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Assessment of Ecosystem Water Needs for Water Resources Management at Catchment Level: The Case of Cheimaditida Lake – Greece

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Title of Paper
Assessment of Ecosystem Water Needs for Water Resources Management at Catchment Level: The Case of Cheimaditida Lake – Greece

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Dimitrios K. Papadimos will present it at the workshop

Surface and geographical/ administrative level
Lake Cheimaditida (9.5 km^2) and its wider catchment (228 km^2) are located at the Northwest part of Greece. Administratively they belong to the Prefecture of Florina and the Region of Dytiki Macedonia - Greece.

Abstract of the paper
The water level in Cheimaditida has decreased drastically the last decades, mainly due to overpumping for irrigation purposes, with adverse effects on the flora and fauna of the area. During winter and spring several conflicts arise between local farmers due to the rising of the lake's water level and the flooding of the adjacent agricultural land. Furthermore the appreciation of the conservation values of the lake by local people is low mainly due to lack of incentives for their active involvement in the management of the site. A LIFE NATURE project aiming at the conservation and management of Lake Cheimaditida coping with the above problems was carried out by the Prefecture of Florina (Directorate of Land Reclamation), EKBY etc. The hydroperiod of the lake was defined taking into account the needs of its biota. The maximum withdrawal of water volume for irrigation purposes was determined. Also following the above, the construction of a dyke for flood protection and expansion of wet grasslands to the NW side of the lake was proposed. Finally all the required studies for environmental interpretation in the catchment as well as for the design and construction of an Information-Visitor Center close to Cheimaditida were elaborated.

Context
Lake Cheimaditida is located at the North West part of Greece and covers an area of 9.5 km^2 at its maximum water level (591.3 m m.a.s.l.). Its wider catchment (228 km^2) includes River Sklithros and two torrents those of Aetos and Fannorema which drain the western mountainous areas, Lake Zazari and the agricultural land that is extended northeast to Cheimaditida. Also the catchment includes a number of small streams that drain hilly areas to the east (fig.1).
River Sklithros constitutes the main source of surface water for lakes Zazari and Cheimaditida. Lake Zazari is located 2 km Northwest of Lake Cheimaditida and covers an area of 1.9 km^2 at its maximum water level (599.3 m m.a.s.l.). In the past it

was fed with water coming only from its subcatchment since River Sklithros was flowing directly into Cheimaditida. In 1965 the northeast part of Cheimaditida was drained and converted into agricultural land. River Sklithros was diverted into Lake Zazari and a canal was constructed to convey the excess of water downstream to Lake Cheimaditida. The maximum water level of the later was 591.3 m and a low dyke (0.5 – 1.0 m height) was build at its northern part to protect the adjacent agricultural land from floods above this level. Overspill from Cheimaditida is partially stored for irrigation purposes in the main drainage canal just downstream the lake and the rest outflows to Lake Petron.

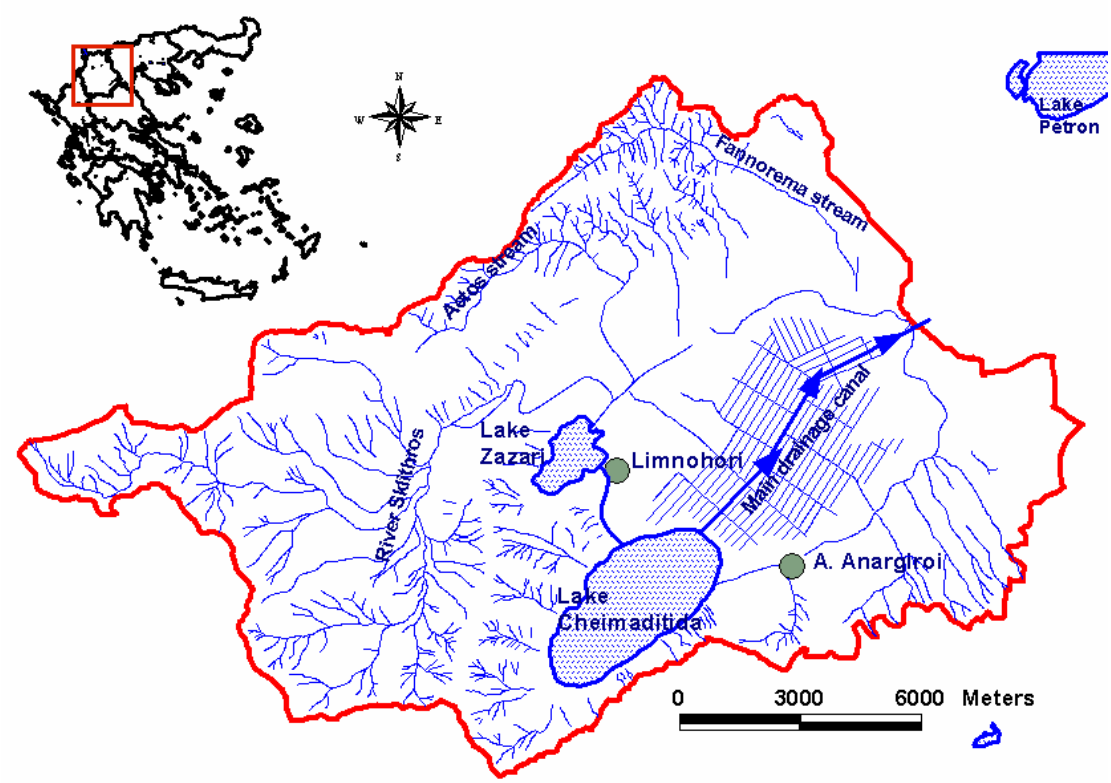

Figure 1. The wider catchment of Cheimaditida Lake

The presence of 5 types of habitats that are listed in the Directive 92/43/EEC and the numerous flora and fauna species provide the area its special ecological importance (Ministry of Environment, Physical Planning and Public Works 2001, Tsiouris 1996). Also the area has been designated as SCI (Site of Community Importance) according to the habitat directive and as SPA (Special Protection Area) according to the bird directive.

To the southern boundary of the catchment area a lignite mine is located belonging to the Public Power Corporation of Greece (DEH). In the future the mine plans to expand to the north approaching lake Cheimaditida at a distance of 2 km. According to a relevant study (Koumantakis and Dimitrakopoulos 1997), the lake is not affected by the exploitation of the mine, since its bottom is sealed. However the Directorate of Land Reclamation Service of Florina is expecting that the forthcoming lowering of the groundwater table in the area due to the mine activities will lead to direct abstractions of water from the lake by the farmers.

The economy in the catchment is mainly based on crop and livestock farming. The income from fishing is low. Agricultural land (about 2,200 ha), is shared among the farmers of the adjacent villages. It is extended mainly northeast to Cheimaditida and

occupies the soils revealed after the lake's partial drainage. An area of 200 ha is cultivated almost every year by wheat (dry farming) while the remaining mainly by alfalfa, maize and sugar beets. The irrigation needs are covered by surface water coming from the lakes and groundwater (Table 1).

Table 1. Irrigated area and water source in Cheimaditida catchment.

Water Source	Irrigated Area, ha	Irrigation Water Management
Lake Zazari	450	2 Collective irrigation schemes
Lake Zazari	50	Individual farmers
Lake Cheimaditida	100	Individual farmers
Overspill from Cheimaditida	500	Individual farmers
Return flows from the mine		
Groundwater (boreholes)	900	Individual farmers

During winder and spring several conflicts crop up among farmers whose land is close to the lakes. Farmers from Limnohori keep always closed the water gate at the outlet of Zazari to ensure its repletion for irrigation purposes. That results in reduced outflows from Zazari to Cheimaditida and negative impacts on the water regime of the latter. At the same time farmers from Agioi Anargiroi block arbitrarily the outlet of Cheimaditida to store more water for irrigation. The rising of its water level results in the inundation of the low land that is extended to a zone of 600 m width northern to the lake. During summer local farmers start pumping water from Cheimaditida after it has stopped overspilling (below the elevation of 591.3 m) causing a farther lowering of its water level.

The absence of any management plan regarding the water resources in the catchment has the following consequences:

- Unsustainable use and over-exploitation of water resources of both lakes
- The water level in Cheimaditida has decreased during the last decades with adverse effects on the flora and fauna of the area.
- Increase of the wetland area covered by dense reedbed vegetation (more than 80 %) and decrease of the open water areas in lake Cheimaditida putting pressures on several protected species in the lake by downgrading their habitats.
- Due to nonpoint agricultural runoff the quality of lake's water has been degraded.
- Conflicts of interest crop up among the farmers with regard to the use of the lakes water.

The main objective of this paper is to present the water management problems of the area of lake Cheimaditida, the procedure which was followed to address them and particularly to assess the most appropriate water regime of the lake which would satisfy the needs of the wetland biota and at the same time the needs of the local farmers.

Methodology and procedure used

To face the above situation Greek Biotope/Wetland Centre (EKBY), initiated a dialogue with representatives of the main stakeholders in the catchment (farmers, fishermen and local authorities). Their perception regarding the current situation of the lake and its ecosystem value and their needs and expectations from a future restoration of the lake were investigated.

Following the results from the dialogise EKBY requested from the Prefecture of Florina the rehabilitation of Cheimaditida's water regime as a measure not only for the conservation of the lake's ecosystem but also to serve as the base for the sustainable water management in the catchment. The request was accepted and a study entitled "Study and proposed works for protection and rehabilitation of Cheimaditida and Zazari wetland functions" was conducted by EKBY and Aristotle University of Thessaloniki (Lazaridou et al. 2001). The specific objectives of the study were:

a) quantification of existing hydrologic conditions and the interactions between the lake and its catchment
b) assessment of the lake's ecosystem water needs and identification of its hydroperiod
c) determination of the maximum allowable water abstraction for irrigation
d) identification of required interventions for the rehabilitation and establishment of a self –sustainable wetland.

For the quantification of the existing hydrologic conditions in the catchment in the abovementioned study the simulation of Cheimaditida's water balance was conducted using the "Reservoir Simulation" method (Tsakiris 1995) at a monthly time step from 1979 to 1998. That allowed the quantification and clarification all of hydrological components in the catchment as well as of the hydroperiod of the lake during those years.

Following the investigation of hydrological conditions in the catchment, the functional approach and the Wetland Evaluation Technique (WET) as described by Adamus et al. (1987) was used for the assessment of the lake's functions and water needs.

On the results of the above study a LIFE NATURE project was conducted by the Prefecture of Florina aiming at the conservation of Cheimaditida through the implementation of the suggested hydroperiod of the lake.

Types of tools for water demand management and for integrated water resources management used

A preliminary dialogue among the main stakeholders in the catchment was used as a tool for the investigation of their perception and needs with regard to the rehabilitation of lake's water regime and its ecosystem. The results of this dialogue showed the following:

a) All the involved parties were disappointed with the continuous drop of the lake's water level and they expressed their willingness for its rehabilitation.

b) Different categories of stakeholders were expecting different benefits from the lake's rehabilitation, as follows:

Farmers	:	a) water supply for irrigation, b) flood protection of agricultural land
Fishermen	:	a) increase the extent and depth of open waters in the lake
Local authorities	:	a) determination of the ecosystem water needs b) a generally accepted management plan of the water in the catchment, c) flood protection of both agricultural and urban areas.

d) Ecosystem values such as biodiversity, opportunities for recreation, scientific study and education were ignored or were of low appreciation.

Taking into account the above it was obvious that any rehabilitation planning should aim not only at conserving the lake's ecosystem but also at improving the wetland's directly exploitable values according to the expectations of stakeholders.

Following the above results the water needs of the biota of Lake Cheimaditida were used as a tool for the sustainable management of water resources in the catchment. They were assessed and quantified through the evaluation of the ecosystem functions using the WET method. The functions that were considered were a) food web support, b) floodwater attenuation, c) water storage, d) groundwater recharge, e) sediment and toxicant trapping and f) nutrient removal and transformation. The degree of their performance was assessed, taking into account the structural elements and the hydroperiod of the wetland, the specific characteristics of its biota and the characteristics of its catchment.

From the above procedure it was found that the functions of food web support and water storage were low. Both of these functions are directly related to the habitat types structure that is under threat due to the expansion of the reed beds and the hydroperiod of the lake. Hence any intervention for the enhancement of the performance of the above functions from "Low" to "High" should aim at the rising of the lake's water level so as to limit the reeds expansion. The following environmental and socioeconomic factors were considered for the determination of the maximum and minimum water level of the lake.

- Maintenance of bird populations and species. Special care should be taken for the conservation of bird populations and especially for protected ones with regard to their needs in habitat types structure.
- Maintenance of a minimum water level in the lake. A minimum water level should be defined for the lake under which irreversible damages are expected in the structure of the habitats and the populations of the species.
- Safeguarding of stakeholders income. The increase of the lake's water volume capacity and the rise of its water level should take into account a) the threat of floods b) the expected rising of the water table in the adjacent agricultural land c) the irrigation needs of the adjacent agricultural land.

With regard to bird populations, the needs of the protected species *Aythya nyroca* that also cover the needs of many other protected species in the lake were used as a criterion for limiting the area of reeds. Hence the rise of the lake's water level should be defined in a way that it will not reduce the habitat of reed beds more than 50% of its current area.

The minimum water level of the lake was defined taking into account the hydroperiod of the lake during past years (Fig. 2), in combination with the spatial distribution of the reed beds. It was observed that in the case of Cheimaditida reeds do not extend in areas where the minimum depth is always above 0.8 – 1.0 m. Using the DEM of the lake and following the abovementioned factors regarding the maximum restriction of reeds area the minimum allowable water level was defined at 590.7 m.

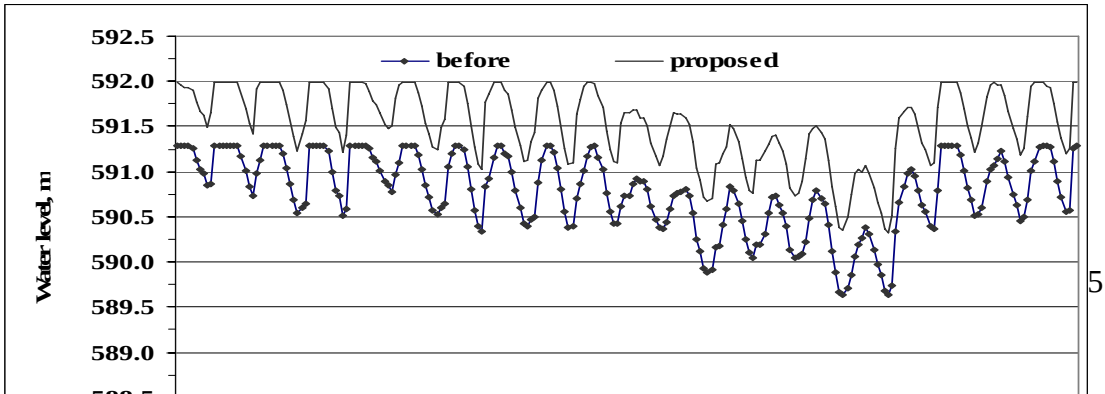

Figure 2. Water level fluctuation in Cheimaditida during 1979 - 1997

Furthermore the water volume required to meet irrigation needs of the adjacent agricultural land was taken into account as an important success factor of the lake's rehabilitation. After deliberation with the Directorate of Land Reclamation of Florina it was agreed that only those areas that were irrigated in the past directly from the two lakes will be supplied by water from the later and no additional land will be irrigated. Hence it was agreed that 500 ha will be irrigated from Zazari and 10 ha from Cheimaditida. The irrigation needs were estimated from May to September on the base of the last 5 years crop distribution in the catchment and for climatic conditions whose probability to occur were less that 20% (high values of temperature and low values of rainfall).
Following the above as well as taking into account the losses due to evaporation the maximum water level of the lake was defined at the elevation of 592.0 m (Fig2). With regard to the desired yearly fluctuation of the lake's water level the following have been proposed: a) the maximum water level should be reached until the end of winter and preserved until the end of spring, b) from mean April to the end of June the water level of the lake should remain stable at its maximum level and c) the minimum water level should be avoided as far as possible.

Results of the experience and <u>lessons to be learnt (regarding water demand management</u>

The results of the above study were accepted by the Prefecture of Florina (Directorate of Land Reclamation) that is the competent authority for the management of the lakes water level and a LIFE NATURE project was carried out by the Prefecture for the implementation of the desired hydroperiod in the lake and conservation of its ecosystem entitled "Conservation management of Cheimaditida wetland". Among the main objectives of the project were: a) restoration of Cheimaditida's water regime (raising of its water level), b) restoration of appropriate habitat structure in reed beds, open waters, humid grassland for the benefit of the priority species of Annex I of the Dir. 79/409/EEC populations in the lake and c) increase of the appreciation of the local communities for the site, its conservation values and the potential economic benefit from the sustainable use of the area.
Partners of the project were the Greek Biotope/Wetland Centre, The Greek Ornithological Society, the Region of Dytiki Macedonia (Forest Department), The Municipality of Aetos and the Planet Northern Greece S.A.
Regarding the arising of the lake's water level the following actions were undertaken:
- Raising and sealing of the existing dyke north of Lake Cheimaditida.

The aim of this action was a) to increase the storage capacity of the lake allowing for the raising of its water level, b) to prevent the inundation of the agricultural areas that extent north of the lake after the raising of its water level and c) to prevent lateral outflows of groundwater to the adjacent agricultural land. It should be mentioned that this action was one of the most welcome ones by local people since it is expected to solve the continuous conflicts among the farmers that are related to the adjustment of the lake's water level.

- Establishment and operation of a system for controlling the water level in the lakes.

The action aims to establish an integrated tool for monitoring and managing of inflows, water level and outflows from the lakes Zazari and Cheimaditida and their subcatchments. It includes the establishment of a) 2 automatic meteorological stations, one in the mountainous and one in the plain part of the catchment area, b) 3 automatic water level recorders, one at the outlet of torrent Sklithros and one in each lake, c) 2 automatically adjusted water gates, one at the outlet of each lake, d) 1 set of computer equipment with the appropriate software for collecting and treating data from the above infrastructure, controlling the water gates and calculating water balance in the catchment.

-Compensation of farmers due to conversion of their properties from agricultural land into wet grasslands. Eventually and after intensive negotiations among the Directorate of Land Reclamation of Florina with the interested farmers the latter agreed to exchange their properties with other ones in a different location.

Regarding the increase of the appreciation of the local communities for the site and its conservation values the following actions were undertaken:

Open meetings with the local people and all stakeholders were organized aiming at informing and increasing public awareness on issues related to nature conservation and values related to wetlands .

Two workshops were held aiming at increasing and improving the knowledge of the stakeholders on the main issues related to water resources management and reed bed management.

All the required studies were elaborated and obtained for the construction of an Information – Vistor Center in an existing building close to Cheimaditida.

Further actions aiming at the environmental interpretation of the site were undertaken e.g. production of leaflets and poster providing concise information on the priority habitats/species of the site and promoting the conservation aims of the project, production of a visitor map, production of a film on the values and functions of Cheimaditida-Zazari wetlands, an environmental activities package for the school children, construction of a bird observatory and of view points with accompanying infrastructure.

Even though the project faced at the beginning the reservations of all involved parties in the catchment, the rehabilitation of the lake's water needs was conducted in a win-win way. As the main success factors the following could be referred:

- The early involvement of the main stakeholders that helped to integrate their needs and expectations in the objectives of the rehabilitation.
- The greater scientific understanding of the ecosystem functions and its water needs as well as the interrelations with its catchment in terms of hydrology and farming practices (irrigation), served as a transparent base for deliberations and appropriate decisions.

Justification of the importance of the paper

The protection and enhancement of the status of aquatic ecosystems and wetlands with regard to their water needs constitutes one of the main purposes of Water Framework Directive 2000/60/EC that already governs legislation in European member states. Furthermore the water needs of the ecosystems should be quantified and be taken into account during the elaboration of the River Basin Management Plans according to the above directive.
This paper provides a valuable and unique example in Greece on how water needs of an ecosystem can be defined as well as on how stakeholders of contradicting roles regarding the use of water in a catchment can collaborate to achieve sustainable management of water at catchment scale.

Discussion
Today, although most countries have recognised that they have a moral and legal obligation to meet the ecosystems water needs, very few have attempted to determine those needs.
In Greece such an attempt was conducted by the Greek Biotope/Wetland Centre (Gerakis et al. 2007) within the framework of a national scale project that aims to elaborate the River Basin Management Plans in the country following the requirements of the WFD Directive 2000/60/EC. Given the lack of adequate data for most of the ecosystems, the study was based on the opinion of experts with long experience and knowledge of the investigated ecosystems and on written publications and oral information.
The determination of aquatic ecosystems water needs must be based on research and monitoring data on hydrological and ecological parameters as well as on socioeconomic ones. Also, specialised knowledge is required, most of which is produced within the country that will have to manage these ecosystems (Gerakis et al. 2007). While hydrological data can be obtained even indirectly e.g. using rainfall – runoff modelling approaches, there is a lack of information regarding ecological parameters or the existing knowledge is usually based on observation rather than experimentation (Davis et al. 2001). Furthermore longer term studies are required to determine the effects of floods and droughts (Bennett and McCosker 1994).
Functional approach and the WET method which have been applied in the case of Cheimaditida can contribute to overcome some of the abovementioned constraints. Even though WET has been based on North American literature it has been used and tested in some restoration, rehabilitation and functional assessment studies in Greece mainly due to its simplicity and low demands in monitoring data.

Key words
Water management, reed beds, wetland functions, ecosystems water needs, rehabilitation

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