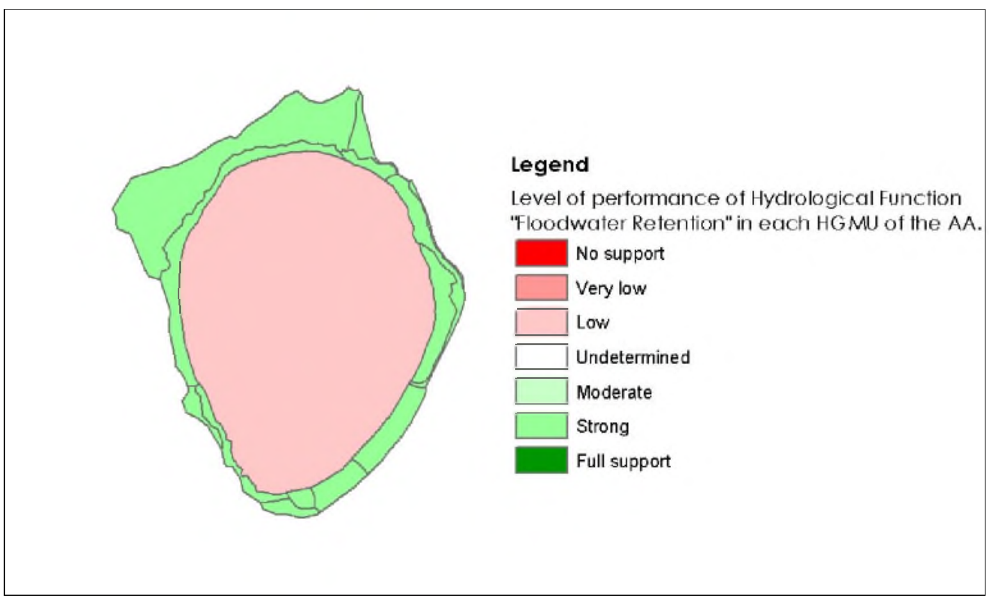

Figure 11. The hydrological function of floodwater retention in the AA is being performed or has the potential to be performed at a strong level

The results of the functional assessment for Floodwater Retention in the AA are illustrated in Figure 11.

It is evident that all HGMUs, except the open water area itself (DLK), have the potential to flood with lake water but only rarely during extreme events. It is also evident that flooding of the HGMUs provides a strong attenuation of floods however it is not feasible with the information available to estimate flow velocity and flood duration.

Function: Floodwater retention

Related value(s)	Rationale
Floods protection	High lake water fluctuations in the past flooded adjacent settlement. Due to the existing road next to the settlements that works as dyke and low water levels floods do not occur. The result is that floodwater retention function is being performed or has the potential to be performed at a strong level at the HGMUs around the lake.

For the Groundwater Recharge Function to occur the following conditions must be met:

1. An HGMU must receive significant water inputs either from runoff or from lake rise. If only inputs from precipitation are present it is very unlikely that recharge will occur at higher rates than in non-wetland areas.
2. Water tables in an HGMU must be sufficiently below the soil surface prior to the water input to allow infiltration of standing water before it evaporates or runs off.
3. An HGMU must be connected to an aquifer - which usually means it must overly it and it must not be separated from it by deposits of low permeability.
4. The water table gradient must be sloping away from an HGMU at least in one direction, allowing groundwater flow out of the HGMU.
5. There can be no groundwater discharge.

The results of the functional assessment for Groundwater Recharge in the AA are illustrated in Figure 12.

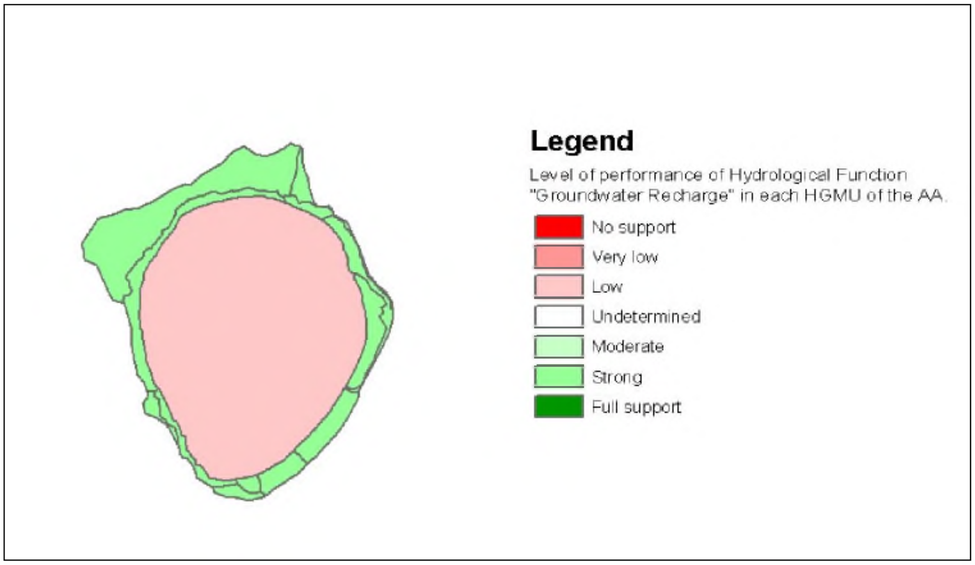

Figure 12. The hydrological function of groundwater recharge in the AA is being performed or has the potential to be performed at a strong level

The functional assessment shows that recharge of groundwater is significant in the HGMUs that represent a large recharge area connected to an aquifer.

Function: Groundwater recharge

Related value(s)	Rationale
Water for irrigation	This value is of high importance for both states, but mainly for the Greek part since most of the cultivated areas are irrigated by groundwater. The significant drop of the lake's water level caused degradation of the groundwater recharge function which in turn resulted in the degradation of the related wetland value.

For the discharge function to occur in an HGMU the following conditions must be met:

1. There must be a recharge area above the HGMU - an area where water can infiltrate.
2. There must be a water source for infiltration in the recharge area. Usually this is rainwater but in some cases it can be runoff input or even stream water.
3. The recharge area must be connected with the HGMU through an aquifer.
4. The permeability of the soil in the HGMU must be high enough to allow upward seepage.
5. Groundwater flow must not be intercepted between recharge area and discharge area - by natural discharge, drainage, and groundwater abstraction or vegetation uptake.
6. There must be sufficient elevation difference between the recharge area to allow a groundwater table gradient capable of producing significant discharge.

The above conditions are met to some extent in very few of the HGMUs (they are situated in depressions and the geology is often conducive to some groundwater flow) and some discharge will occur. However it is not as often a significant function, as it may only make a minor contribution to a water budget dominated by inputs from rainfall, runoff and flooding. Therefore this is a measure of potential significance, albeit a very limited one.

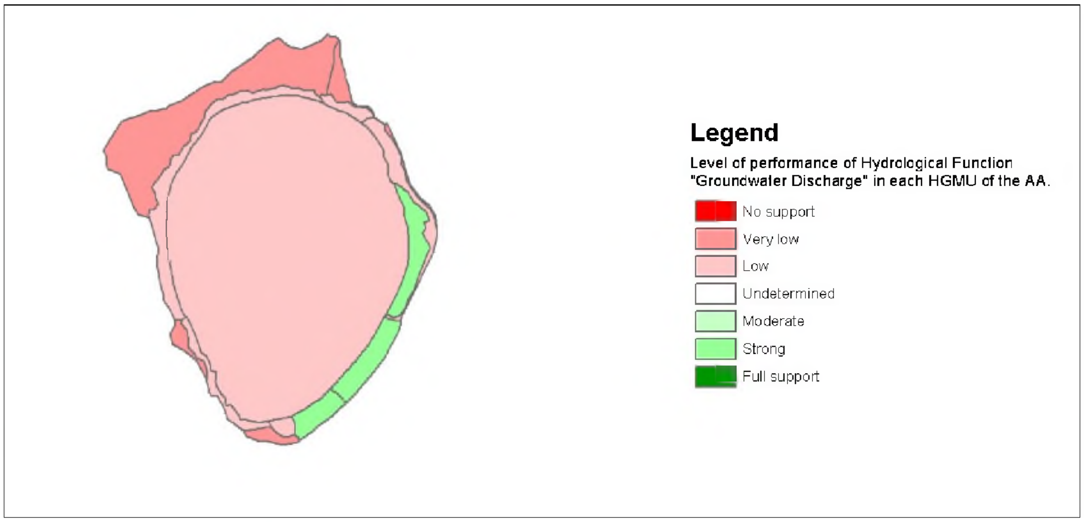

Figure 13. The hydrological function of groundwater discharge in the AA is being performed or has the potential to be performed at a very low level in the largest part of the AA

Groundwater discharge is poorly performed in the largest part of the assessment area and only in three HGMUs) is performed to a moderate level (light green) (Figure 13).

Function: Groundwater discharge

Related value(s)	Rationale
Fishing Recreation Biodiversity Water quality improvement	Groundwater discharge function is of high importance, since it results in the discharge of water into the lake. Groundwater wells used for irrigation have been increased during the last 15 years in the watershed, resulting in the reduction of groundwater discharging into the lake. Degradation of this function drives (in parallel with the other parameters affecting water level drop) to the decrease of water volume into the lake which in turn affects water quality, fish populations, and biodiversity and recreation value of the lake.

For the Sediment Retention function to occur the following conditions must be met:

1. An HGMU must receive significant water inputs either from runoff or from significant flooding.
2. The water inputs must have a significant suspended sediment load.

3. The flow velocity in the HGMU must be sufficiently low for the sediment to settle, but high enough to ensure continued inputs of sediments.
4. Erosion in the HGMU must be negligible.

A complication with the Sediment Retention function is that it is highly variable in time and in space - current sedimentation patterns and - rates can be completely different from those in the recent past due to changes in local flow conditions (e.g. major constructions such as roads etc) and erosion conditions upslope. These changes cannot be detected easily. Only a limited attempt is therefore made to assess the significance of the Sediment Retention function (Figure 14).

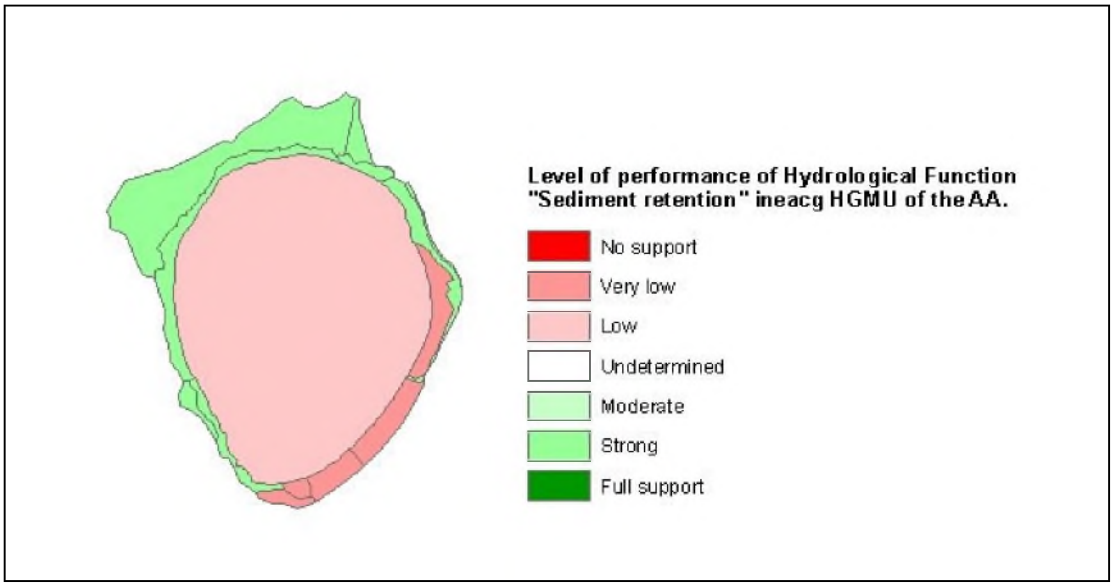

Figure 14. The hydrological function of sediment retention in the AA is being performed or has the potential to be performed at a strong level in the largest part of the AA

For those HGMUs that were assessed to perform this function at a strong level it is unknown if this forms a significant portion of the suspended sediment load in the lake. A lack of erosion indicators in the AA suggests that the retention will be long-term.

Function: Sediment retention

Related value(s)	Rationale
Recreation Biodiversity	Sediment load entering the lake is retained by the HGMUs around the lake, resulting to low SS concentrations. It is noteworthy, that the existence of the lake’s marginal wetland plays an important role to the performance of the sediment retention function. As a result, low suspended solids concentrations enhance water quality, biodiversity and recreation value.

4.2. Biogeochemical Functions

Nutrient (N, P) export function

According to the EVALUWET methodology, the nutrient export function is related to the following 4 processes by which 3 are naturally occurring and one regards to humans activities: a) *gaseous export of N (denitrification), b) gaseous export of N (ammonia volatilisation), c) export of nutrients through vegetation management, d) export of nutrients via water and wind mediated mechanisms.*

a) Gaseous export of N (denitrification)

Denitrification is the bacterial reduction of nitrate (NO_3^-) to nitrous oxide (N_2O) and dinitrogen (atmospheric nitrogen, N_2) and their subsequent export from an HGMU into the atmosphere. One requirement for the process to occur is that an HGMU is in receipt of nitrogen in the form of nitrate from directly applied nitrate-rich fertiliser, directly applied nitrogenous materials/fertilisers which are transformed to produce nitrate, and/or interaction with nitrate/nitrogenous material bearing waters (Johnston, C.A., 1991). Optimal soil conditions for the process include the presence of a carbon source for bacterial respiration, an anaerobic soil atmosphere, interstitial water with pH above 6 and soil temperatures greater than 8°C (Pinay et al 1995).

The importance of the function relates to the improvement of water quality in the lake receiving surface or subsurface water from the wetland by removal of nitrogen by denitrification.

b) Gaseous export of N (ammonia volatilisation)

One requirement for the physico-chemical release of excess ammonium or ammonia nitrogen as gaseous ammonia and export from an HGMU into the atmosphere to occur is that an HGMU is in receipt of ammonium/ammonia by direct input to the soil surface (especially the urea excreted by mammals or of the uric acid excreted by birds). It may also occur from shallow water bodies that are in receipt of ammonium/ammonia-rich water/material/fertilizers, when conditions are optimal.

Conditions are optimal when pH in soil water or in the water column is above 7, soil/water temperature is above 8°C, the soil is composed of predominantly mineral material of sand/gravel particle size and the soil/water body is exposed so that the diffusion gradient from soil/water body to atmosphere is enhanced.

The overall importance of ammonia volatilisation as a loss mechanism in wetlands is poorly documented. Because of the small amount of information on rates of ammonia volatilisation from wetlands this process cannot be assessed quantitatively. Therefore only a rough qualitative assessment of ammonia volatilisation is provided by the method. High emissions of ammonia lead to an increase in N-deposition, which will acidify and eutrophicate both aquatic and terrestrial ecosystems.

c) Export of nutrients through vegetation management

Many plants can retain excess nutrients (nitrogen and/or phosphorus) by assimilation into their biomass. However, this is a short-term retention of nutrients since at the end of the growing season, the death of the plants and their subsequent decomposition results in a return of the nutrients to the wetland system. However, through management the nutrients retained in vegetation can be exported from the wetland system before they are re-released. Burning of vegetation is a management practice that can result in the export of nutrients via gaseous emissions. However, the amount of nutrients lost by this process is relatively small compared to the other management techniques, and therefore was not assessed.

One requirement for the process to occur is that an HGMU is in receipt of excess nutrients from direct applications of nutrient-rich material/fertiliser and/or interaction with nutrient-bearing waters. These excess nutrients must be available to plants capable of a high rate of nutrient uptake. Subsequent management of the vegetation can result in the removal from the wetland system of plant biomass and the nutrients stored therein. The process of nutrient uptake is optimised in HGMUs experiencing low levels of disturbance so that the ability of plants to take up nutrients is not affected. The main vegetation management practices which one would recommend in the case of Lake Doirani are harvesting of biomass and grazing by livestock.The assimilation of excess nutrients into plant tissue and subsequent removal from the wetland system may improve water quality in water bodies receiving surface or subsurface runoff from the wetland.

d) Export of nutrients via water and wind mediated mechanisms

This refers to the transport of excess nutrients (nitrogen or phosphorus) either dissolved in water or chemically bound to particulate matter, by water and/or wind mediated processes and subsequent export from an HGMU. The process is considered to occur when an HGMU has an input of nutrients from either direct application of fertiliser and/or interaction with nutrient-rich waters, or when nutrients have been previously retained by other wetland processes, and these are removed by water and/or wind transport processes.

De-sorption of nutrients from soil particles (*i.e.* the mobilisation of previously adsorbed nutrients) resulting in nutrients becoming available in the water column was not considered. It is difficult to quantify the process of export of nutrients via water and wind mediated processes because it is temporally and spatially highly variable. Therefore only a qualitative assessment of export of nutrients via water and wind mediated processes are given by the method. The significance of the process lies in that the wetland may be supporting systems elsewhere by providing a nutrient supply. In most cases the amount of nutrients exported by wind-mediated processes is likely to be small in comparison to the amount exported by water mediated processes.

Figure 15 depicts the results of the evaluation of the nutrients export wetland function performed in Lake Doiran.

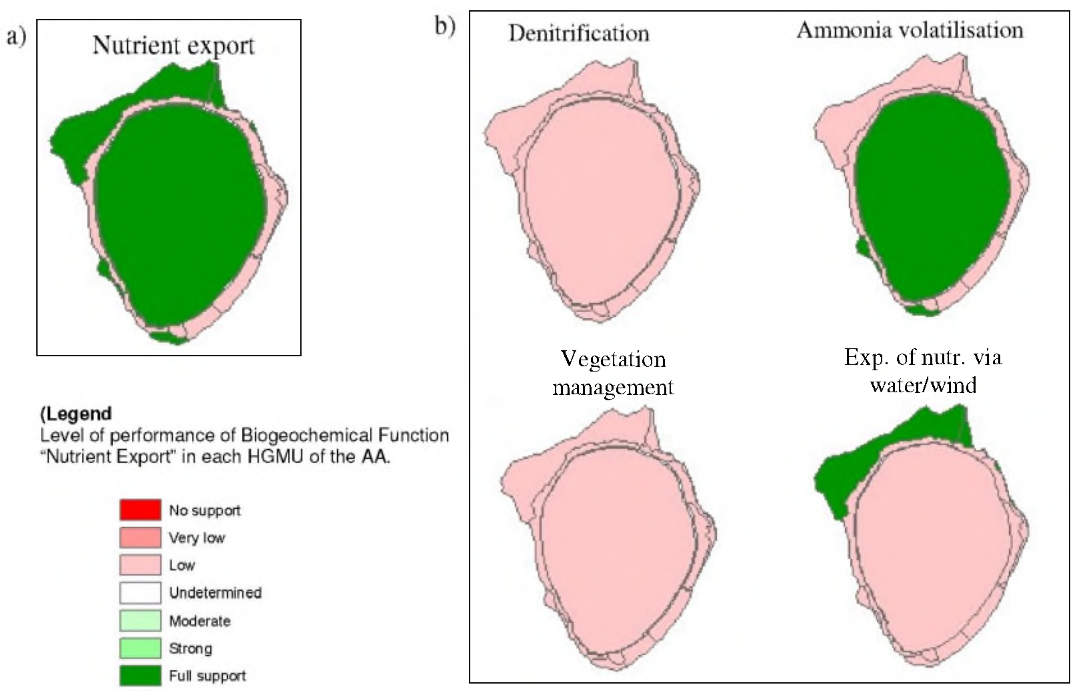

Figure 15. Functional Assessment of nutrient export ((a) total assessment) via four component processes (b): gaseous export of N (denitrification), gaseous export of N (ammonia volatilsation), export of nutrients through vegetation management and export of nutrients via water/wind mediated processes

Function: *Nutrient export*

Related value(s)	Rationale
Water quality	The significance of the function lies to the improvement of water quality in the lake receiving surface or subsurface water from the AA and the CA by export of nitrogen by loss of ammonia into the atmosphere. Lake water of high quality is of great significance for both States for it is related to the most of other values of the wetland.

Nutrient retention (it relates to water quality value) occurs through the following processes

a)Long-term retention of nutrients (N and P) through plant uptake

Many wetland plants can retain excess nutrients (nitrogen and/or phosphorus) by assimilation of nutrients into their biomass. However, at the end of the growing season, the death and decomposition of plant material will result in the release of these nutrients back into soil and water. Nutrients incorporated into woody tissue will be retained for a longer period, as the tissue will not die after each growing season. Nutrients assimilated in herbaceous vegetation may be exported from the system through land use management (this process was assessed separately and commended previously).

One requirement for the process to occur is that an HGMU is in receipt of nutrients (from direct application of nutrient-rich material/fertilisers and/or interaction with nutrient-bearing waters). Vegetation indicative of a high rate of nutrient uptake can use these excess nutrients for their own growth. Also areas of low disturbance are likely to optimise the uptake of excess nutrients.

The importance of the retention of excess nutrients by assimilation into woody biomass will result in an improvement of the water quality of the lake receiving water from the AA/CA. The uptake of excess nutrients by herbaceous plant material will result only in a seasonal improvement of water quality because at the end of the growing season the nutrients will be re-released.

The assessment deals predominantly with the long-term retention of nutrients in woody tissue.

b) Storage of nutrients (N and P) in soil organic matter

The retention of excess nutrients (nitrogen and/or phosphorus) in the marginal wetland by assimilation into plant biomass and their subsequent storage in the soil in either/both a partially decomposed and decomposed form.

One requirement for the process to occur is that an HGMU is in receipt of nutrients (from direct application of nutrient-rich material/fertilisers and/or interaction with nutrient-bearing waters), which are taken-up by plants and subsequently stored in dead biomass. Decomposition reduces plant biomass first into compost (dead biomass which stores N and P for a certain period of time) which eventually will be fully decomposed into nutrients that return to the soil and enable new plant growth to occur.

Soil conditions must be conducive to accumulation of organic matter *i.e.* waterlogged/anaerobic soil conditions must prevail.

The process is optimal in HGMUs in which there is a high degree of interaction between the soil and the nutrient inputs and in areas of low disturbance, so that the ability of plants to take up nutrients is not affected.

Because nutrients are stored in soil organic matter, water quality is improved in the lakewater receiving surface or subsurface water from the AA/CA.

c) Adsorption of N as ammonium

Next process refers to the permanent and semi-permanent adsorption of nitrogen as ammonium to soil mineral and/or organic material.

One requirement for the process to occur is that an HGMU is in direct or indirect receipt of ammonium and/or other nitrogenous materials, if there is a capability to transform the latter to ammonium.

The process is optimised in soils with a pH of 4 – 7, soils with a high clay content and/or soils with a high, well decomposed organic matter content. Clay minerals and highly decomposed organic matter in the soil provide adsorption sites for ammonium.

The process of ammonium adsorption has a threshold after which further addition of ammonium will not lead to more adsorption. Also, it is possible for ammonium to be gradually released from the soil colloids over time if soil conditions change. Adsorption of nitrogen as ammonium will therefore result in only temporary retention.

Similarly to the previous process the significance of this one lies to the improvement of water quality in lake water receiving surface or subsurface water from the AA/CA by retention of nitrogen in the form of ammonium within the soil.

d) Adsorption and precipitation of P in the soil

Next process is summarized as the adsorption of excess phosphate-phosphorus to soil particles by physico-chemical processes resulting in temporary retention in the wetland.

One requirement for the process to occur is that an HGMU is in receipt of phosphate from direct or indirect sources.

The process is optimised when aluminum, calcium or iron are present; P can bind with these elements. Acidic conditions (pH 4 – 6.5) indicate the presence of iron or aluminium while alkaline conditions (pH 6.5 – 8) indicate the presence of calcium.

The value of the function lies in the improvement of water quality in lake receiving surface or subsurface water from the AA/CA by retention of phosphorus within the soil.

e) Retention of particulate nutrients (N and P)

The process of retention of particulate nutrients is considered to occur in an HGMU when nutrients (nitrogen and phosphorus), which are physico-chemically bound to particulate matter transported in water from (main) surface water bodies or other HGMUs within the AA or CA, are deposited and retained within an HGMU under assessment.

Similarly to the other functions the significance lies in the improvement of water quality in the lake receiving surface or subsurface water from the wetland by retention of nutrients bound to retained sediment.

Figure 16 depicts the results of the evaluation of the nutrients export wetland function performed in Lake Doiran.

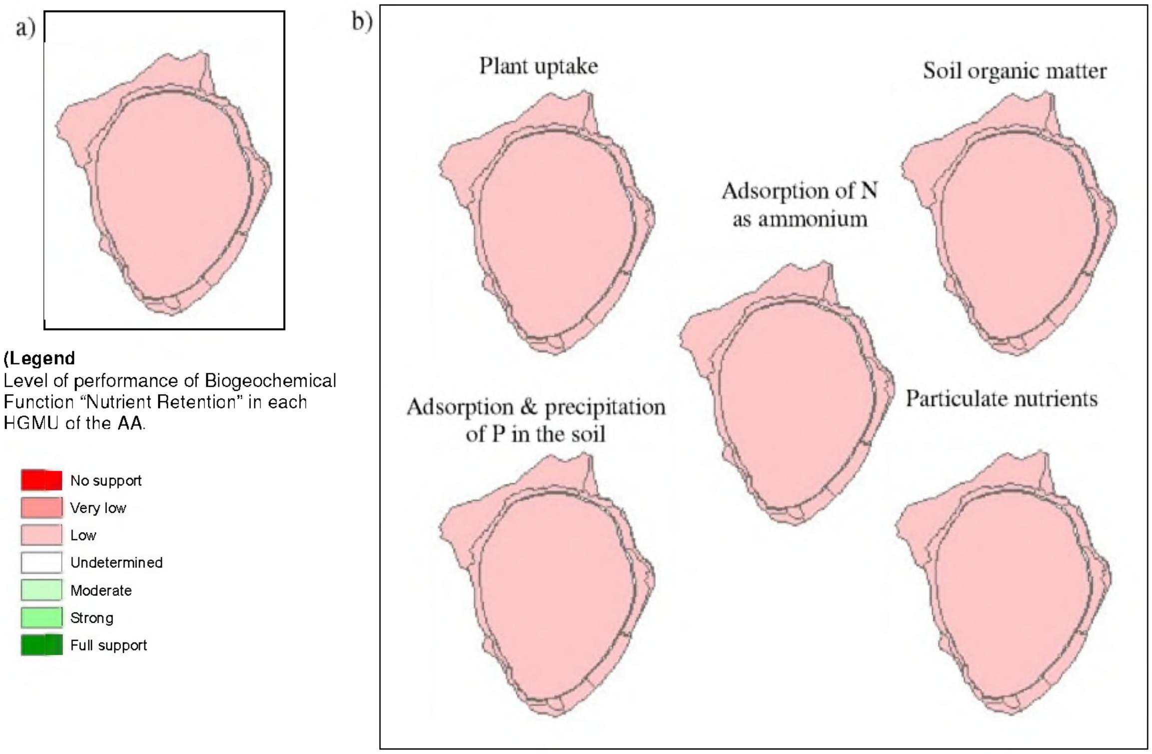

Figure 16. Functional Assessment of nutrient retention ((a) total assessment) via five component processes (b): long-term through plant uptake, storage in soil organic matter, adsorption of N as ammonium, adsorption & precipitation of O in the soil and retention of particulate nutrients

Function: *Nutrient retention*

Related value(s)	Rationale
Water quality	The significance of the function lies in the improvement of water quality in the lake receiving surface or subsurface water from the AA and the CA by retention of nutrients bound to retained sediment. Lake water of high quality is of great significance for both States for it is related to the most of other values of the wetland.

CHAPTER 5. ECOLOGICAL FUNCTIONS

Ecosystem maintenance: As a wetland function comprises the provision of habitat for animals and plants through the interaction of physical, chemical and biological wetland processes. These processes which occur in Lake Doirani combine to provide a variety of high-value habitats, which in turn are capable of supporting a variety of organisms adapted to these habitats. This also contributes to biodiversity and recreational activities and the potential scale of importance of this function lies in the key role Lake Doirani plays in the ecological balance at local and regional level.

The assessment of ecosystem maintenance is achieved by the combination of outcomes from three main processes.

Provision of overall habitat structural diversity: Through this process the method assesses the diversity of habitats that the wetland supports by examining its variety of different structural components.

Light land use and management practices in the largest part of the assessment area are contributing towards the production and maintenance of diversified habitats. The architectural diversity of plants within the habitat is high. Small-scale micro-topographical variations, and soil organic matter contribute towards maintaining a great number of hydro-chemical niches available for plants (and invertebrates) (Figure 17).

Provision of microsites: It is the wetland's ability to provide habitats for different groups of animals. The method uses historical survey records and presence of microsites/habitats that can support them. This process is divided into five groups for assessing macro-invertebrates, fish, herpetiles (reptiles and amphibians), mammals and birds (Figure 17).

However due to the adverse trophic conditions of the lake water (Katsavouni & Petkovski, 2004) the lake has lost its previous importance as regards fishery. During the last 50 years fish yield has decreased by almost 95% (25 tonnes in 2002 over 529 tonnes in 1946). It is evident from the functional assessment procedures (FAPs) that although the lake has a large potential to support fish populations this is actually very limited and it results from the fact the FAPs consider occurrence of protected species in the AA and not fish yield. So the method might give misleading results (Figure 17 *Fish support*) however as the method states from the start the user based on scientific knowledge and gathered information should always cross-check final assessment.

Provision of plant and habitat diversity: The method assesses the wetland's ability to provide habitats for plants using historical survey records and vegetation composition.

The assessment area is of conservation importance and is already protected under national and international legislation. Part of the lake marginal wetland (HGMUs on the Greek side, Figure 6) contains habitat types described by the Habitats Directive and therefore is of conservation importance (Figure 17).

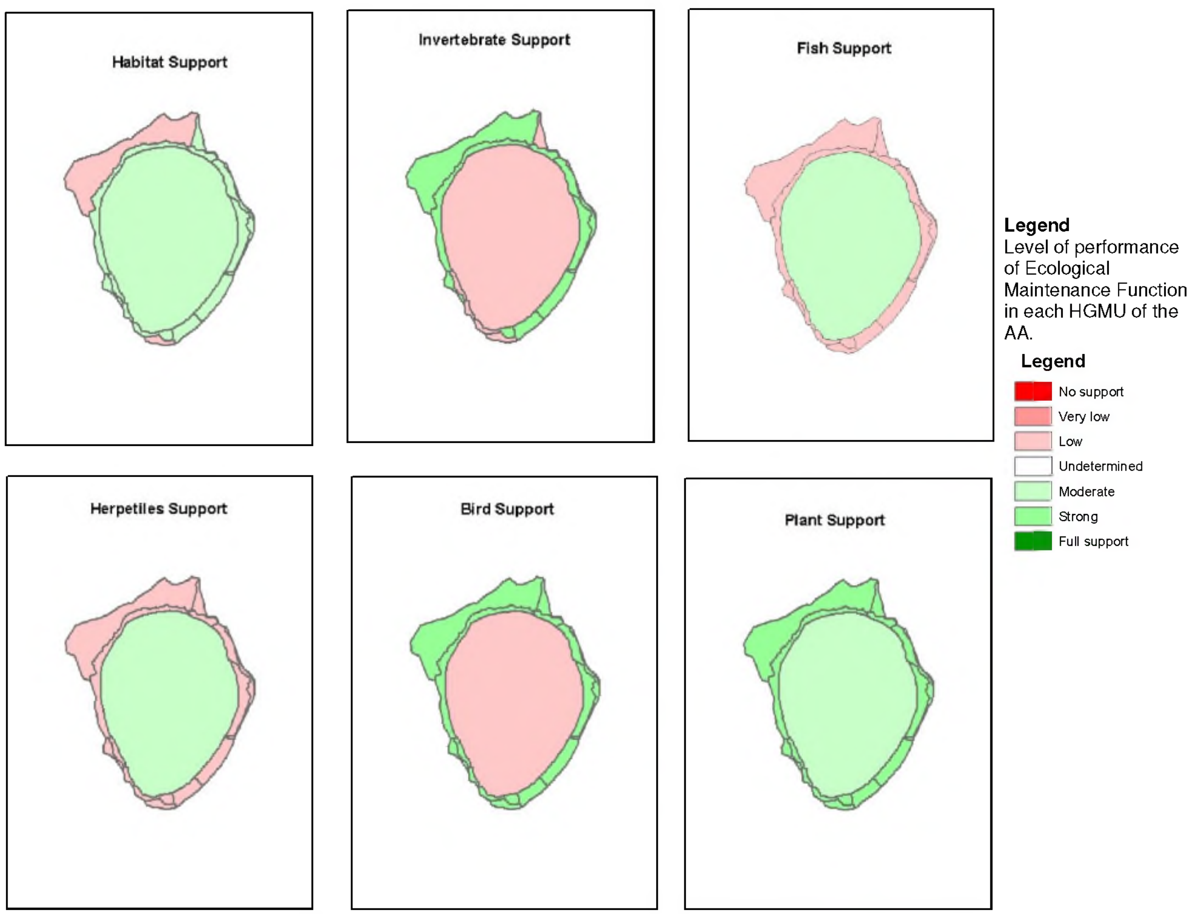

Figure17. Functional Assessment of the Ecological System Maintenance Function of Doiran wetland

Ecological function: Habitat support

Related value(s)	Rationale
Biodiversity Fishing Recreation Scientific research	Habitat diversity enhances biodiversity, fish populations (habitats for breeding, feeding etc.), recreation and scientific value.

Ecological function: Invertebrate support

Related value(s)	Rationale
Biodiversity	Low invertebrate populations, result to low biodiversity.

Ecological function: Fish support

Related value(s)	Rationale
Biodiversity Fishing	Fish populations have been significantly declined for the last 20 – 25 years.

Ecological function: Herpetiles support

Related value(s)	Rationale
Biodiversity	Low herpetiles populations, result to low biodiversity.

Ecological function: Bird support

Related value(s)	Rationale
Biodiversity Recreation Scientific research	Low bird populations, result to low biodiversity, affecting also recreation and scientific observation.

Ecological function: Plant support

Related value(s)	Rationale
Biodiversity Fishing	High flora existence enhances biodiversity and fish populations (acting as habitat for fauna)

Food web support function of the assessment area refers to the biomass input that can be produced on-site through the growth of vegetation or can be transported to the site from elsewhere in the form of detritus or as mobile organisms. It is also possible that on-site biomass production can support off-site food webs.

In order to assess this function we first assessed the productivity of the AA and this is defined as the rate of biomass increase of the plants, algae and bacteria which can use sun energy and chemical energy to produce their biomass.

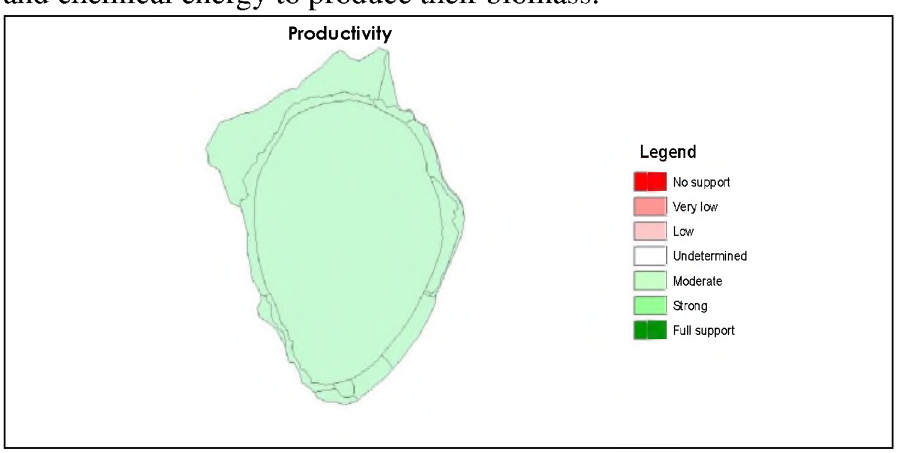

Figure 18. Functional Assessment of the Food Web Support - Productivity component of Doirani wetland

Productivity assessment shows that grassland and aquatic vegetation as well as human induced vegetation are present. Additional nutrients are added both indirectly and directly into the assessment area and this causes a low degree stress as a result of agriculture, recreational activities and untreated domestic sewage (Figure 18).

Ecological function: Productivity

Related value(s)	Rationale
Biodiversity Fishing	Biomass production is high in the Assessment Area, enhancing biodiversity in general, as well as fish populations.

On a second stage the method assesses the import and export of biomass which can either support the food webs of the wetland or support other food webs elsewhere respectively. Macro invertebrates, birds and mammals represent the main way of biomass import by means of migration, harvesting, defecation and death (Figure 19). Due to some differences on the environmental conditions (dense vegetation, small inlet) the FAPs resulted that this function is performed at a higher level compared to the rest (Fig 19).

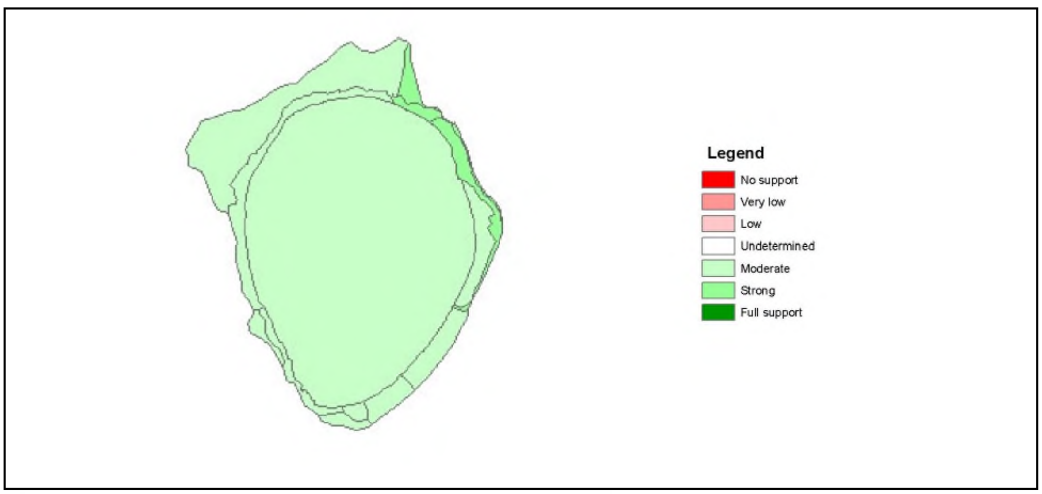

Figure 19. Functional Assessment of Biomass Import via Biological processes

Ecological function: Biomass Import

Related value(s)	Rationale
Biodiversity Fishing	Biomass import through biological processes is relatively high in the AA, supporting biodiversity. Wetland value as regards fishing is also supported.

After all the controlling processes and the functions in the AA have been assessed we may say that of hydrological functions those of groundwater discharge and recharge need to be restored. The restoration of these functions will then result to the enhancement of biological functions. Concrete mitigation measures should be proposed on a following phase of the project.

CHAPTER 6. EVALUATION OF WETLAND VALUES

6.1. Introduction

Wetland values include all commodities and services provided by wetlands to mankind. These values may either be directly exploitable, such as drinking and irrigation water, or indirectly beneficial, such as biodiversity, opportunities for recreation, scientific study, and education (Gerakis P.A. and E.T. Koutrakis 1996).

Whether direct or indirect, wetland values derive from wetland functions. The existence of a wetland value is strongly related with the degree of performance of its associated wetland functions. It is also noteworthy, that the levels of values and the degree of their use by humans may substantially change even from one year to another.

The evaluation of the wetland values for Lake Doiran is presented below.

6.2. Evaluation of wetland values

6.2.1. Recreation

The beauty and the diversity of animal and plant life in many wetlands make them ideal locations for tourists. Many sites in the Mediterranean are able to generate considerable income from tourist and recreational uses contributing significantly in some countries revenue. Recreational activities associated with wetlands, include fauna and flora watching, water sports, hunting, walking etc.

According to Bojadzieski & Vekic (2001), tourism at Lake Doiran may be divided into three periods:

- 1965 to 1981, characterised by intensive construction of accommodation facilities;
- 1981 to 1991, a very successful period with respect to the number of visitors, overnight stay, and economic benefits;
- 1992 to the present, characterised by a collapse in the tourist industry as a result of the decrease in lake water level and the political transition of the country.

A relative analysis for the period 1981 to 1998, reveals that the Municipality of Star Doiran was one of the FYROM's "10 most successful municipalities in tourism activity" (Katsavouni and Petkovski 2004).

Tourism in the Greek part is not developed at all. It is only during the last 5 years that the local municipalities initiated plans to attract tourists interested in the natural values of the area. It is indicative that the Municipality of Doirani has under construction a Museum of Natural History and other environmental interpretation structures for the Doirani Area. Additionally, a horse farm exists for riding around the lake.

Wetland functions related to this value are: Groundwater discharge, Sediment retention, Bird support and Habitat support.

The Recreation Value is evaluated as "Low".

6.2.2. Fishing

The fishing value of a wetland depends a) on the complexity of the food web, b) relationships between predator – prey and c) the trophic level of the water body. Human activities (excess-fishing, untreated wastewater discharge etc.) may negatively influence this value. The existence of breeding areas, open water areas, as well as areas providing protection during winter, are prerequisites for the existence of commercial fish populations in a wetland (Tsiouris et al. 1991).

Fisheries have always been the major economic activity for both countries. In the past, the lake was reported (in world scientific literature) as one of the most productive lakes in Europe, playing an important role in supplying the local human population with fish. Average annual catch, represented 50% of the total national catch for the FYROM (prior to the initiation of more intensive construction of artificial fishponds). From 1946 to 1986, average annual catch decreased from 529 tn to 323 tn and further to 193 tn by 1989, in FYROM. In the years following 1990, it was reduced to 70 tn and dropped to only 25 tn in 2002. Furthermore, the composition of the fish catch has also been changed markedly (Katsavouni and Petkovski 2004).

The considerable decrease of fish yield over the past 40 years poses a serious problem for the local economy. Lake water level decrease and the deterioration of water quality, had a negative impact on fish stocks.

Measures related to the increase of the Lake's water volume and the preservation of water of good quality, are judged as crucial, as regards the enhancement of this value.

Wetland functions related to this value are: Groundwater discharge, Habitat support, Fish support, Plant support, Productivity, Biomass Import

The Fishing Value is evaluated as "Low".

6.2.3. Ecological value

The ecological value of wetlands stems mainly from three functions biodiversity support, wildlife habitat provision and food web support. It is in many cases regarded as the most significant benefit provided by a wetland as it is related to a lesser or higher degree to most other wetland functions. Lake Doirani has a high potential of ecological value, however, there are signs of severe threat and degradation of the natural environment. The remains of the old ash-elm-oak woods and four habitat types from Annex I of the Habitats Directive reflect its value for provision of food, shelter and nesting for animals, breeding grounds for various resident and migratory birds (Katsavouni and Petkovski 2004). During the latest investigations made by Levkov & Stojanovski (2002) 139 diatom taxa were detected in contrast to 257 taxa previously recorded (Katsavouni and Petkovski 2004).

Wetland functions related to this value are: Groundwater discharge, Sediment retention, Habitat support, Invertebrate support, Herpetiles support, Bird support, Fish support, Plant support, Productivity, Biomass Import

The Biological Value is evaluated as “Moderate”.

6.2.4. Protection against floods

Most of the wetlands may provide protection against floods for downstream or adjacent agricultural and urban areas, by retaining floodwaters in the surface waters of lakes, marshes etc. or by storing the water in the soil. Additionally, wetland vegetation plays a key role in this, by reducing the velocity of floodwater during a high flood event.

According to historical information, floods occurred in the past, when high water levels were prevailing in the lake. Nowdays the potential of the lake to mitigate floods has been improved due to the drop of its water level and the subsequent enhancement of its ability to retain floodwaters during flood events.

A wetland function related to this value is the Floodwater retention.

The Protection Against Floods value is evaluated as “High”.

6.2.5. Water for irrigation

The largest portion of either natural or manmade wetlands is used in a higher or lower degree, for irrigation purposes. Unwise use of irrigation water is one of the main reasons of wetland degradation.

Even though surface water of Lake Doiran is appropriate for irrigation it is not used for such purpose. In fact the present value is the result of the performance of the Groundwater recharge function.

The functional evaluation showed that the groundwater recharge function is being performed or has the potential to be performed to strong degree only through the peripheral HGMUs. As far as the lake water level remains low, then its value of providing water for irrigation will also remain moderate to low.

Hence, the Water for Irrigation value is evaluated as “Moderate to Low”. Of course this is a theoretical way to look at this matter, because in practice due to the present condition of the lake (very strong stress from the drop in the water level), it makes no sense at all to consider any pumping of lake water for irrigation.

6.2.6. Scientific value

Biodiversity appoints wetlands as attractive areas for research (including several scientific expertises). Both qualitative and quantitative issues of lake Doiran are of high scientific importance in our days taking into account the degradation of the lake’s ecosystem. Additionally, the wise management of trans-boundary water bodies has been set as a high priority by both countries, as well as by European Union legislation (Official Journal of the European Communities 2000).

Almost all the functions are related to this value which is evaluated as “High”

6.2.7. Water quality improvement

Wetlands have the ability to improve the quality of the water entering them, through the performance of the hydrological and biochemical functions. It has to be noted that this value (which in turn drives to the improvement of other values) should not be enhanced for the treatment of municipal wastewater.

Lake Dorian has long been characterized as a eutrophic natural lake. Recent events, however, particularly the decline in water level due to a prolonged dry period and anthropogenic impacts, have begun to accelerate the lake toward a higher eutrophic state (Katsavouni and Petkovski 2004).

Wetland functions related to this value include: Groundwater discharge, Sediment retention, and Biogeochemical functions (nutrient export and nutrient retention).

Taking into account the results of the functional evaluation the Water quality Improvement value is evaluated as “Moderate to Low”.

CHAPTER 7. PROPOSED RESTORATION MEASURES

TITLE

Environmental friendly agricultural practices

OBJECTIVE

The objective of this measure is to promote/increase the application of environmental friendly agricultural practices, for water saving and environmental protection purposes.

RATIONALE

As regards the Greek part of the watershed, irrigation water demand is covered mainly by groundwater (pumping wells) and only partially by surface waters. More specifically, the Greek lowlands adjacent to Lake Doiran (about 2,430 hectares) are irrigated by means of some 300 groundwater pumping wells [or 270 according to a study for the development of Lake Doiran (Nikolaidis et al. 2001)]. The estimate for annual groundwater extraction for irrigation is believed to be approximately 12.2×10^6 m^3/year.

Similarly, groundwater in FYROM is used for domestic as well as for agricultural use and it is mainly pumped from the north-eastern aquifer (near the village of Nikolich - Asanlisko Plain). There are also two groups of wells close to the lake, one at Mrdaja and one at Deribas. The total annual groundwater extraction capacity within the FYROM part of the catchment area, is estimated to be 5.7×10^6 m^3. Of this amount, about 50 % or 2.84 $\times 10^6$ m^3 is currently being used by all sectors combined. The portion of the groundwater extraction capacity currently used for irrigation now amounts to only 350,000 m^3 per year.

Although it is well known that surface water use for any purpose in the catchment affects the Lake's water level, the question arising is whether groundwater exploitation affects it as well, or not. Within the framework of the present project, EKBY has elaborated a relevant investigation, which was based on available (although limited) data and on the use of a specialized software for the simulation of the lake's hydroperiod. The software that was used (MIKE SHE - Danish Hydraulic Institute) is a fully distributed, physical based, finite difference hydrological modeling system, that simulates the hydrology of a catchment, taking into account all the elements affecting the hydrological cycle. The simulation procedure included the following steps:

1. Setting up the conceptual model of the catchment, including the Digital Elevation Model, soil types, geology, hydrographic network, land uses as well as meteorological data of the catchment.
2. Simulation of the lake's hydroperiod and validation of the results, based on existing water level data and according to three scenarios described below. It has to be mentioned that the only period with regularly monitored and without gaps daily rainfall data, was the period 1987-1992 that represents the main period for the simulation and validation. The daily rainfall data were acquired by the Doirani station.

   The three simulation scenarios examined, were the following:

   Scenario 1: Simulation for the period 1987 – 1992, according to a) the prevailing irrigated areas, b) reduction of the irrigated areas by 10%, c) reduction of the irrigated areas by 30%, d) no irrigation in the catchment. Simulation results are presented in Figure 1.

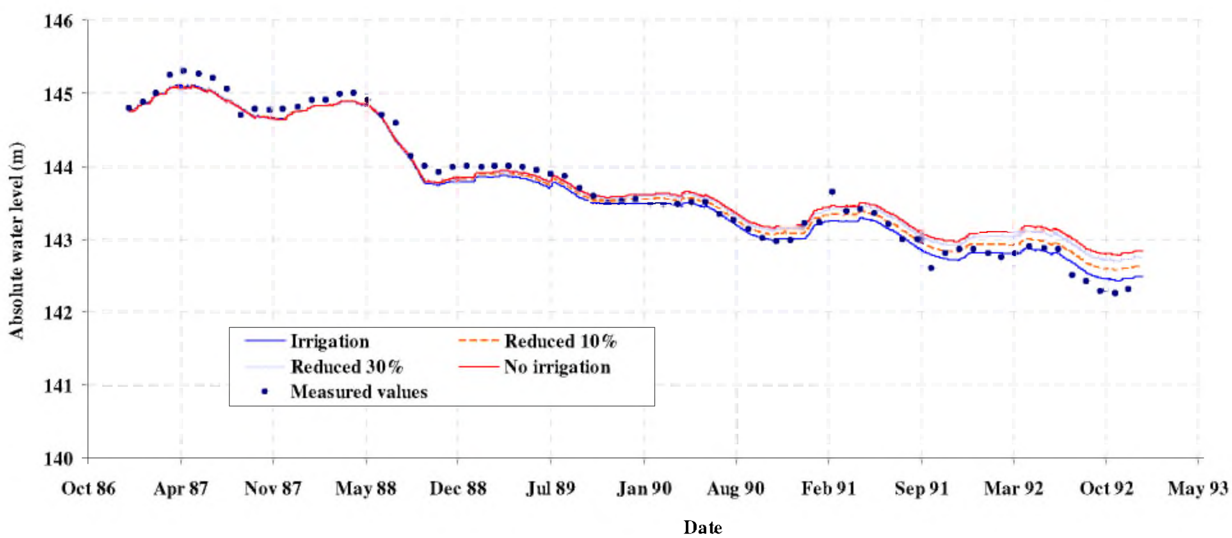

Figure 1. Simulation results according to Scenario 1

The following Figure 2 presents the correlation between the absolute water level and the flooded area, by which it may be noted that the lake covers approximately $1.87 \cdot 10^7$ m^2 and $1.99 \cdot 10^7$ m^2 according to scenarios 1a and 1d respectively.

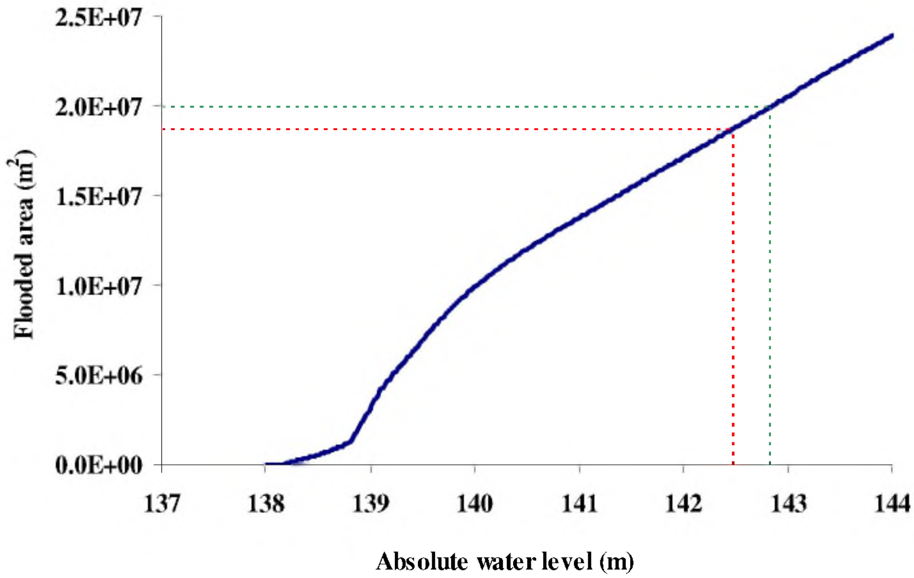

Figure 2. Flooded area, according to scenarios 1a and 1d

Scenario 2: Simulation for the period 1993 – 2003, according to a) the prevailing irrigated areas and b) no irrigation in the catchment. According to this scenario, and since daily meteorological data were not available, it was assumed a mean annual precipitation rate of 560 mm (the same time series was used for each year of the examined period). Simulation results are presented in Figure 3.

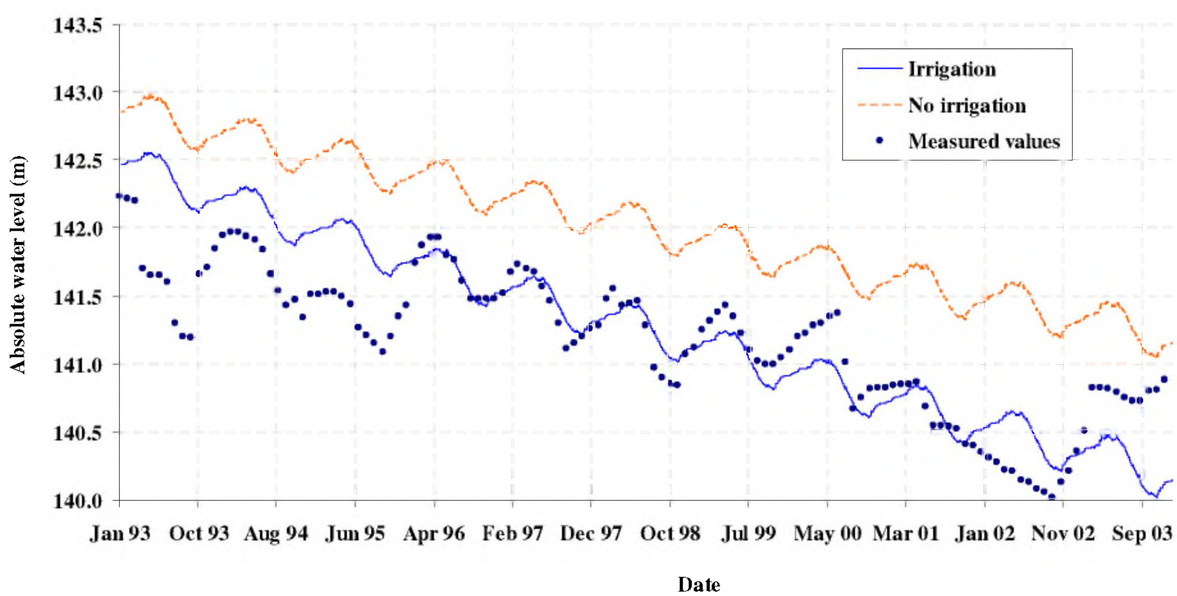

Figure 3. Simulation results according to Scenario 2

The following Figure 4 presents the correlation between the absolute water level and the flooded area, by which it may be noted that the lake covers approximately $1.10 \cdot 10^7$ m^2 and $1.43 \cdot 10^7$ m^2 according to scenarios 2a and 2b respectively.

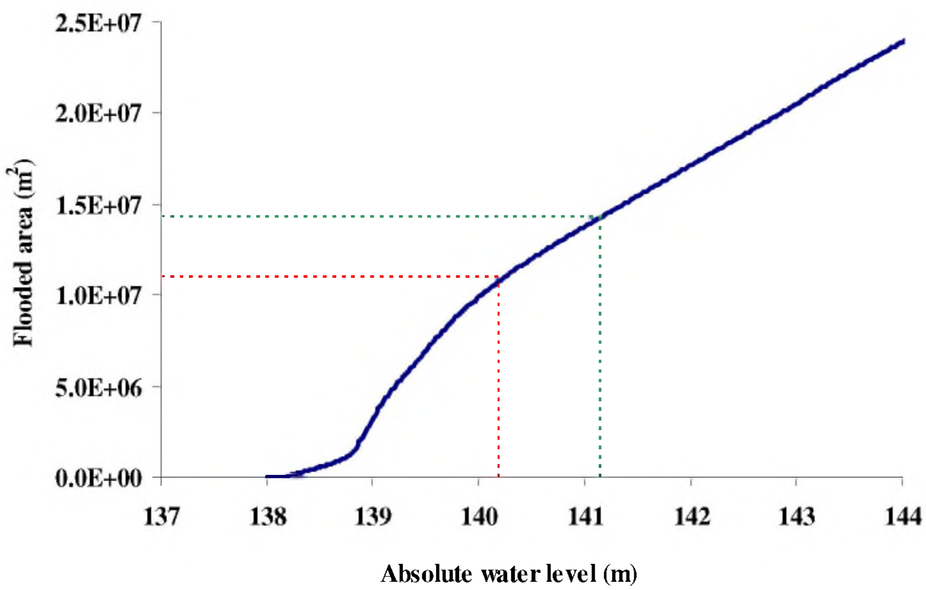

Figure 4. Flooded area, according to scenarios 2a and 2b

<u>Scenario 3</u>: Simulation for the period 1987 – 1992 was based a) on the prevailing irrigated areas and b) taking into account a constant water inflow discharge into the lake of 0.25 m^3/sec (representing the transportation of water from 10 wells in the area of Gjavato, near the Axios (Vardar) River, via a hydro-system of two stage pumps and a 20 km pipeline). Simulation results are presented in Figure 5.
Figure 6 presents the correlation between the absolute water level and the flooded area, by which it may be noted that the lake covers approximately $1.80 \cdot 10^7$ m^2 and $2.29 \cdot 10^7$ m^2 according to scenarios 3a and 3b respectively.

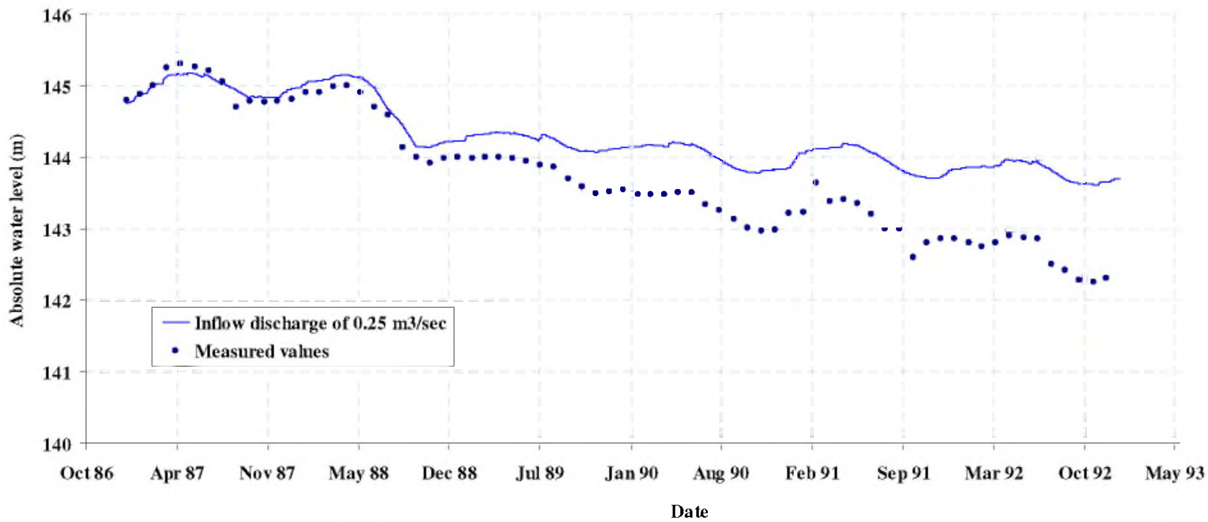

Figure 5. Simulation results according to Scenario 3

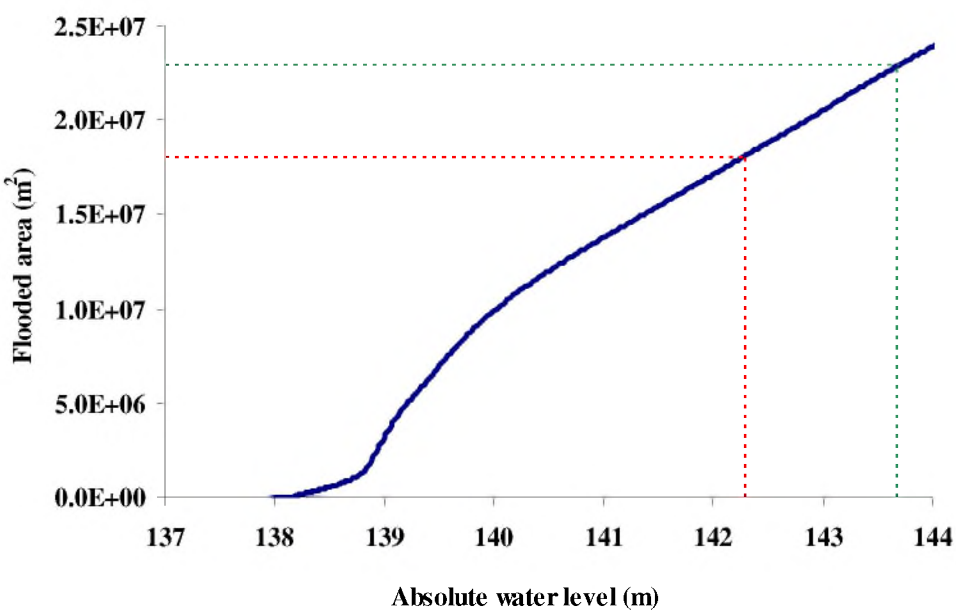

Figure 6. Flooded area, according to scenarios 3a and 3b

The results of Scenario 1 (Figure 1) show that the examined scenario with no irrigation in the catchment resulted in the raise of the water level at the end of year 1992 (compared with the irrigation scenario), by approximately 40 cm. Furthermore, the other two examined scenarios (reduction of the irrigated area by 10% and 30%), show a relevant water level rise (by 0.15 m and 0.3 m respectively, compared with the irrigation scenario).

The results of Scenario 2 (Figure 3), show that the examined “no irrigation” scenario, resulted in the raise of the water level at the end of year 2003 (compared with the “irrigation” scenario for the same period), by approximately 1m.

The results of Scenario 3 (Figure 5) show that a constant water inflow discharge into the lake of 0.25 m^3/sec for the period 1987 – 1992 (taking into account the prevailing irrigation scheme), resulted in water level increase of approximately 1.4 m at the end of year 1992.

From the above, one concludes that:

a) Irrigation affects the lake’s water level (reduction of the irrigated area by 10%, 30% and 100% (no irrigation), shows a relevant water level rise by 0.15 m, 0.3 m and 0.40 m respectively, compared with the irrigation scenario).
b) Even in the case of no irrigation in the catchment, water level drops following the same general trend observed in the cases of irrigated scenarios. This shows that the lake’s hydroperiod is mainly affected by the prevailing environmental conditions (precipitation and temperature).
c) The transportation of water from an external source, positively affected the lake’s water level.

DESCRIPTION

The present restoration measure will include the following agro-environmental practices:

1. Implementation of an agro-environmental measure aiming at the reduction of the total irrigated area, by at least 30%. This may be achieved through the replacement of irrigated crops by non irrigated ones or by expanding the fallow areas or both. The measure should be applied to the areas adjacent to the lake.

2. Public awareness concerning the use of water saving irrigation techniques and farmers training. Proper irrigation scheduling should be part of the training for the farmers and for water users' associations in the region.
3. Setting up of experimental fields where water saving techniques can be applied. Additionally, establishment of a meteorological station for the collection of data and further calculation of evapotranspiration in the cultivated areas.
4. According to the results of Scenario 3, water transportation from an external source to Lake Doiran at a rate of 0,25 m^3/sec, is estimated to lead in approximately 1,4 m rise in the water level (at the end of the examined period). In the last years, FYROM transports water from 10 wells in the area of Gjavato, via a hydro-system to the Lake. It is noted that in case of water transportation from an external source to Lake Doiran, an Environmental Impact Assessment should precede, taking into account its transboundary character and according to the relevant provisions of national, European Union and international legislation.

REQUIREMENTS

- Relevant calls in each country, regarding financial support to expand fallow land in the catchment.
- Call in each country, regarding financial support for the conversion of the existing irrigation techniques to water saving techniques
- A campaign to promote the training of farmers on the advantages of using drip irrigation. The campaign will also include the production of leaflets and training material.
- Experimental plots with drip irrigated vegetables and maize and microsprinkler irrigated orchards equipped with equipment for irrigation scheduling
- A mini-meteorological station with the capacity to estimate evapotranspiration.

PROVISIONAL COST

The financial support for fallow application, will cost approximately 600 €/ha/year.

The cost for setting up experimental plots in private farmers' fields will be about 5,000€/ha for the cultivation and 2,000 to 5,000 €/ha for the application of drip irrigation. The cost for one mini-meteorological station is about €8,000.

The cost for raising the environmental awareness and irrigation training of farmers, water users' associations and the extension service will be about €15,000.

PROPOSED FUNDING MECHANISM

In FYROM, part of the source for financing can be the Program for the support of agriculture and part from the support of water management. There is allocated money for training and for modernization of irrigation.

In Greece, the potential funding mechanisms may be associated with a) the Planning for Rural Development – EPAA (Hellenic Ministry of Rural Development and Food), b) the Regional Operational Programs for the period 2007-2012 (Region of Central Macedonia), through the incorporation of relevant measures specifically for the Doiran lake and c) the Financial Instrument of the European Economic Area.

PRIORITY

High

TITLE

Wastewater treatment facilities

OBJECTIVE

To elaborate the appropriate studies and construct the required facilities/technical works, for municipal and industrial wastewater treatment in the Doiran catchment.

RATIONALE

Lake Doiran has long been characterized as a eutrophic natural lake. However, recent events, particularly the decline in water level due to anthropogenic impacts and a prolonged dry period, have begun to accelerate the lake toward a higher eutrophic state.

Taking into account the need for achieving a good chemical and biological status in the Lake's waters, the establishment of sewage networks and construction of wastewater treatment facilities should proceed.

As far as the current situation concerns, regarding wastewater treatment facilities in the Doiran catchment, the situation is as follows:

FYROM

A sewage collecting network and a municipal wastewater treatment plant exist (part of it since 1989), consisting of:

- A Wastewater Treatment Plant (WWTP) in Toplec, with a maximum capacity of 12,000 equivalent inhabitants. Currently, the WWTP treats a percentage of approximately 25% of the municipal wastewaters produced in Star and Nov Doiran villages, due to the absence of full sewage collecting systems in these two villages. The treated wastewaters are pumped with a maximum capacity of 160 lit/sec, and further discharged (via an existing pipeline having a total length of 2,250 m and diameter of 350mm) out of the Doiran catchment, to Luda Mara River (Anska Reka catchment).
- A sewage collecting system including 9 pumping stations, for the transfer of raw wastewaters from the Mrdaja village to the Nov Doiran village (and further to the Toplec WWTP). The system consists of PVC pipes with a total length of 8,230 m and diameters between 250 mm and 500 mm.

Excluding the Nicolic village, all major tourist facilities are already connected to the existing wastewater sewage collecting system. Operation and maintenance costs are covered by relevant service fee collection.

As regards the Nikolic village, which presently has no sewage network, the appropriate technical studies for its construction are ongoing and are expected to be completed during summer 2005.

GREECE

On the Greek side (villages of Akrita, Amaranta, Agia Paraskevi, Mouries, Myriophyto and Mouries RS), septic tanks are used for the collection and treatment of wastewaters at the household level. Only in the village of Drosato (1,392 inhabitants in year 2001 - approximately 33.1% of the total population in the catchment), a wastewater sewage collecting system and a constructed wetland have been established for that purpose, which will start operating in winter 2005.

It is noteworthy that both sides may examine the use of constructed wetlands, since (for various reasons) these systems are ideal for small municipalities, have low maintenance cost and high treatment potential. Additionally, the potential of establishing plants for the treatment of industrial wastewaters in FYROM should be investigated for those industries affecting Lake Doiran and lacking such facilities.

DESCRIPTION

The present proposed measure, includes the following:

FYROM

1. Construction of a sewage collecting system, for the transfer of municipal wastewaters from Nikolic to the Topletc WWTP (total length of approximately 6 km).
2. Construction of a sewage collecting system in Nikolic, for the collection of the produced municipal wastewaters (approximately 150 housholds).
3. Completion of the existing sewage collecting systems in Nov Dojran and Star Dojran (for approximately 1000 households and weekend houses).
4. Study regarding the investigation of industrial wastewaters affecting Lake Doiran.
5. Elaboration of reuse studies, regarding the use of treated wastewaters for irrigation purposes.

GREECE

1. Elaboration of the required technical studies (according to Greek legislation), for the construction of a) sewage collecting systems and b) constructed wetlands, in the villages of Akrita, Amaranta, Agia Paraskevi, Mouries, Myriophyto and Mouries RS.

2. Construction of the above mentioned, under point 1, facilities (i.e. sewage collecting systems and constructed wetlands).
3. Elaboration of reuse studies, regarding the use of treated wastewaters for irrigation purposes.

REQUIREMENTS

Studies with realistic cost estimates regarding completion of the municipal wastewater collection system in FYROM, already exist. Detailed studies have to be completed.

The study related to industrial wastewater treatment in FYROM, should include an investigation regarding the status of industrial wastewater treatment of those industries functioning in the Doiran catchment and conclude in appropriate proposals regarding this field.

As far as the proposed constructions in Greece is concerned and according to Greek legislation, the procedure required to obtain permission for major constructions involves the elaboration of the following studies:

1. Siting Approval.
2. Environmental Impact Assessment
3. Final technical study.

More specifically, after Siting Approval, the submission of an Environmental Impact Assessment follows for approval of Environmental Terms. The final technical study is then elaborated, allowing the construction of the constructed wetlands.

PROVISIONAL COST

FYROM[1]

1.	Sewage collecting system (Nikolic to Toplec WWTP):	450,000 €
2.	Sewage collecting system in Nikolic:	230,000 €
3.	Sewage collecting systems Nov Dojran and Star Dojran:	500,000 €
4.	Industrial wastewater study and detailed design elaboration	125,000 €
	Provisional cost (FYROM)	1,305,000 €

GREECE

1.	Studies ellaboration:	125,000 €
2.	Sewage collecting systems[2]:	8,000,000 €
3.	Constructed wetlands establishment:	680,000 €
	Provisional cost (Greece)	8,805,000 €
	Total provisional cost	10,110,000 €

[1] Estimated by the Water Development Institute (FYROM)

Approximately 2,000 € for each reuse study.

PROPOSED FUNDING MECHANISM

As regards the collecting system for the transfer of municipal wastewaters from Nikolic to the Topletc WWTP, the possibility exists that it could be partly funded from the CARDS 2003 Programme *Improvement Of Management Of Trans-Boundary Water Resources* with two components: (1) Dojran Lake[3] and (2) Water Quality Management In River Vardar Catchment, to be implemented by European Agency for Reconstruction (EAR). For the other proposed measures the funding has yet to be investigated.

For FYROM, funding may be asked from the national budget and from international technical and financial aid. For this, detailed project designs have to be elaborated, and the Municipality of Star Dojran is actively working on these issues.

For Greece, possible funds may be searched for in the EU environmental funds and mechanisms, as well as on the local (Municipality Doirani) and regional level (Prefecture of Kilkis and Region of Central Macedonia).

PRIORITY

High

[2] Includes estimated cost for studies and construction. The estimation was based on the population of the Greek villages in year 2001.

[3] Dojran Lake: The project will assess causes and level of water quality degradation of Lake Dojran. It will also provide an economically feasible concept for completing the existing wastewater collection network of the principal communities bordering the lake. Additionally, the project will carry out a comprehensive diagnostic study of Lake Dojran encompassing an assessment of the hydrology, ecology and risks posed by present lake and catchment management practices. This study will inform the establishment of a joint catchment area and lake management plan (*Source: EAR/2003/21/62*)

TITLE

Monitoring of water quality and quantity

OBJECTIVE

The continuous and coherent monitoring of lake's Doiran water quality and quantity.

RATIONALE

Any restoration measure dooms to fail, in the absence of a monitoring system. A well designed and well functioning monitoring system may act as the basis for the judgment of the success/failure or the need for alteration of a restoration measure. Furthermore, lake Doiran's drop in water level significantly affects its physico-chemical and biological quality elements. The establishment of a monitoring system, that will provide continuous data to both countries, is thus considered necessary.

DESCRIPTION

Monitoring will be carried for parameters indicative of the biological, hydromorphological and general physico-chemical quality elements, most sensitive to pressures to which lake Doiran is subject.

Taking into account the requirements of the European Water Framework Directive (60/2000/EC), the monitoring program shall include at the minimum, the following parameters:

Surface waters

- Lake's Doiran water level.
- Discharge (for the streams inflowing lake Doiran on a regular basis).
- Physicochemical water quality data (NH_4-N, NO_2-N, NO_3-N, PO_4-P, Dissolved oxygen, Biochemical Oxygen Demand, pH, Electrical conductivity, Turbidity and Visibility-Secchi disk)
- Biological quality elements.

Groundwaters

- Fluctuation of the groundwater table

The monitoring system should also include measurement of meteorological parameters in the watershed (i.e. air temperature, precipitation, relative humidity, solar radiation, wind velocity – direction, barometric pressure and evaporation).

Furthermore, and given that the area of Lake Doiran has been designated as a Special Protected Area, the monitoring system shall include monitoring of birds dependent on water.

REQUIREMENTS

In order the surface water – groundwater monitoring to be performed, the following equipment should be established:

Surface waters

- Automatic water level recorder. The recorder should be equipped with the appropriate system for the wireless data transfer to both countries and the appropriate software for the data download. The data will be downloaded by the pertinent authorities responsible for water management in each country. In that sense, both countries will be able to have real time data of the lake's water level.
- Construction of an overspill and establishment of an automatic water level recorder, for the continuous calculation of water quantities inflowing the lake. This system should be established to those streams inflowing lake Doiran and having permanent or semi-permanent flow. It should also be supplemented with the appropriate system for the wireless data transfer and download by the pertinent authorities.
- Water sampling and analysis. Once a month, water samples should be collected and chemically analyzed (with jointly acceptable methods) for the parameters mentioned above. The water sampling and analysis should be proceeded at the same day by both countries and the results should be communicated to the other part. Supplementary sampling and analysis should be performed in case of specific reasons (accidents etc), and mitigation methods should jointly be discussed.

  Additionally, the acquisition of two polyparametric water quality recorders (one for each country) for in situ measurements of temperature, electrical conductivity, pH, dissolved oxygen and Turbidity, is considered necessary.

Groundwaters

- Establishment of automatic groundwater level recorders, in drills that will be constructed specifically for that purpose. Their exact locations should be selected according to the spatial distribution of the main groundwater bodies of the watershed. According to an estimation made during the implementation of the present project, 6 monitoring drills (at the minimum) are required (3 drills of approximately 30 m depth and 3 drills of approximately 120 m depth). As in the case of the surface water level monitoring system, the automatic groundwater level recorders should be supplemented with the appropriate equipment for the wireless data transfer and download by the pertinent authorities.

As far as the meteorological data concerns, it is proposed the following:

- Establishment of 2 automatic meteorological stations in Greece (including the system and software for the wireless transfer and download by both countries). The first station shall be established on the plain part of the watershed and shall measure all the above mentioned parameters that will allow the calculation of the potential evapotranspiration with the use of the Penman-Monteith method. The second station shall be established on the mountainous area, and shall measure only Precipitation, Temperature and Evaporation, that will allow both runoff calculation and potential evapotranspiration with the use of the Thornwaitte method.
- Establishment of the appropriate equipment for the wireless transfer and download (by both countries) of the meteorological data from the stations in Mrdaja and Star Dojran (FYROM).

With regard to biological quality elements, phytoplankton is the most sensitive to pressures. The specifications for the phytoplankton monitoring program for lake Doiran, is codified below:

- Parameters : Species composition, abundance and biomass
- Number of sampling stations : 3 – 5
- Number of sampling depths : 1 integrated sample
- Sampling period : Whole year
- Sampling frequency : Seasonally (bimonthly during summer)
- Method : Nanser sampler, inverted microscope method (Uteröhl 1958)[(1)]

Finally, the specifications for the birds monitoring program for lake Doiran are codified below:

- Parameters : Species composition and abundance, habitats requirements, conservation status
- Observation period : During reproduction (March to June), migration (spring and autumn) and wintering periods depending on the seasonal occurrence of species.

[(1)] Utermöhl, H. 1958. Zur Vervollkommnung der quantitativen Phytoplankton - Methodik. Mitt. int. Verein. theor. angew. Limnol., 9:1-38.

- Observation duration : Twenty to thirty days.
- Method : The method applied by Birdlife International, during the update of Important Bird Areas (Heath et al. 2000)(2) or comparable to that.
  For field work, the methods cited in Bibby et al. (1992) and Gilbert et al. (1998)(3).

PROVISIONAL COST

Physicochemical – Hydrological monitoring

- 60,000 € for equipment acquisition and establishment.
- 6,000 € per year for water chemical analysis.
- 95.000 € for 6 monitoring drills.
- 3,500 € per automatic groundwater level recorder.

Biological quality elements

2,000 € per sample

Birds monitoring

7,000 €/year

PROPOSED FUNDING MECHANISM

Hellenic Ministry of Foreign Affairs – Hellenic Aid. It funds humanitarian and development assistance projects in certain developing or under developed countries. New project applications may be submitted each year, on the condition that they fall into the priorities for that year.

INTERREG Greece – FYROM. It is a Community initiative, which aims to stimulate interregional cooperation in the EU between 2000 and 2006. It is financed under the European Regional Development Fund (ERDF). The Operational Programme Interreg III Greece - Former Yugoslav Republic of Macedonia 2000-2006 was approved by the European Union by the Decision No. E (2002) 118 /19-03-2002. Priority axis 3.3. is entitled “Protection, promotion and management of natural environment”.

PRIORITY

High

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(2) Heath, M.F., M.I. Evans, D.G. Hoccom, A.J. Payne and N.B. Peet. 2000. Important Bird Areas in Europe. Priority sites for conservation. Birdlife Conservation Series No 8.

(3) · Bibby, C. J., N.D. Burgess and D.A. Hill. 1992. Bird Census Techniques. Published for BTO and RSPB by the Academic Press, London. 257 pp.

· Gilbert, G., D.W. Gibbons and J. Evans. 1998. Bird Monitoring Methods. RSPB, The Lodge, Sandy, Bedfordshire, UK. 464 pp.

TITLE

Study regarding the fish fauna in Lake Doiran

OBJECTIVE

To set the basis for sustainable fisheries management.

RATIONALE

Fisheries in Doiran Lake have always been a major economic activity for both countries. The most significant fish in economic terms are the roach (*Rutilus rutilus*), bleak (*Alburnus alburnus*) and carp (*Cyprinus caprio*). The other fish species within the lake contribute only insignificantly to the total fish catch. The average annual catch dropped from 529 tonnes in 1946 to only 25 tonnes in 2002. Furthermore, the composition of the fish catch and the location of the fish nurseries grounds have changed. Further to the impacts on fishfauna itself, this considerable decrease of fish yield over the past 40 years poses a serious problem for the local economy.
It is thus necessary for both counties to proceed on the elaboration of a research study regarding the current situation on fishfauna with emphasis on commercial fish (composition, abundance, age structure, nurseries grounds), including a) an estimation of the fish parameters of Lake Doiran, b) proposals for fisheries management in order to regulate the fishing activity and c) other management measures if necessary.

DESCRIPTION

1. <u>Literature review</u>

The study should examine the ecology of the fish fauna of the lake, focussing on the commercial fish; the carp, the roach and the bleak (habitats, feeding habits, growth parameters, reproduction and fecundity etc).

2. <u>Recording of fisheries parameters</u>

This will include fishing methods and gear, number of fishermen active, boats and existing works

3. <u>Assessment of relative abundance of the above commercial fish</u>.

4. <u>Identification of the period and reproduction location of the main species</u>.

5. <u>Proposed management measures for the conservation and sustainable fisheries management</u>.

<u>Report</u>

A report should be delivered with the findings of the above research and a map of the nurseries grounds. The report should conclude with management proposals regarding:

a) fisheries management, i.e. technical specifications for the fishing activities in order for the fishing yield to be sustainable such as fish gear, mesh size, time of year, duration, maximum yield for each of the three fish and

b) other management measures specifically oriented to fish populations

REQUIREMENTS

This study should be undertaken by fish experts and can be completed within 18 months.

PROVISIONAL COST

100,000 Euros

PROPOSED FUNDING MECHANISM

Hellenic Ministry of Foreign Affairs – Hellenic Aid. It funds humanitarian and development assistance projects in certain developing or under developed countries. New project applications may be submitted each year, on the condition that they fall into the priorities for that year.

INTERREG Greece – FYROM. It is a Community initiative, which aims to stimulate interregional cooperation in the EU between 2000-06. It is financed under the European Regional Development Fund (ERDF). The Operational Programme Interreg III Greece - Former Yugoslav Republic of Macedonia 2000-2006 that was approved by the European Union by the Decision No. E (2002) 118 /19-03-2002 includes priority axis 3.3, which is entitled “Protection, promotion and management of natural environment”. For the period 2007-2012 relevant measures could be incorporated in the Programme.

PRIORITY

Medium

TITLE

Visitor management plan, design and establishment of environmental interpretation facilities in Lake Doiran

OBJECTIVE

The objective of this measure is to set the basis for sustainable tourism in Lake Doiran, to promote the biological, recreational, educational and aesthetic values of the lake and to raise economic benefits for the local communities.

RATIONALE

Protected area tourism depends on the quality of the natural and cultural resources of the area. The impact of tourism on these resources must be carefully managed, directed and mitigated wherever possible. Even small levels of recreational use can lead to negative impacts, and all recreational use causes some impact. The principal question in visitor planning is to determine what degree of impact is acceptable.

Lake Doiran combines the following main features: a) it is an important area for nature conservation, b) the number of visitors, mainly in the Greek side, is increasing, c) it lacks an organised framework for visitor management, information and interpretation infrastructures and services and d) the locals' appreciation of the wetland is very low.

Due to the unique landscape, the location (close to Thessaloniki and Lake Kerkini Ramsar site) and the traditional fish tavernas, Lake Doiran used to be a very popular place for diverse visitor groups. There are weekend visitors for the tavernas, some schools for environmental education activities, birdwatchers, scientists and nature lovers, etc.

At Lake Doiran although the last years the visitors increase, there are limited "commercialized" services and infrastructures, lacking various important features and there are no economic benefits for the locals. These services have been developed without planning, and landscape quality is being degraded. Only basic services are being provided. Most of the visitors, just visit tavernas and the very close surrounding area. Public awareness and interpretation on the importance of the area is absent. Another important issue regards the management responsibilities, since various bodies have jurisdiction in the area, a fact causing difficulties in decision making on management issues.

It is thus necessary for both countries to proceed to the elaboration of a visitor management plan, design and establishment of environmental interpretation facilities.

DESCRIPTION

A. Visitor management plan

The main goal of the visitor management plan in Lake Doiran will be to improve the conservation of the lake, to enhance the quality of life of the local community, to improve the "tourism" product and services. As all management plans, this will define guidelines and priorities for measures to be taken for the effective visitor management. It will include a time schedule of the activities to be undertaken, cost, and economic and human resources.

The visitor management plan for Lake Doiran will follow rules and specifications, such as:

1. *Definition of the visitor management specific goals and objectives.* Defining goals and objectives is the first step in the planning process and the most difficult component. They must reflect the fundamental purpose of the protected area. The potential of the Lake Doiran visitor development depends on its main conservation and sustainable management goals and objectives. So the goals which will be stated in the visitor management plan reflect the importance attached to attributes of Lake Doiran by various interest groups, and interpret the legislation or decree establishing the protected area. The objectives will have the following characteristics: output oriented, time bound, specific, measurable and attainable.

2. *Analysis of visitation characteristics (number of visitors, typology, preferences and requirements, etc.),* analysis of the visitors' profiles, of the present patterns of visitation and their impacts on the area, of the expectations of the visitors and the degree to which they are met. We will try to segment visitors: by socio-demographic characteristics (e.g. variables such as age, sex, occupation, origin, income level, level of education), by geographic characteristics (e.g. origin, distance from site, whether local visitors or national/international travelers), by psychographic segments (e.g. some of them might be considered escapers who look for adventure, while others might be considered green and actively seeking environmentally sensitive services), by active participation (taverna visitors, birdwatchers), by frequency of visiting (frequent visitors, repeat visitors, first time, etc), by perceived product benefits (extreme sports while others might expect to learn about nature). The value of segmentation is to predict behavior, so to plan in a better way.

3. *Stakeholder analysis and public participation.* Protected area-based tourism has many stakeholders. Each group has its own particular values and objectives and this complex mosaic of stakeholder interests makes constant demands upon visitor management. The groups, who have a direct interest in, and are affected in different ways by, visitor management policies, in Doiran, can include in both countries: local

communities, local authorities, decision makers, relevant public services, ministries, landowners, profit-making private sector, NGOs, visitors and users, fishermen, small industries, schools, research bodies, media, etc. The identification of stakeholders, the analysis of their characteristics and role in tourism development, and their active involvement, will be the objectives of this action. From the very beginning an active involvement of all stakeholders is needed, in such a way that each can contribute constructively to the various components of the process, and thus feel "ownership" of the plan. The entire decision-making process will be designed for stakeholder involvement throughout, not just added on to the process, after the fact. Consensus building is needed for acceptance, so that public resources can be allocated to implement the plan or specific measures. Therefore, development of a stakeholder participation process will be important to meet the specific needs of the area and try to avoid tokenism: to tell them we want their involvement and then only budget two weeks for it. The stakeholder participation process will have 5 phases: the early involvement (informal consultations to determine the major issues raised, estimation level of public interest, identify key individuals), initial planning (identify stakeholders, determine information exchange needs, clarify public involvement objectives), programme development (specific methods of stakeholder involvement, establishment of internal communications, commit resources, schedule and assign work), implementation (carrying out the programme, monitoring and evaluating the results of involvement), post decision public involvement (notify public of decision and how their comments were used). Some of the techniques will be used are: public information (advertising, newspaper inserts), information feedback (briefs, focus groups, stakeholder meetings, public meetings, and interviews), consultation, and negotiation.

4. Establishment of visitor management zones. These will be identified according to the main and specific visitor management objectives. The main questions that will be answered are: which part has to be protected, what is the carrying capacity for visitors of the area, how visitors' activity will be regulated, zoning regulations used to concentrate visitors in some places where the environment is less vulnerable and excluded the remaining part.

B. Design and establishment of environmental interpretation facilities

Potential and existing protected areas open to visitors require information. This varies from simple information on park location, fees, etc., to much complex interpretation of cultural history and local ecology. Interpretation goes beyond simply informing, towards developing an understanding and appreciation.

Three fundamental objectives of interpretation will be followed for the environmental interpretation facilities in Lake Doiran: to promote management goals, to support local communities, and to improve understanding of protected area. To be used as a visitor management tool, interpretation has to affect visitor's behavior and in order to do this, motivate through an appeal to human needs and emotions.

Interpretation in environmental infrastructures in Lake Doiran (such as existing ECO-Museums, proposed viewpoints, sign postings, ecotrails) will be more than presentation of data and facts, but will include weaving them together so that visitors come to understand and appreciate the values for which Lake Doiran is an important protected area.

Interpretation is required to communicate the significance of the area to visitors, and to members of the local communities, and the need of its conservation. In Lake Doiran interpretation will aim to develop awareness of, and respect for cultural and heritage values, the present-day community of the heritage, and the landscapes and cultures within which that heritage has evolved. It will be used to help develop support for the stewardship of the area.

For each of the proposed or existing environmental interpretation facilities in Lake Doiran, the design guidelines will be given, the interpretation themes will be determined; the media to present the themes will be chosen, the presentation techniques, etc.

The existing interpretation facilities are:
FYROM: 1. Eco-Museum in the Municipality of Star Dojran
Greece: 1. Eco-Museum in the Municipality of Doiran
2. Eco-trail along the lakeside.

The proposed interpretation facilities are:
FYROM: 1. Three nature trails (starting point the existing Eco-Museum)
2. Three viewpoints
3. One rest area with environmental playground and information kiosk

Greece: 1. Four nature trails (starting point the existing Eco-Museum)
2. Three viewpoints
3. One rest area with environmental playground and information kiosk

Some of the interpretation techniques which will be proposed to be used in Lake Doiran are: personal services (provide information directly to visitors by staff, information duty at park gate, trail head and visitor center, guided walks, theatre dramas, etc), non personal services (provide information directly to visitors by using technology, publications, sighs, films, internet sites), supporting activities and facilities (visitor centers, nature trails, information boards, signs, specialized audio and visual equipment). These are the means for the introduction of visitors to the values of the area and for helping develop appropriate visitor behavior.

Eco-Museums in Lake Doiran (in both countries) will be used to fulfill important management tasks. The Eco-Museums are located in positions, which attract the most visitors. The "new design" will be in order to draw visitors into the building, persuade them to look at the displays and lead them out, better informed, into the real protected area itself. The Ecomuseums in Doiran will be built in a strong interpretive component, help visitors to understand the significance of the area, and thus to assist the protection of the area.

REQUIREMENTS

The studies should be undertaken by organisations active in related fields and can be completed within 24 months.

PROVISIONAL COST

600,000 Euros

PROPOSED FUNDING MECHANISM

Hellenic Ministry of Foreign Affairs – Hellenic Aid. It funds humanitarian and development assistance projects in certain developing or under developed countries. New project applications may be submitted each year, on the condition that they fall into the priorities for that year. In January 2005, the Greek Biotope Wetland Centre (EKBY) submitted a project proposal incorporating part of the proposed measures for approval under this funding mechanism.

INTERREG Greece – FYROM. It is a Community initiative, which aims to stimulate interregional cooperation in the EU between 2000-06. It is financed under the European Regional Development Fund (ERDF). The Operational Programme Interreg III Greece - Former Yugoslav Republic of Macedonia 2000-2006 was approved by the European Union by the Decision No. E (2002) 118 /19-03-2002. Priority axis 3.3. is entitled "Protection, promotion and management of natural environment".

PRIORITY

High

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