

# Multiple Anthropogenic Pressures and Interventions and Environmental Management of Some Wetlands in Phthiotis (Central Greece)

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## Authors' contributions

*This manuscript was carried out in collaboration between both authors. Author M. Aristeidis designed the study, performed the main anthropogenic pressures and interventions in recent decades in the aquatic resources and sensitive ecosystems in Phthiotis Prefecture and evaluate the impact-changes on the natural environment of the research areas. Authors M. Aristeidis and M. Asimina elaborated the literature searches, the data of maps, aerial photographs, satellite images and the "in situ" observations and proceeded to comparative observations on the changes has been the natural environment in the under study areas. Also authors M. Aristeidis and M. Asimina elaborated: a. the environmental management of aquatic resources and delicate ecosystems under study and b. the ecological restoration proposals and monitoring. Authors M. Aristeidis and M. Asimina wrote the protocol and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.*

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## ABSTRACT

Freshwater springs and natural hot-water springs, alpine, subalpine lakes and the Mediterranean temporary ponds in Mt Oiti and Mt Kallidromos, coastal lakes, lagoons and marshes in the coastal zones of Maliakos gulf, and the protected wetlands that exist in the area of River Spercheios valley

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and delta, included among the aquatic resources and sensitive ecosystems of Phthiotis Prefecture. The purpose of the present research is to highlight the main anthropogenic pressures and interventions in recent decades in the aquatic resources and sensitive ecosystems, evaluate the impact-changes on the natural environment of the research areas, and to propose some ecological restoration proposals and monitoring.

For the depiction of the environmental situation and for the assessment of the environmental impact caused by certain anthropogenic interventions on the aquatic resources and sensitive ecosystems of Phthiotis Prefecture, involved a series of different stages: the study of bibliographical references, systematic in situ observations (field-work), measurements using the Global Positioning System (GPS) satellite signals, observation and direct digitizing on the basis of different aged aerial photos and satellite images (Landsat, Google Earth). The “in situ” observations were conducted, at least, every 5 years during the months of April, July, October and January for the years 1996, 2001, 2006, 2011 and 2016, in selected places of each aquatic resource and sensitive ecosystem under study. Data were analyzed quantitative and qualitative, while apposite thematic checklists and tables were created.

The environmental destabilization of most of the wetlands in the area under study, is mainly caused by certain anthropogenic pressures and interventions which alter “critical” parameters of the environment, leading to wetland alteration or degradation and have a significant impact/changes on: a. Flora and local natural ecosystems, b. Landscape, c. Surface and underground waters and d. Geomorphology.

*Keywords: Environment; Fthiotis; geomorphology; lagoons; lakes; ponds; springs; wetlands.*

## 1. INTRODUCTION

The intensification of multiple anthropogenic pressures and interventions in recent decades in the deltas and in the drainage basin of some rivers and streams in Phthiotis Prefecture has affected the aquatic resources such as lakes, temporary ponds, springs, lagoons, especially degrading sensitive wetland habitats (Figs. 1, 2, 16 and 17).

Freshwater wetlands around the Mediterranean Sea have decreased considerably in number and

quality. Greece has lost two thirds of its wetlands during the last seventy five years; however, many wetlands with considerable conservation value remained [1-7]. Coastal zones are among the most densely populated ecosystems in which are evident abuse and pollution [8]. The mid - 1950s to the mid- 1970s were a time of major national wetland loss. Since 1950, extensive losses have occurred, many of the original wetlands have been drained and converted to other uses, such as farmland, industrial sittings, urban and touristic development [9].



**Figs. 1 and 2. View of Atalanti lagoon (12 PhthiWETL) near Scala and Tragana. Anthropogenic pressures and interventions in the lagoon (roads, industries, opencast mining-quarries, intensive agriculture and settlements) create a significant impact on the natural environment of the wetland (Photos by Mertzani Asimina)**

According [4], efforts to improve land, in order to make it more productive for agriculture, have been undertaken since antiquity. Homer, Hesiod and Strabo mention drainage works in the Copais wetlands (Homer, Hesiod), while Philip of Macedonia was said to have constructed the tunnel of Angilos to drain the Filippi marshes North of Kavala [10]. Similar works were carried out by the Romans. All of these were abandoned during the Turkish occupation (1453-1829) and many of the drained wetlands returned to their former status. After the liberation, drainage works started again with Copais lake in 1880 [10]. Drainage was intensified during the period 1925 to 1940, due mainly to the need to establish the refugee farmers from Asia Minor. In 15 years, besides Copais, the lakes Yannitsa, Artzan, Amatova and Achinos were drained, as well as the marshes of Loudias and Filippi, while the river beds of Axios, Aliakmon and Strymon in Macedonia, and Louros and Arachthos in western Greece were rearranged [4]. Major drainage works were carried out in Thessalia [11-13]. According to estimates made by the Ministry of Agriculture, these works resulted in the drainage of 89,900 ha of wetlands, the irrigation of 14,000 ha and the protection from floods of 369,000 ha. Thus the total loss of wetlands, including periodically flooded areas, was truly enormous [4].

After the War and during the period 1948-1958, land "improvement" works were boosted by U.S. aid and better technology [4]. Within that decade, diversion dams were erected on Acheloos, Tavropos, Aliakmon and Axios Rivers, while three drainage tunnels were constructed (Karla in Thessaly, destroying the invaluable Karla Lake, Lapsista and Langasta in Ipiros) [4]. The Xyniada lake near Domokos, drained in 1942. From 1960 onwards, land reclamation by draining wetlands was carried out in all parts of the Country, but on a smaller scale, as seen, for example, along lakes Prespa and Vistonis, and in Amvrakikos and Evros [10,4].

The main anthropogenic degradation and stresses on these ecosystems includes wetland draining, intensification and development of agriculture projects, river engineering works, hydroelectric power dams, irrigation dams and water supply dams, water pollution, holiday home building, and uncontrolled water abstraction from surface & underground water tables [1,2]. Pollutants such as sediment, nutrients, pesticides, and heavy metals degrade wetlands and water quality. Diverse land use changes

concerning the coastal and inland plains, lakes, deltas and coastal wetlands are also detected. Sprawling urban areas are also located in and near the lowland plain of the Spercheios delta, including the conurbation of Lamia [2].

The timely and accurate information regarding multiple stressors causing deterioration on aquatic resources and sensitive ecosystems, the proper environmental impact assessment and the systematic monitoring can provide important input to managing and mitigating the negative effects of human land management and freshwater ecosystems and sensitive wetland habitats.

The main objectives of this paper are: a) to highlight the multiple stressors and manmade interventions in recent decades in the aquatic resources and sensitive ecosystems of Phthiotis Prefecture, b) to evaluate the impact-changes on the natural environment of the research areas such as wetland ecosystems, lakes, temporary ponds, lagoons, marshes, freshwater and thermal spring and c) to describe a strategy for the mitigation of the manmade eco-environmental impact, in order to propose improvements over the sustainable management of the aquatic resources and sensitive ecosystems of Phthiotis Prefecture. Finally, proposals are made regarding ecological restoration and monitoring.

## **2. MATERIALS AND METHODS**

### **2.1 Geographical Location of the Study Area**

This paper deals with the aquatic resources and sensitive wetland ecosystems, i.e. the lakes, freshwater springs and natural hot-water springs, coastal lakes, lagoons and marshes that exist in Phthiotis Prefecture in Central Greece. Most of these aquatic resources and sensitive wetlands, have suffered serious alterations from the manmade interference, in the broader area and in the watersheds or on their coastal zone [1,2]. This study mainly focuses in some delicate wetland ecosystems which have undergone alterations due to anthropogenic pressures and interventions [1-3]. These delicate ecosystems, should be located in the Central Greece region and especially:

- a. Freshwater springs with a small permanent lake: 1. Agia Paraskevi Springs (1PhthiFreWSp) near Agia Paraskevi, Lamia and Stylida.

- b. Natural hot-water springs with a small permanent lake: 1. Kallidromos thermal springs I (Psoroneria I) (1PhthiTherSp) near Kato Damasta (Lamia) (Fig. 3), 2. Kallidromos thermal springs II (Psoroneria II) (2PhthiTherSp) near Kato Damasta (Lamia) (Fig. 4), 3. Thermopylae thermal springs (3PhthiTherSp) near Thermopylae (Lamia) (Figs. 5 and 6), 4. Loutra Koniaviti Thermal springs (4PhthiTherSp) near Kamena Vourla.
- c. Delicate wetland ecosystems, coastal lakes, lagoons and marshes: 1. Agios Sostis lake (Glyfa lake)(1PhthiWETL) southeastern of Glyfa, 2. Pelasgia lagoon (2PhthiWETL) southwest of Paralia Pelasgias (Fig. 10), 3. Almyropotamos marsh (Achladi) (3PhthiWETL), western of Achladi near Stylida, 4. Spercheios river delta-estuaries (4PhthiWETL) and surrounding marine ecosystems (Fig. 18), 5. Latzorrema (Ag. Triada) river delta (5PhthiWETL), near Ag. Triada and Thermopylae, 6. Molos I marsh, (6PhthiWETL) northwest of Molos, 7. Molos II marsh (7PhthiWETL), Potamia stream estuaries, northeastern of Molos, 8. Skarfeia marsh, (8PhthiWETL), Liapatorrema stream estuaries north of Skarfeia (Fig. 9), 9. Agios Serapheim marsh (9PhthiWETL), western of Neo Thronio, Voagrios river estuaries, 10. Vromolimni lake (Asproneri) (10PhthiWETL), near Kamena Vourla and Agios Konstantinos (Fig. 8), 11. Kalamos (Loggos)(11PhthiWETL) Xerias stream estuaries, northeastern of Loggos, 12. Atalanti lagoon (12PhthiWETL) near Scala and Tragana (Figs. 1, 2 and 7), 13. Larymna I (13Phthi WETL), Anonymous torrent estuaries, northeastern of Larymna, 14. Larymna II (14Phthi WETL), Anonymous torrent estuaries, northeastern of Larymna, 15. Larymna III (15Phthi WETL), Anonymous torrent estuaries, southern of Larymna.
- d. Alpine, subalpine lakes and temporary ponds: In these delicate wetlands of Central Greece region, are include several alpine or subalpine lakes, such as the temporary ponds: 1. Leivadies (1PhthiTPo) (Fig. 12), 2. Greveno (2PhthiTPo), 3. Louka (3PhthiTPo) (Mt. Oiti), and 4. Zirelia (4PhthiTPo) (Mt. Vardousia) [9,10]. Also, in the Central Greece region, at lower altitudes, there are a number of "mediterranean seasonal lakes" or "temporary ponds" such as: 5. Nevropolis I (5PhthiTPo)(Mt Kallidromo) (Fig. 11), 6. Nevropolis II (6PhthiTPo) (Mt Kallidromo), 7. Paliosouvala (7PhthiTPo)(Mt Kallidromo) and 8. the artificial pond Metalleio lake (8PhthiTPo), Omvriaki, near Domokos.

It should be noted that most the names of aquatic resources and wetlands and all the codes (e.g. 3PhthiTPo) have been given by the study group for the studied areas. These codes are combinations of letters and numbers. The number represents the scenting number of the relevant category (e.g. 3). The letters represent the initials of the prefectures' name (e.g. Phthi= Phthiotis). The end of the code represents the initials of these aquatic resources and wetlands (e.g. TPo= Temporary Ponds).



**Figs. 3 and 4. View of Kallidromos thermal springs I&II or Psoroneria I (Fig. 3) and Psoroneria I (Fig. 4) (1 PhthiTherSp & 2 PhthiTherSp), near Kato Damasta and Lamia (Photos by Mertzani Asimina)**



**Figs. 5 and 6. View of Thermopylae thermal springs (3 PhthiTherSp) near Thermopylae and Lamia (Photos by Mertzani Asimina)**

## 2.2 Study Methodology

This study used both secondary and primary data. Secondary data collection involved review of existing reports (unpublished, gray and published reports) from libraries and documentation centers in various institutions in Athens and Lamia [1,2]. Some reports were also made available through internet search [1]. Secondary information were supplemented by primary data at “aquatic resource unit” level, whereby small meeting were made with the local non-government environmental organizations, the relevant Forest Services, the Management Body of Mt Oiti National Park, and the Hellenic Alpine Club of Lamia.

For the depiction of the environmental situation of the aquatic resources and sensitive wetland ecosystems (lakes, temporary ponds, springs, lagoons, deltas, wetlands) of Phthiotis Prefecture, involved a series of different stages: the study of bibliographical references, systematic in situ observations (field-work), measurements using the Global Positioning System (GPS) satellite signals, observation and direct digitizing on the basis of different aged aerial photos and satellite images (Landsat, Google Earth, TriplnView) [1-3]. For the assessment and evaluation of the impact caused by certain human activities to the environment and geomorphology of the areas under study and especially, to the hydro-geomorphological processes in the coastal zones, shorelines, lagoons, deltas, lakes, ponds, marshes, wetlands and watersheds, have been used aerial photos various years and scale as well as satellite images (Landsat, Google Earth, TriplnView) [1,2]. The “in situ” observations were conducted, at least, every 5 years during the months of April,

July, October and January for the years 1996, 2001, 2006, 2011 and 2016, in selected places of each aquatic resource and sensitive ecosystem under study.

Also, have been used contemporary and older topographical maps (Hellenic Military Geographical Service, scale 1:50.000 and 1:100.000), geological maps (Institute of Geology and Mineral Exploration, scale: 1:50.000), hydrological and oceanographic data and maps of vegetation and land use (Ministry of Reconstruction of Production, Environment & Energy, scale: 1:200.000) [1,2]. All primary data were imported in an apposite database and were transferred in topographical map and onto satellite images. Thus the database was developed and updated with data deriving from different sources. Data were analyzed quantitative and qualitative, while apposite thematic checklists and tables were created [1,2].

## 3. RESULTS AND DISCUSSION

### 3.1 Anthropogenic Pressures and Interventions on the Aquatic Resources and Delicate Ecosystems of Phthiotis Prefecture

The anthropogenic pressures and interventions in the under study areas, was of different aims in each location, but it all resulted in the disruption of the natural environment and alteration of the dynamic evolution of the hydro-geomorphological processes which has led to the creation of an “artificial” environment, controlled to a great extend by human power and which in turn, in the long term re-strengthens and re-enforces the possibility of environmental destabilization [1,2,14-20]. Unfortunately, most of the aquatic

resources and delicate ecosystems of Phthiotis Prefecture are being degraded and are under imminent threat by multiple human-induced pressures. The main anthropogenic degradation and stresses on these ecosystems includes wetland draining, intensification and development of agriculture projects, river engineering works, water pollution, holiday home building, and uncontrolled water abstraction from surface & underground water tables. The intensification of multiple anthropogenic pressures and interventions in recent decades in the river mouths, deltas and lagoons and in the drainage basin of its rivers and streams has affected the natural ecosystems, especially degrading sensitive wetland habitats. It should be noted that the future regression of the shoreline, primarily caused by the climate change and the rising sea level, is expected to affect harshly the low lying coastal areas, such as those in the pictures (Figs. 1, 2, 7, 8, 9 and 10).

The most common man-made changes on the natural environment of the delta areas, river mouths, marshes, lagoons and lakes, under study, are [1-3]: A. Alterations to the fauna, the

flora and the local natural ecosystems, b. Landscape changes, c. Alterations to the surface and underground waters and c. Alterations on the geological-geomorphological features and the hydro-geomorphological processes.

Below there are presented the cumulative charts (Figs. 13, 14 and 15) referred to the list of the anthropogenic pressures and interventions that stress the aquatic resources and delicate ecosystems of Phthiotis Prefecture. More specifically, there are presented separately the cumulative charts for the various categories of the aquatic resources and delicate ecosystems, under investigation: 1) Freshwater springs and Natural hot-water springs, Alpine, Subalpine lakes and the Temporary ponds (Figs. 11 and 12) and 2) Wetlands, Coastal lakes, Lagoons and Marshes.

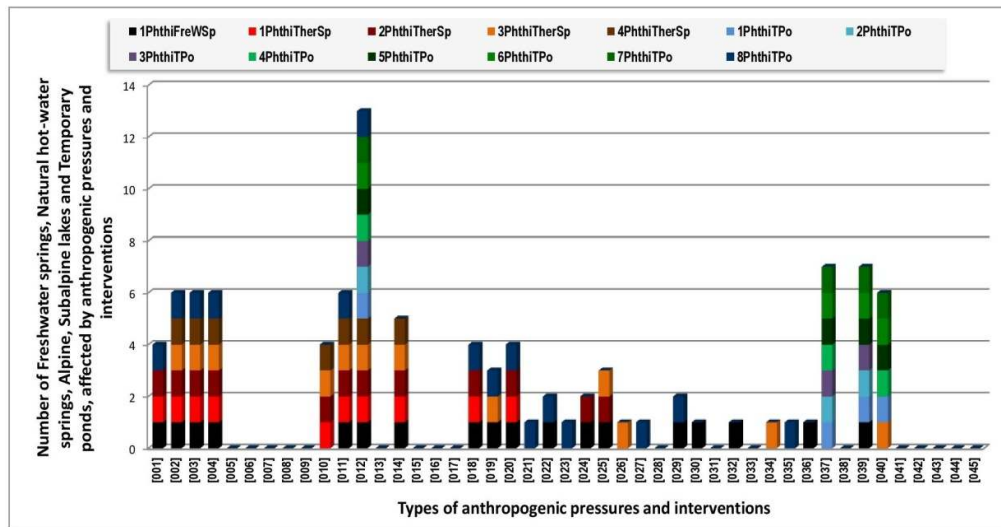
It should be noted that in the cumulative charts of Figs. 13, 14 and 15, each one of the anthropogenic pressures and interventions that stress the aquatic resources and sensitive wetlands of Phthiotis Prefecture, receive one point.



**Figs. 7, 8, 9 and 10. Aerial photos of Atalanti lagoon (12 PhthiWETL) (Fig. 7), Vromolimni lake (Asproneri) (10 PhthiWETL) (Fig. 8), Skarfeia marsh, (8 PhthiWETL) (Fig. 9), Pelasgia lagoon (2 PhthiWETL) (Fig. 10) (Source of aerial photos: TripInView/Geotag Aeroview 2014) These images are part of GEOTAG AEROVIEW photos. The main anthropogenic degradation and stresses on these ecosystems includes wetland draining, intensification and development of agriculture projects, river engineering works, water pollution, holiday home building, and uncontrolled abstraction from surface & underground water tables**



**Figs. 11 and 12. View of temporary ponds in Mt Kallidromo and Mt Oiti: Nevropolis I (5 PhthiTPo) in Mt Kallidromo (Fig. 11). Leivadies (1 PhthiTPo) in Mt Oiti (Fig.12). Some alpine, subalpine lakes and temporary ponds, that exist in Phthiotis Prefecture, such as the ponds Leivadies, Greveno and Louka in Mt. Oiti, Zirelia in Mt. Vardousia, Nevropolis I & II and Paliosouvala in Mt Kallidromo, remain unaffected by uncontrolled anthropogenic interventions. The only influences applied onto them are those of off-road 4x4 and motocross races and of the climate conditions and consequently of the global climate change (Photos by Mertzani Asimina)**



**Fig. 13. Cumulative chart of the anthropogenic pressures and interventions that stress the Freshwater springs, Natural hot-water springs, Alpine, Subalpine lakes and Temporary ponds, under investigation**

The legend of Figs. 13, 14 and 15 are [1-3]:

[001]. Intensification and development of agriculture, [002]. Construction of irrigation channels and drainage pits, [003]. Deepening and creation of channels, [004]. Construction of drainage - anti flooding protection works, [005]. Construction and function of large dams and reservoirs (hydroelectric power dams, irrigation dams and water supply dams) on the main bed of the river (>15.0 m height or reservoir volume

> 3.0 million m<sup>3</sup>), [006]. Construction and function of large dams and reservoirs (hydroelectric power dams, irrigation dams and water supply dams) on tributaries of major river (>15.0 m height or reservoir volume > 3.0 million m<sup>3</sup>), [007]. Intense construction of anti-erosion works in mountainous catchment basins (small dams, etc.), [008]. Intense construction of coastal defence management schemes (seawalls, breakwaters, groins, revetments, rock armour, gabions, beach replenishment, sand

dune stabilization, etc.), [009]. Construction of jetties in the coastal zone, [010]. Motorway in operation or under construction, [011]. National or provincial roads in operation or under construction, [012]. Opening up new agricultural and forest roads, [013]. Railway line in operation or under construction, [014]. Infrastructure works, [015]. Wood cutting, intense deforestation/Forest fires, [016]. Intense deforestation of riparian vegetation, [017]. Industrial activities upstream, [018]. Small business activities upstream, [019]. Urban and industrial development without any planning, [020]. Uncontrolled deposition of urban waste, industrial effluents, solid domestic and industrial waste, [021]. Excessive use of pesticides and fertilizers, [022]. Contamination-pollution (water & soil pollution, etc.), [023]. Alteration of the physicochemical characteristics - deterioration of the quality of water (salinity, etc.), [024]. Embankment-filling of lagoons or lakes with sediment, [025]. Drain of marshes, lakes lagoons/Exsiccation-desiccation of marshes and lakes, [026]. Canal shifting and entrenchment of the main river channels/river diversion projects, [027]. Intense mining activities (quarries, mines)/in upstream, [028]. Sand and gravel extraction from river beds (in upstream), [029]. Uncontrolled watering from surface water tables, [030]. Uncontrolled pumping of underground waters, [031]. Mass touristic activities, recreation, [032]. Domestic use, [033]. Intense urbanization of large coastal zones with impacts on the natural environment and the local natural ecosystems, [034]. Holiday home building, [035]. Sources of water pollution/in upstream, [036]. Solid wastes/Rubbish water pollution, [037]. Grazing in the forest, [038]. Overgrazing, [039]. Hunting-poaching, [040]. Various off-road 4x4 and motocross races, [041]. Use of lagoons or lakes for fishery, water cultivations, [042]. Coastal farming - Fish farming in coastal waters <500 m from shore and <10 m water depth, [043]. Coastal farming - Fish farming in coastal waters <500 m from shore and >10 m water depth, [044]. Off-coast farming - Fish farming in coastal waters 500 m to 3 Km from shore and 10 to 50 m water depth, [045]. Use of lagoons for salt production.

As shown in Fig. 13, there are several established anthropogenic pressures and interventions that stress the Freshwater springs,

Natural hot-water springs, Alpine, Subalpine lakes and Temporary ponds, under investigation under investigation. The most important ones are the following, in decreasing order: "Opening up new agricultural and forest roads-Code 012", "Grazing in the forest-Code 037", "Hunting-poaching-Code 039", "Construction of irrigation channels and drainage pits-Code 002", "Deepening and creation of channels-Code 003", "National or provincial roads in operation or under construction-Code 011" and "Various off-road 4x4 and motocross races-Code 040".

Most of the mediterranean seasonal lakes (intermittent lakes, ephemeral lakes), of Phthiotis Prefecture, have a temporary status, while some of them may retain the water throughout the year, if allowed by climate conditions and anthropogenic interventions [1,2].

Mediterranean temporary ponds, by definition, wetlands that present a seasonal hydrologic period. Ecosystem functions and, consequently, the biota of the ponds depend strongly on the hydrological status. The characteristic flora and fauna species are highly specialised and vulnerable to any changes in hydrology. The establishment of a quantitative assessment of the hydrological functions and the identification of potential direct or indirect modifications require frequent monitoring of the components of the water cycle, and of their effects on the seasonal and interannual variations of the pond water level. In addition, the biological phenomena of the ponds strongly depend on the hydric state and geochemistry of the sediments, the water chemistry, and their interactions. These are also controlled by flooding/drying cycles through soil redox potential changes [13].

Some alpine, subalpine lakes and temporary ponds, that exist in Phthiotis Prefecture, such as the ponds Leivadies, Greveno and Louka in Mt. Oiti, Zirelia in Mt. Vardousia, Nevropolis I & II and Paliosouvala in Mt Kallidromo, remain unaffected by uncontrolled anthropogenic interventions (Figs. 11 and 12). The only influences applied onto them are those of off-road 4x4 and motocross races and of the climate conditions and consequently of the global climate change.

As shown in Fig. 14, there are several established anthropogenic pressures and interventions that stress the Wetlands, Coastal lakes, Lagoons and Marshes under investigation. The most important ones are the following, in decreasing order: "Contamination-pollution



(water & soil pollution, etc.)-Code 022”, “Alteration of the physicochemical characteristics-deterioration of the quality of water (salinity, etc.)-Code 023”, “Intensification and development of agriculture-Code 001”, “National or provincial roads in operation or under construction-Code 011”, “Uncontrolled deposition of urban waste, industrial effluents, solid domestic and industrial waste-Code 020” and “Solid wastes/Rubbish water pollution-Code 036”.

Spercheios is the main river of Phthiotis Prefecture. Spercheios river drains an area of 1907,2 Km<sup>2</sup>. It contributes significant amounts of brought materials in the lower area of discharge, in Maliakos gulf, due to the presence of erosion prone flysch in its basin. These materials deposit and enrich the plane of Lamia and the Delta [2]. The canal shifting/partial diversion to the northern Maliakos gulf, of the main river channel of Spercheios river, resulted the creation of a new Delta in the area of new mouth to the Maliakos gulf and the shrinkage of old delta (Figs. 16 and 18) [2,21-27,19,20]. Spercheios valley and its deltaic ecosystem is an important ecosystem in Greece and is included in the NATURA 2000 network (Code number GR2440002 & GR2440005). It should be noted that the future regression of the shoreline, primarily caused by the climate change and the rising sea level, is expected to affect harshly the low lying coastal areas (Figs. 1, 2, 7, 8, 9, 10 and 18).

The identification, recording and evaluation of the multiple anthropogenic pressures and interventions that have been encountered as of now in the aquatic resources and sensitive ecosystems of Phthiotis Prefecture region, have been summarized the Cumulative chart of Fig. 15. The most important ones are the following, in decreasing order: “Opening up new agricultural and forest roads-Code 012”, “National or provincial roads in operation or under construction-Code 011”, “Intensification and development of agriculture-Code 001”, “Uncontrolled deposition of urban waste, industrial effluents, solid domestic and industrial waste-Code 020”, “Infrastructure works-Code 014”, “Small business activities upstream-Code 018”, “Contamination-pollution (water & soil pollution, etc.)-Code 022”, “Alteration of the physicochemical characteristics-deterioration of the quality of water (salinity, etc.)-Code 023”, “Urban and industrial development without any planning-Code 019” and “Solid wastes/Rubbish water pollution-Code 036”.

This Cumulative chart serves as a “tool” for the rational environmental management of the aquatic resources and sensitive ecosystems of Phthiotis Prefecture, offering an overall visualization of the pressures/impact, in order to protect the function and value of wetlands.

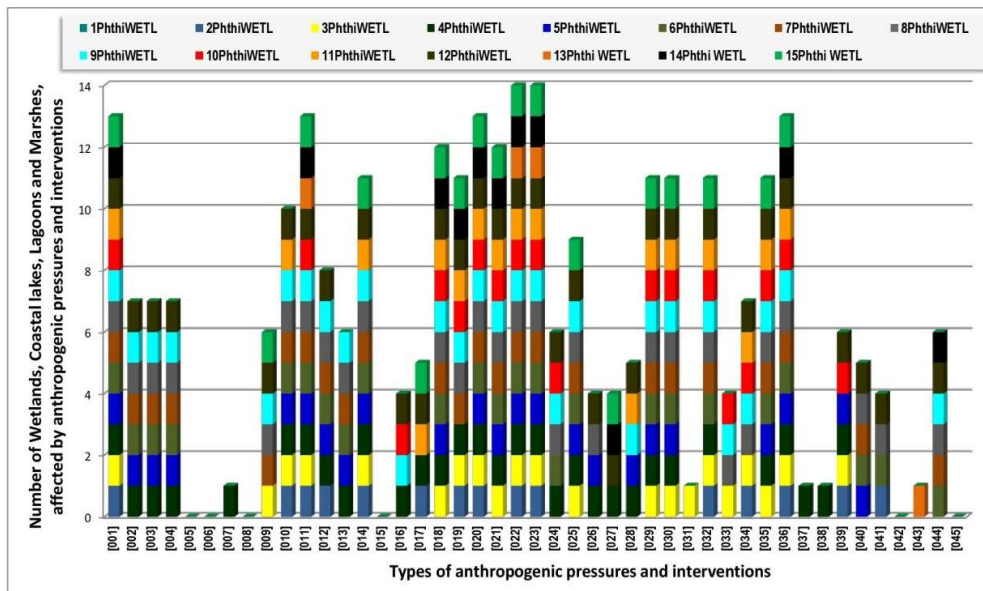
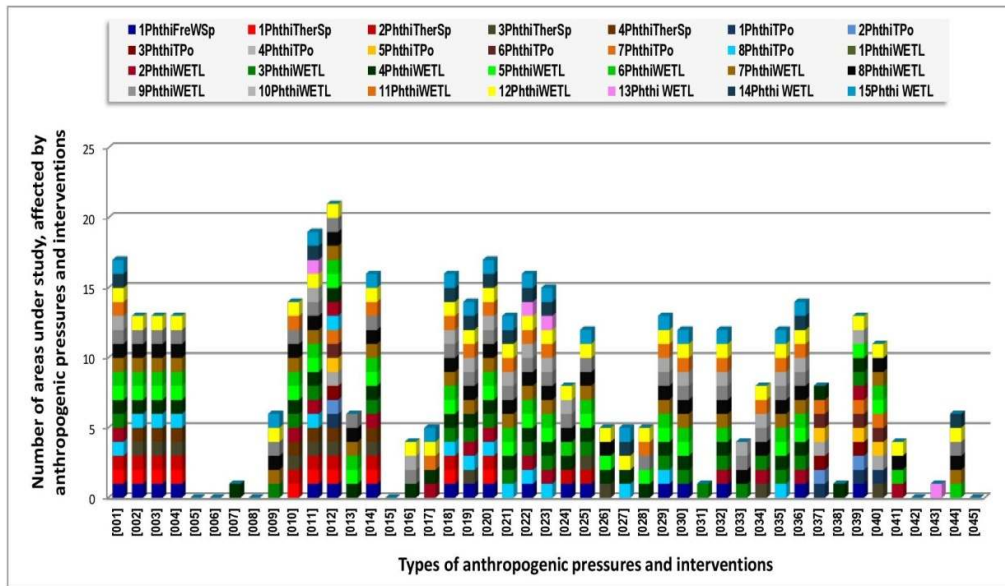


Fig. 14. Cumulative chart of the anthropogenic pressures and interventions that stress the Wetlands, Coastal lakes, Lagoons and Marshes, under investigation



**Fig. 15. Cumulative chart of the anthropogenic pressures and interventions that stress the aquatic resources and sensitive ecosystems of Phthiotis Prefecture**



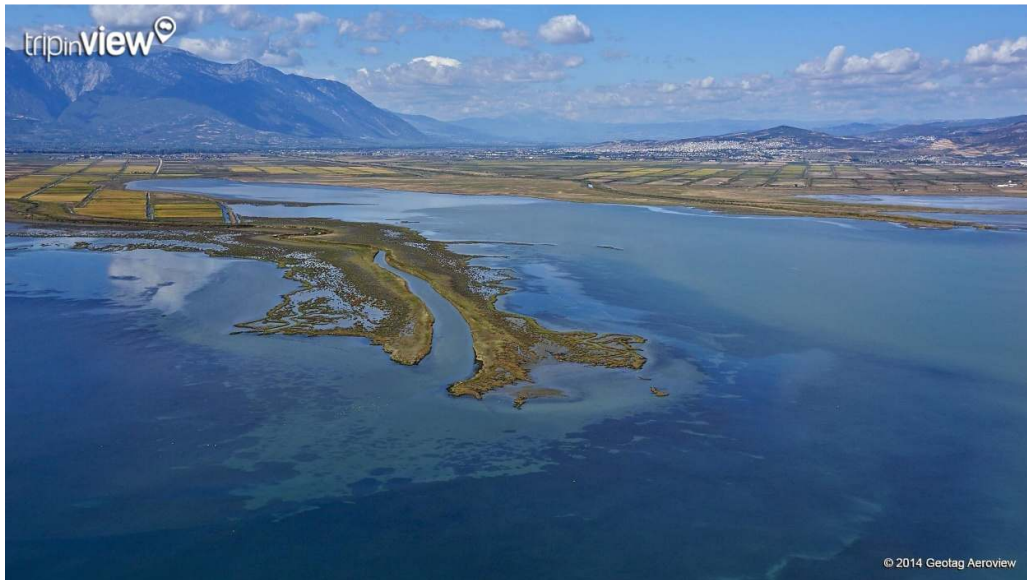
**Figs. 16 and 17. The new riverbed (artificial channel) of Spercheios (Fig. 16). Rice cultivation in Spercheios delta area (Fig. 17)(Photos by Mertzani Asimina). Spercheios valley and its deltaic ecosystem is an important ecosystem in Greece and is included in the NATURA 2000 network (Code GR2440002 & GR2440005)**

**3.2 Environmental Management of Aquatic Resources and Delicate Ecosystems of Central Greece Region - Ecological Restoration Proposals and Monitoring**

For the rational environmental management of the aquatic resources and delicate ecosystems of Phthiotis Prefecture, in order to address the environmental impact of projects and activities and in order to restore gradually the disturbed balance of affected natural ecosystems, many measures have to be taken. These include the use of specialized

environmental protection measures, strict control and monitoring of these measures and the safeguarding of the boundaries of protected areas.

The main protective measures listed below and are: 1. Detailed surveying, identification and high spatial resolution mapping of the aquatic resources and delicate ecosystems under study. A related program LIFE11 NAT/GR/1014 is implemented in the mountains of Oiti and Kalidromo [13], 2. Comprehensive study of all habitats in the different sites of Phthiotis, 3. Comprehensive study of the geological,



**Fig. 18. Aerial photo of the old delta of Spercheios River (4 PhthiWETL) to the Maliakos and the surrounding marine ecosystems. To the right (northwest) of old delta, is distinguished the new estuary, after the diversion to the north of the main river channel. As shown in the aerial photo of Fig. 16, intensification and development of agriculture, included among the multiple anthropogenic pressures and interventions that have been encountered as of now in the protected area of the delta**

*(Source: TripInView/Geotag Aeroview 2014)*

geomorphological and hydrogeological characteristics of the areas under investigation, such as the natural and artificial lakes, freshwater springs and natural hot-water springs, deltas, coastal wetlands, coastal lakes, lagoons and marshes, alpine or subalpine lakes and temporary ponds, that exist in Central Greece, 4. Reduction of pollutant emissions and more generally of the environmental impact of the different anthropogenic pressures and interventions, 5. Reevaluation of locating the different anthropogenic pressures and interventions under study and taking adequate measures, 6. Reevaluation of the operation of treatment plants of urban waste water and taking adequate measures, 7. Reevaluation of the operation of industrial wastewater treatment plants and livestock installations and taking adequate measures, 8. Reevaluation of the operation of industrial and manufacturing installations wastewater treatment plants as well as livestock installations and taking adequate measures, 9. Reduction of gaseous pollutant emissions and aerosols, 10. Implementation of municipal solid waste management projects, 11. Implementation of projects on waste management and recycling, 12. Implementation of hazardous and toxic waste management

projects, 13. Implementation of water saving programs in irrigation and industrial production, 14. Reduction of fertilizers, herbicides, and pesticides in agricultural production, 15. Implementation of ecosystem restoration project for improving and increasing aquatic and terrestrial habitats and ecological function in the lakes, lagoons, delta and its tributaries. The "Ecosystem Restoration Program" is guided by the following six strategic goals [24]: a. Recover endangered and other at-risk species and native biotic communities, b. Rehabilitate ecological processes, c. Maintain or enhance harvested species populations, d. Protect and restore habitats, e. Prevent the establishment of and reduce impacts from non-native invasive species, and f. Improve or maintain water and sediment quality, 16. Multi-temporal monitoring of the broader area of the aquatic resources and delicate ecosystems under study.

#### 4. CONCLUSION

A significant segment of Phthiotis Prefecture is in a fragile equilibrium, mainly because of the anthropogenic interventions that were carried out without preliminary studies regarding the long-term consequences of these activities. The

intensification of human activities, such as, engineering works, intensification and development of agriculture projects, exsiccation of lagoons and lakes, river damming, canal shifting and entrenchment of the main river channels- river diversion projects, waste disposal and water pollution, fertilizers, herbicides, and pesticides, uncontrolled watering from surface and underground water tables, etc., combined with the climate change, influence the local natural environment and the geomorphological evolution processes, and constitute the main causes of the environmental degradation [1,2].

The environmental destabilization of most of the aquatic resources and sensitive wetlands of the Phthiotis Prefecture, is mainly caused by certain anthropogenic pressures and interventions which alter "critical" parameters of the environment, leading to wetland alteration or degradation and have a significant impact/changes on: a. Flora and local natural ecosystems, b. Landscape, c. Surface and underground waters and c. Geomorphology. According to Mertzanis et al. [1], just like in Epirus region, diverse land use changes concerning the coastal and inland plains, freshwater springs and natural hot-water springs, deltas, coastal wetlands, coastal lakes, lagoons and marshes are also detected, while the alpine or subalpine lakes and temporary ponds that exist in Phthiotis Prefecture, remain unaffected or affected less, by the uncontrolled anthropogenic interventions [1]. The only influences applied onto them (alpine, subalpine lakes and temporary ponds) are those of off-road 4x4 and motocross races and of the climate conditions and consequently of the global climate change.

The appropriate design and the application of methods and techniques for the management of aquatic resources and delicate ecosystems is a condition for the preservation of the equilibrium of the natural hydrological and geomorphological processes, the renewal of the natural resources and, in general, environmental protection.

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## **COMPETING INTERESTS**

Authors have declared that no competing interests exist.

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