Conflict/Synergy Among Different Uses on Land and at Sea and land-sea Interaction in Blue Growth

Greece scale

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Co-Evolve4BG

Analysis of Threats and Enabling Factors for Sustainable Tourism at Pilot Scale

Conflict/Synergy among different uses on land and at sea and land-sea interactions in Blue Growth

Greece Scale

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OVERVIEW

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REVIEW

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I. Introduction

In Europe or the Mediterranean, Greece has more coastline than any other country. According to estimates, the Greek coastline comprises almost one third of the entire Mediterranean coastline (approx. 15,000 km) and almost a quarter of the coastline of the European Union. The Greek islands and islets represent 20% of the surface area and 14% of the population, whereas 70% of the population lives in coastal areas. The Greek coastal area, however, is not homogeneous. It presents a variety of natural characteristics with strong local variations, due to a strong geomorphologic characteristic.

Historical and archaeological resources have been accumulated over time in coastal areas, where humans have always preferred to live. Coastal regions have either been motivating factors for establishing and sustaining human activities or have been factors which have contributed to economic prosperity. The possibility of preference for agriculture is in the low plains, due to the existence of productive soils, as well as fishing. Moreover, those landscapes, because of their attractiveness, have a corresponding benefit by the evolution of tourism.

In addition to supporting the welfare of coastal areas, the development of trade and industry catalysed their development. Among the notable examples are the industrial units, which looked for locations near ports, because shipping was inexpensive and there was ample water for processing their products. An increasingly developed transport infrastructure also played a part. This transport infrastructure had a result in the creation of more and more cities connecting over the years and making a linear complex, which further improved a “coastalisation” process.

Moreover, their growth connectivity provided a strong motivation for establishing industrial and commercial units, leisure activities, and in more recent years, tourism activities leading to economic prosperity, while attracting a permanent population. Although these activities are closely related to human activities in coastal areas, they are also associated with the high concentration of population. The inappropriate placement of infrastructure and the overexploitation of natural resources are only part of “degradation”.

II. The coastal and maritime domain: characteristics and impacts

II.1. The main geomorphological and natural characteristics of the Greek coastline

The geomorphology and fragmented structure of Greece have resulted in a wide variety of environmental conditions with a wide range of natural conditions, from high mountain areas to subtropical regions. Its mountains, many of which exceed 2,000 m in altitude, offer all kinds of conditions with a wide variety of woods, fields, and rocks; its lowlands include wide river deltas and lagoons. Greece also has many lakes and streams. Some large rivers in northern Greece (the Axios, Strimon, Nestos, and Evros) enter from the Balkan Peninsula, crossing two or more countries.

Greece's total coastline amounts to about 15,000 km. Greece has more than 3,000 islands with rocky or sandy coasts, duns, caves, bushes, and woods, scattered from the North Ionian Sea to the southernmost point of Europe (Gavdos Island) to the easternmost point of Europe (Castellorizon Island). Areas of more than 2,000 m in depth exist in the Greek seas (General Environmental Characteristics of Greece, 2000).

Figure 1. Geographic map of Greece
(https://en.wikipedia.org/wiki/Geography_of_Greece)

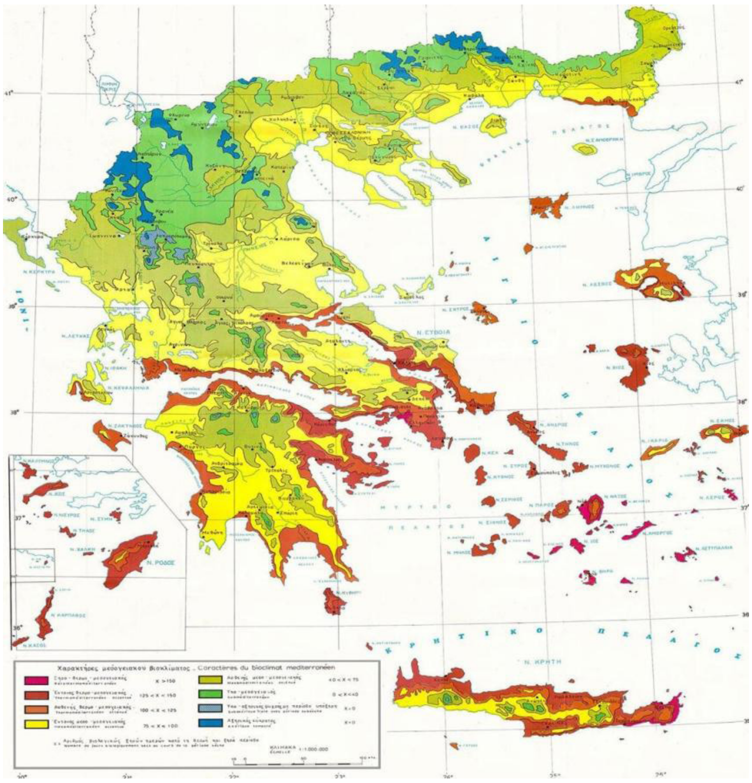

Figure 2. Bioclimatic map of Greece (https://www.geogreece.gr/bioclima_en.php)

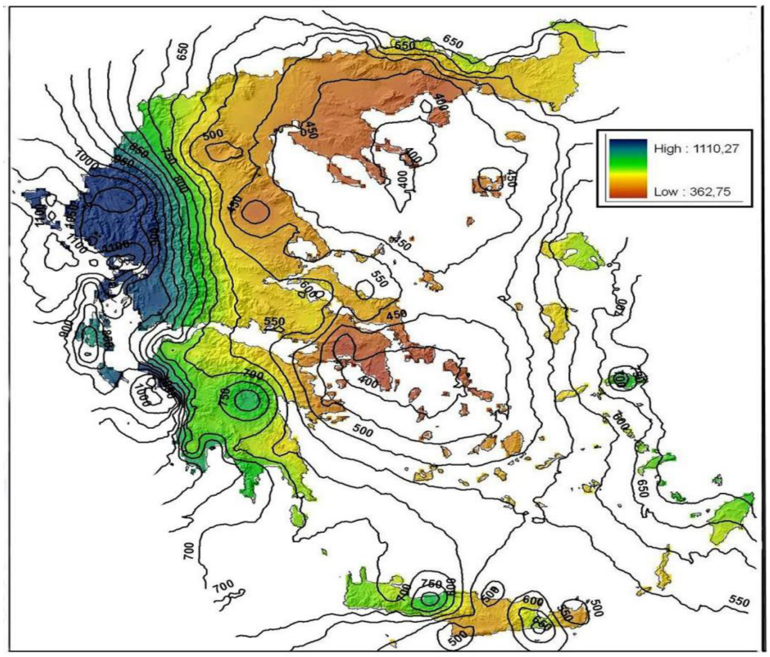

Figure 3. Rainfall map of Greece (https://www.geogreece.gr/rain_en.php)

Beaches and sand-dunes

A variety of fauna and flora can be found along these areas. Biological and abiotic properties allow them to describe areas where most human activities occur. Due to their sensitivity to minor environmental pressure, sand dunes are an especially sensitive ecosystem. Tourism development places a great deal of pressure on dunes, as does the construction of recreation facilities, roads for rapid access, urbanization, *etc.* Sand dunes in some cases have been ruined. During the last decade the worth of these ecosystems has been widely recognized.

Rocky coasts

They represent 70% of the Greek coastline. The fauna and more particularly the flora of these areas are significantly different, but still present a high quantum of biodiversity.

Wetlands

There are a variety of wetland types throughout the country, where rare bird species can be found. There are a lot of lagoons and marshes along the coast. There are also 8 large deltas. These ecosystems are exceptionally fragile and constitute the biotope of a large number of species (Kosmas *et al.* 1997).

Coastal ecosystems

In particular, the wetlands and sand-dunes of the Greek coastal and marine ecosystems show high productivity, and the survival of numerous species of fauna is particularly important to the preservation of biological diversity.

In Greece there are:

- More than 6,000 species of flora, a considerable part of which is found in coastal areas and islands. 263 of them are considered rare and threatened
- More than 670 species of vertebrates
- 436 bird species, covering almost all those mentioned in the EC Directive 79/409
- 81 specially protected areas for wildlife in coastal areas out of 151 for the whole country, because small islands and rock formations provide valuable shelter and habitat for seabirds.

Forests and shrubs in coastal areas often create, together with the sea, a landscape of great aesthetic value, while minimizing flooding, erosion, and other natural hazards.

II.2 Impacts of coastal uses (SEA and LAND) on economic sectors

Natural habitats and resources (land, freshwater / sea, energy, fisheries, *etc.*) are under increasing pressure, and infrastructure development (ports / marinas, transport, wastewater treatment plants, *etc.*) is also affecting coastal areas (EEA, 1999).

It has been already identified by the National Report on the management of coastal zones in Greece (European Environment Agency, 2017) four types of problems arising from human activities and human mismanagement, indifference, and ignorance in coastal ecosystems:

a) concentration of population and activities in a relatively limited and sensitive area.

b) frequent collisions from incompatible uses in the same or adjacent areas.

c) overexploitation of natural resources

d) Inability to make decisions, implement policies and coordinate competent authorities.

The main pressures currently facing the marine and coastal environment are (Gilek *et al.* 2021):

- In coastal areas, industrial development reduces wetland productivity by polluting the area, which includes heavy metals and nutrients (risk of blooms), as well as affecting circulation conditions and water temperatures.
- The construction of embankments or dams, to block quantities of water for use in agriculture can affect the operation of coastal wetlands by reducing freshwater inflows and through changes in water circulation.
- The development of activities in the coastal zone and in the dunes, can change the patterns of transport of sediments or modify the existing ones.
- Activities associated with marine aquaculture (which in tropical areas often involve the destruction of mangrove forests to create artificial aquaculture ponds), can negatively affect the complex interrelationships of mangrove systems that regulate shorelines and shores.
- Port development can, for example, degrade coral reefs and seagrass through sediment accumulation.
- Coastal pollution is also caused by land activities such as logging, agricultural practices, such as the reckless use of pesticides (*e.g.*, nitrate pollution), and livestock production practices such as the contamination of waterways by animal waste.

II.3. Depletion of beach sediment budget

The human interventions at the origin of coastal erosion, almost always at the same time as natural causes, are mainly the following:

- Coastal river basins management projects (hydroelectric dams, irrigation dams, water reservoirs) as well as technical interventions in river sources and the deltas, can considerably reduce the river.
- The effluents and consequently the coastal sedimentary river (Kevrekidis *et al.* 2003).
- Intensive construction of coastal defense projects (e.g., breakwaters, jetties) in most cases, but also earthworks and embankments (Aristeidis, 2012).
- Sediment extraction (sand mining) from riverbeds, beaches and the inland plateau which can significantly alter the coastal sediment balance (Kapsimalis *et al.* 2005).
- Buildings within the active wave zone, especially those on or near the coast, which interfere with the natural processes of wave energy, creating erosion and generally disrupting the dynamic behavior of large sections of the coast, along with the construction of coastal roads and port projects that can significantly alter coastal sediment transport and cause systemic erosion (Marchand, 2010).
- Overexploitation of coastal aquifers (which also causes salinization problems) and / or natural gas deposits that can dramatically increase the relative rise in sea level.
- And more recently, the creation of strong, high-curvature ripples from speedboats sailing near the shores (Soomere, 2005) which can create intense coastal erosion.

Table 1. Types of shoreline classification proposed according to the modes of shoreline modification (Galgano and Leatherman, 2019)

Type	Classification
1	Simple linear retreat
2	Alternating erosion and accretion
3	Progressive erosion alongshore
4	Storm punctuated erosion
5	Inlet-induced erosion
6	Cyclic shoreline change
7	Mesotidal barrier behavior
8	Apparent island rotation
9	Pre-Holocene controlled configuration
10	Gradual erosion over time
11	Cape-like features
12	Spit elongation

II.4 The erosion of the Greek coastline

According to studies conducted in Europe (Map 3), 1/5 of its coasts recede at rates ranging from 0.5 to 2 meters per year. In extreme cases, the rate even reaches 15 meters per year. EUROSION study4 reports that more than 15 square kilometers per year are lost or significantly affected (European Environment Agency, 2017). The effects of coastal erosion vary from region to region. Greece is the 4th EU country with the highest levels of erosion (28.6%) after Latvia (32.8%), Cyprus (37.8%) and Poland (55%). A distinctive characteristic of coastal erosion in Europe is that it is caused more by human activity than by natural factors (National Institute for Coastal and Marine Management of the Netherlands, 2004).

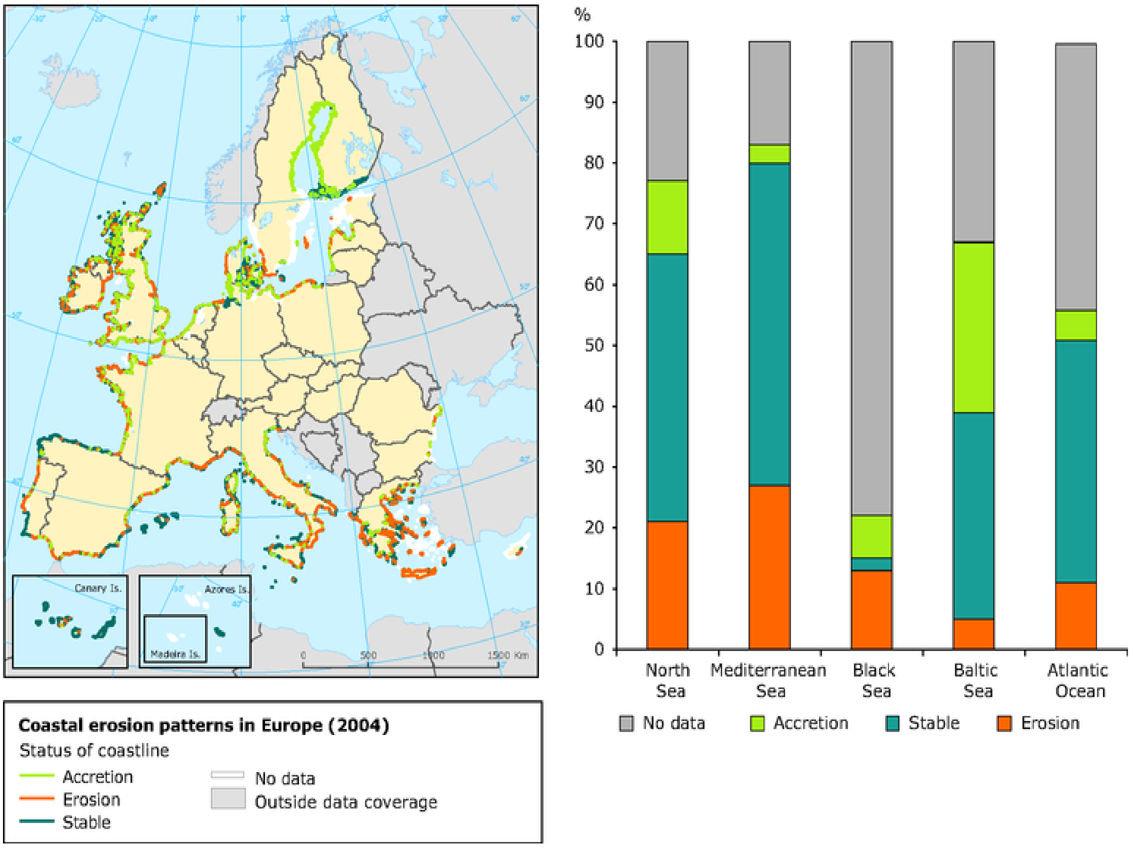

Figure 4. The map and the graph show the coastal erosion patterns in Europe (2004) (https://www.eea.europa.eu/data-and-maps/figures/coastal-erosion-patterns-in-europe-1)

There are three main reasons for the increased erosion in Greece: strong winds and storm surges (especially in the Aegean Sea), human intervention (*e.g.*, dams that reduce the solid supply (Llasat *et al.* 2010), as well as the geomorphologic substratum of the Greek coastline: 2,400 km (15% of the total coastline) correspond to soft sediments, while 960 km (6% of the total coastline) correspond to coastal deltas.
The construction of technical works in coastal areas or the development of other similar activities have disturbed the natural balance and have accelerated the erosion and retreat of the coast. It has now been confirmed that the widespread use of concrete, although originally aimed at stabilizing the coast, has nevertheless had negative effects. In most cases, parts of the coast that were subject to “harsh” “protection” methods after short periods of time ended up in a worse situation. In particular, the inefficiency of the purely technical approach became evident when the cost of repair work became more expensive than shore protection units.

II.5. Degradation of coastal water quality and associated life forms

Worldwide, humans have heavily impacted coastal and estuarine ecosystems through pollution and habitat loss. More than 80% of all marine pollution originates on land, primarily from industrial, agricultural, and urban sources. Pollution accompanies most kinds of human activities, including offshore oil and gas production and marine oil transportation. Besides altering the marine environment, pollution also causes economic losses.

Degradation of the marine and coastal environment is caused by tourism and urbanization (roads, houses, hotels) in coastal regions. Sewage is the largest source of contamination. The state of pollution in most ports, gulfs, estuaries, and marine coastal areas in Greece assorted considerably. With the completion of sewage works in many Greek cities in the last decade, an improvement in the quality of seawater has been established.

The Greek coastal areas are of high biological, geophysical, aesthetic, cultural, and economic value, while at the same time they constitute a natural resource and a common heritage of Mediterranean and European seas. The Greek coastal and marine ecosystems are distinguished by high productivity, particularly the lagoons, river estuaries and deltas, meadows of Posidonia, wetlands, sand dunes *etc.* The sea coastline contains the biotopes of numerous species of flora and fauna with high biological diversity. Marine waters and environmental conditions in Greece have been studied more methodically and widely in recent years. Marine flora and fauna were studied at physiological and ecological levels (Valavanidis, 2018).

III. The impact of visitors on coastal ecosystems

The coastal areas of the country are home to over 57% of the population. The land in the four out of five prefectures is along the coast, covering 76% of the total land area. Greece with a total population of 10,964,020 (in 2001) is characterized by its high coastal concentration. Specifically, the population living on a relatively narrow strip of land 1-2 kilometers from the coast constitutes 33% of the total population (Tsimopoulou and Lioutas, 2010). The economic activities of the coastal population cause intense pressure on the natural habitat.

The economic activities and the impact of human intervention on the coastal zones can be summarized in four types of problems:

- Concentration of population and activities in rather limited and sensitive space.
- Frequent conflicts of incompatible uses in the same or adjacent areas.
- Overexploitation of natural resources.
- Weaknesses in the decision-making process, the implementation of policies and the coordination of competent authorities.

IV. Identification of uses and impacts on the coastline and coastal fringe

IV.1. Impact on tourism

The tourism industry is one of the main sources of national income for Greece, as it annually contributes annually more than 18% of the country's GNP (Gross National Product), creating around 700,000 jobs and contributing significantly to the regional development. Tourist activities cover an important part of Greek coastal areas. Specifically, 90% of all tourist activities and recreation are placed on the coast. Accordingly, this concentration of sun, sea, and sand makes sense for the type of tourism developed in Greece, although it is often linked to cultural sightseeing. A very small part of tourist installations can be found in other areas. Policy makers and investors have focused their efforts on expanding the tourism product and improving the services available in recent years.

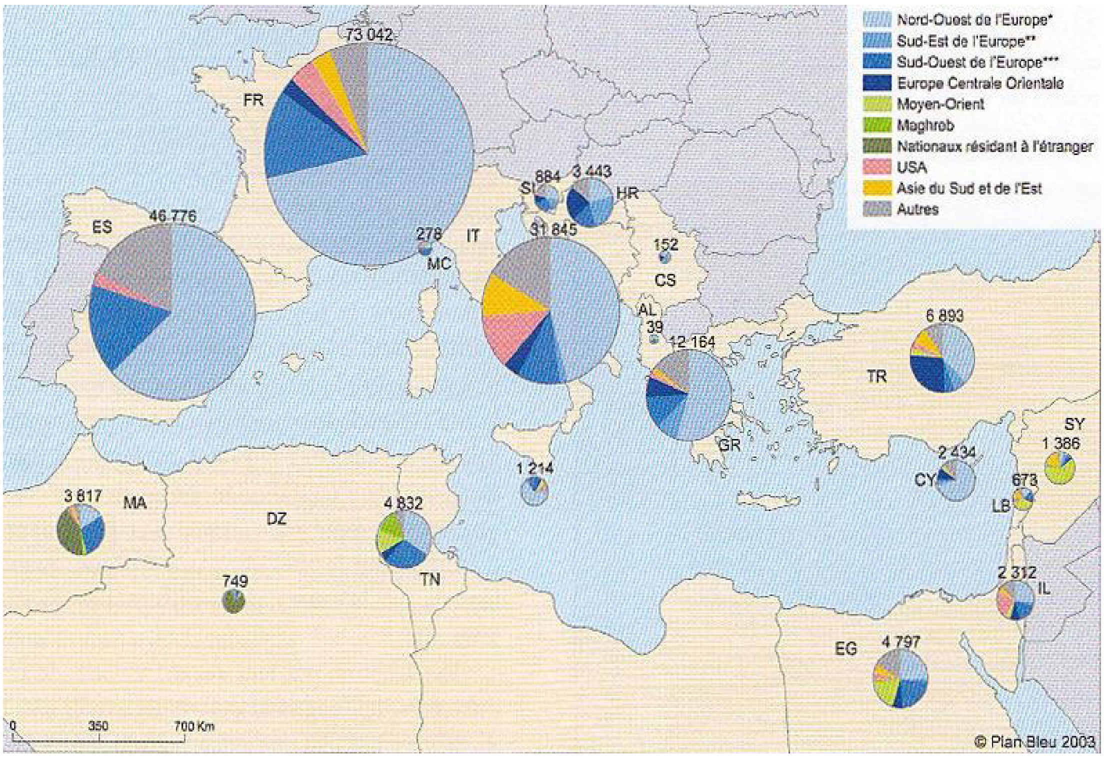

Figure 5. Number (in thousands) and origin of international tourists in Mediterranean countries in 1999 (Omeau, 2005)

As tourism develops rapidly, the regions that make the most profit are mainly those with coastal or island parts like Crete, Rhodes, Cos, Cyclades, Corfu, Halkidiki, Argolida, *etc.* There is still a strong opportunity for tourist development in these and other areas, which is gradually materializing as new public investments give better access (*i.e.*, roads, airports, marinas, *etc.*) or better services (*i.e.*, wastewater treatment, telecommunications *etc.*).

Tourism development has been correlated with a gradual degradation of environmental quality, including environmental destruction, due to urbanization along the coast and deterioration of the built environment in traditional settlements. Although Greece is not characterized by large-scale tourist facilities, to the extent that other Mediterranean destinations have developed, in several cases the impacts of tourism associated with urban development and sprawl have altered the scale and architectural character of traditional settlements, despite the rules of construction and aesthetic control. Many islands that are popular tourist destinations have small human settlements. Besides the control of urban evolution, tourism also has to do with the function of human settlements. It can be cited as typical problems of several tourist areas, where profusion of services and beach locations, liquid and solid waste disposal, noise, and traffic congestion often exceeds the capacities of local governments to manage. Such problems are caused by the strong seasonality of tourism in Greece. During summer, population concentration is high, often exceeding the carrying capacity of the natural ecosystem and organizational structures (*i.e.*, infrastructure and services), resulting in severe impacts.

Tourist development along popular Greek tourist destinations (*i.e.*, on the Aegean islands) leads to problems with natural resources and ecosystems. These problems are directly related to the mass arrivals of people to specific tourist destinations in summer months, which may exceed the endurance limits of the host sites (Tsimopoulou and Lioutas, 2010).

There is an overexploitation of water due to the increased needs created by tourist activity. This phenomenon occurs more often on islands and coastal areas of the country during the summer, when water reservoirs are limited, further causing the water to salinize. Consequently, fresh water is no longer available for drinking, and at the same time agricultural fields which are irrigated by the same water reservoirs become salinized, negatively impacting agricultural production and soil health ecosystem. There is therefore degradation in the form of desertification with arid and humid zones with the typical example of insular Greece.

The case of Heraklion in the Cyclades highlights the above problem, since the daily water consumption in winter amounts to 30 m^3, while in summer, due to tourist traffic, it reaches 150 m^3 (Tsartas *et al.* 2010).

On top of this, illegal constructions and rubble on the hydrographic network, the poor location in general, as well as inadequate design of projects lead to erosion of the landscape and geomorphologic changes around the area. The uncontrolled construction of facilities in tourist and potentially tourist areas bring in turn an imbalance in the ecosystems of the wider area, in addition to the aesthetic degradation of the landscape.

A large percentage of the carbon footprint of the global aviation industry is the result of its transportation, which is linked to the movement of tourists. Approximately 3% of Europe's energy consumption comes from tourism, which is responsible for more than 50% of the nitrogen oxide emissions associated with the photochemical cloud (Maridakis, 2017).

Improper waste management, which multiplies during peak periods of tourist traffic, leads to catastrophic consequences for the environment and affects the natural resources. The operation of illegal landfills, in addition to the aesthetic degradation of the landscape, contaminates the aquifer and land horizon, endangering the marine and terrestrial flora and fauna. At the same time, the risk of deliberate ignition or incineration of waste there is high, and when it occurs, it releases harmful chemicals into the atmosphere, making it heavier. 10% of annual fires in Greece are attributed to illegal landfills.

Likewise, sewage pipelines contribute to the eutrophication of lakes and seas, manifesting as an overgrowth of phytoplankton and other organisms, contributing to the development of harmful organisms that pollute water sources. The fines paid by Greece for operation illegal landfills Indicative of this problem are the fines paid by Greece in the South Aegean Sea, which amounted to three million in 2015, 2.4 million in 2016, two million in 2017 and 920 thousand in the first half of 2018, are indicative of this problem (mykonosvoice.gr).

The erratic expansion of infrastructure and housing for the sole purpose of making a profit by attracting and facilitating more tourists, without taking into account the carrying capacity of the place, can disrupt the functioning of ecosystems. Fragmentation of natural space by road construction and noise degrades ecologically sensitive areas and limits living space, hampering communication and movement of species. Typical cases of rare species of animals affected by the phenomenon of mass tourism are the *Caretta caretta* turtle that lays its eggs on the beaches of Zakynthos at a time when there is a strong tourist presence, as well as the *Monachus monachus* seal that leaves sea areas because of marine motor sports activities (Tsimopoulou and Lioutas, 2010).

IV.2. Industrial impacts on the coast and coastal zone

More than 80% of all industrial activities are in coastal areas. In most cases, the industries that lean toward coastal locations are those that use water as a process or require water to be accessible for transportation purposes. Coastal areas constitute all major industrial centers of Greece, as all major cities of the country are located on the coasts. The traditional role of maritime transport in transporting industrial products (*i.e.*, mining raw materials, cement, *etc.*); but also due to the location of the Patras-Athens-Thessaloniki major road transport axis scheme.

With the evolution of cities, urban environmental issues became significant both locally and on a national and global scale. Serious environmental issues like habitat degradation, water contamination, coastal erosion, and resource depletion.

There are serious problems with other activities in some mining areas, mainly tourism, because mining is usually located near the coast. Industrial locations have been in the past also a cause for environmental or land use conflicts in coastal sites mainly relating to the processing of raw materials (*i.e.*, alumina plants, oil refining or gold smelting).

IV.3. Marine transport

Due to the length of the coastline and the number of islands in Greece, maritime transport is of particular importance. Coastal navigation services are directly responsible for the stability and reliability of the territorial and social fabric of the union, serving 94 islands and transporting 36 million passengers per year. There are altogether 20 ports with more than one million tons of cargo per year each. Regarding general shipping activities the following facts can be mentioned:

- Greek interests control 3,338 vessels of various categories.
- Greek vessels registered under the Greek flag included 969 vessels in 2005.
- Internationally, Greek interests control approximately 9.1% of the world's total number of vessels in service and on order, and 18% of the deadweight of the world fleet, or 15.5% in gross tons.
- In terms of vessels on order, Greek interests represent 7.8% of the total number of vessels, 12.2% of the total DW or 10.2% of the total GT.

Compared to other modes of transport, maritime transport is considered more environmentally friendly. In principle, the state of the environment in the areas connected to the ports can be considered satisfactory. However, the constant evolution of the volume transported has led to the overloading of many ports. For this reason, together with a lack of as well as a lack of available space and suitable access, there is a greater possibility for negative effects on the marine habitat as well as the deterioration of nearby urban areas.

V. Maritime activities and impacts

V.1. Fishing

There are most fishing vessels in the Mediterranean coastal states of Europe, including Greece, Italy, Spain and France. As technology advances, trawlers are becoming larger and multi-purpose vessels are becoming more powerful, advancing fishing techniques. According to statistics, "passive" ships have increased, while trawler numbers have remained stable thanks to EU fleet reduction programs. This is linked to the reduction in the number of trawlers in Spain and Italy. It was not the same with France, Greece, and North-West African countries where their operations increased (EEA, 1999).

Fishermen often target species of commercial value, such as cod, red mullet, sardines, and anchovies, due to periodic changes in consumers' preferences and distribution centers. This sector is considered of high importance for the national economy, because, despite its small contribution to the GNP, it contributes to the social and economic cohesion of the coastal zones, which constitute an extended part of the country. Around 40 000 people are employed in this sector, with a fishing fleet of around 19,000 vessels, while the annual production in all categories (sea fisheries, aquaculture, lagoons *etc*.) amounts to around 231,000 tons.

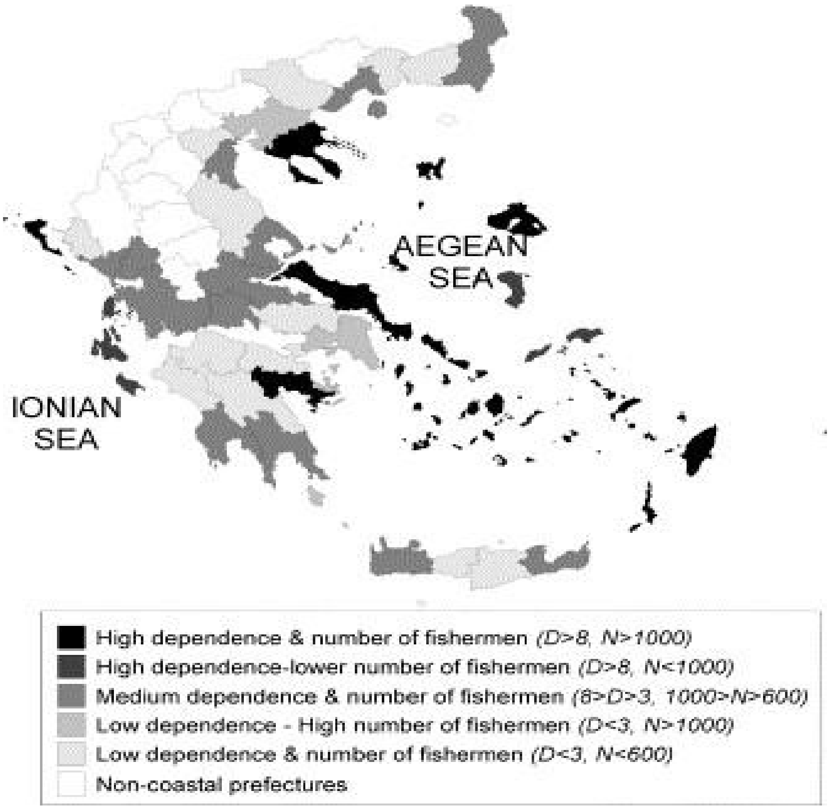

Figure 6. Grouping of Greek prefectures using as criteria the dependence on fisheries (D) and the number of fishermen (N) (Tzanatos *et al.* 2005)

There are almost 17,000 professional fishing boats in Greece with a wide variety of features and activities, mostly used for multi-species and multi-gear fishing. There are 360 trawlers over 12 meters, 300 purse seines, 400 beach seines, 530 surface long liners, 16,800 gill-netters and bottom long line, the majority of which are less than 12 meters in length. The large number of gillnet fisherman highlights the importance of shore fishing, even today, which continues to be one of the most important activities of the coastal zone, both economically and socially. In distant islands or isolated areas fishing is still the main activity. In these areas, where there is generally no alternative to agricultural employment, fishing and tourism support each other and allow many families to live in areas that would otherwise be empty (Maina *et al.* 2016).

V.1.1. Trawlers

The Greek offshore vessels have two types of licensing. There are vessels with a license for bottom trawling and vessels that incorporate both licenses for bottom trawling and purse seine. Since the 1970s fishing with bottom trawling has been forbidden for the period June to September every year in Greek waters. Some of the offshore vessels that had both licenses, before the inspection system that has become widespread today, had this superiority and could therefore change both ways of fishing. In accordance with the pertinent arrangements, purse seiners stop fishing during the period 15 December - 28 February. However, there are two factors that determine the start of the alternative purse seine fishery:

- The amount of benthopelagic species that are caught, deciding the costs of fish in the market.
- The costs of the small pelagic fish specifically anchovy and sardine.

These are usually the months when bottom trawling is lucrative when bottom trawler efficiency decreases and eventually stops at the end of the month, but dual-licensed vessels allow bottom trawling to continue throughout the month. However, if the quantities of benthopelagic species decrease or if the demand for anchovies and sardines, which are the main pelagic species fished, is high; then gradually these vessels change their gear and start fishing with purse seines. With the above pattern the number of vessels that are landing their catch in the country's fish wharfs gradually diminishes towards the end of May (Maina *et al.* 2016).

Greek fisheries are affected by the general principles of Mediterranean fishing policy and the measures proposed at a European level. The current Common European Policy which aims at the general reduction of the fishing vessels is leading many fishermen to withdraw their vessels and retire from the profession. In that way the most dynamic sectors, those of professional fishermen, are being weakened and strengthened the tendency for a partial occupation in fishery. In addition, it excessively increased the number of coastal fishing vessels with crews that, in some cases, have the slightest relationship with the sea.

V.2. Importance and diversity of the fishing sector

Overfishing in the Mediterranean and Greek seas averages 82%, compared to 63% for that of the Atlantic Ocean; thus, reflecting the increased threat to fish biodiversity in the Mediterranean.

In addition, overfishing can result in the degradation of the seabed and its ecosystems. The use of sliding fishing equipment at the bottom has negative effects on the benthic flora and fauna. Trawls, dragging their doors and nets to the bottom, are ruining sensitive marine ecosystems such as coral colonies and Posidonia meadows that take hundreds of years to form. In the same way, stony and coral bottoms are threatened. Sandy bottoms though are also affected by trawling to varying degrees with alterations in sand grain distribution, porosity and suspended sediment growth. Explosives have been used as fishing methods in some sea areas, with more dire consequences for the environment and the endangerment of thousands of dolphins and other mammals.

Fishing gear is threatened by marine life, such as pelagic long nets, foam nets, trawls, trash, and plastics that organisms such as sea turtles mistakenly swallow thinking they are warblers (EEA, 1999).

V.3. Aquaculture

With about 110,000 tons of mixed production in 2015, the Greek aquaculture industry consists primarily of farming offshore cages that farm marine finfish, primarily gilthead sea bream and European seabass. Next comes the breeding of Mediterranean mussels with an annual production capacity of up to 35,000 – 40,000 tons in 2015. Several crises have led to a restructuring of the marine fish sector, which is intended to double its production by 2030, primarily due to imbalances between supply and demand. To achieve this goal, methods containing targeted research, evolution, and modernizations to optimize production diversification of products; and concerned marketing actions through evolution of new approaches, such as producers' organizations, are under consideration. Freshwater species and extensive lagoon aquaculture have limited growth potential mainly due to the lack of availability of natural resources (water, wild stocks). Marine fish is the top Greek exported animal product and contributes about 11 percent of the total national agricultural exports (which together account for 19 percent of the total Greek exports).

Marine fish farming large cages of about 120 m in perimeter, suitable for holding up to 250–300 tons of finfish, are available to escalate production and move the industry further offshore to evade environmental problems. Fish reach marketable size (350–450 g) in 12–24 months, depending on the local water temperature which alters between sites (FAO, 2005).

Mussel farming Traditionally, mussel farming exists in hanging parks located in shallow waters near estuaries in the northern part of Greece. The use of single longline floating ropes allowed to extend further offshore and to mechanize the production process as much as possible.

Lagoon aquaculture Widespread aquaculture is in coastal lagoons mostly located in the western and northern part of Greece. As a capture-based activity, the fry is collected from wild stocks, usually euryhaline species, such as flathead grey mullet (*Mugil cephalus*), sparoids, seabass, and eels. The juveniles then mature naturally until they reach harvest size.

Number of Installations in Greece, as of 2012–13, there were 1,045 aquaculture installations of which 57 percent were mussel farmers, 36 percent were marine fish farm sites including hatcheries and the remaining 7 percent were inland installations. In the mussel farming sector, there were 595 farm sites, most of them in northern Greece.

As far as the marine finfish sector is concerned, there are 63 companies operating 336 farm sites spread throughout the country, as well as 36 land-based hatcheries. Marine on-growing farms can be categorized according to their annual production into small (<300 tons), medium (300–1,200 tons) and large (>1,200 tons). The broad category is often made up of producer groups and organizations of individual enterprises. In Greece, most of the producers are small to medium-sized family businesses.

There were 78 farms focusing on freshwater aquaculture on the mainland. The lagoon aquaculture industry included 72 organizations, most of which were cooperatives, occupying a space of 40,000 ha with a production of around 600 tons. The number of farms has been relatively stable and did not expand during the crisis period (FAO, 2005).

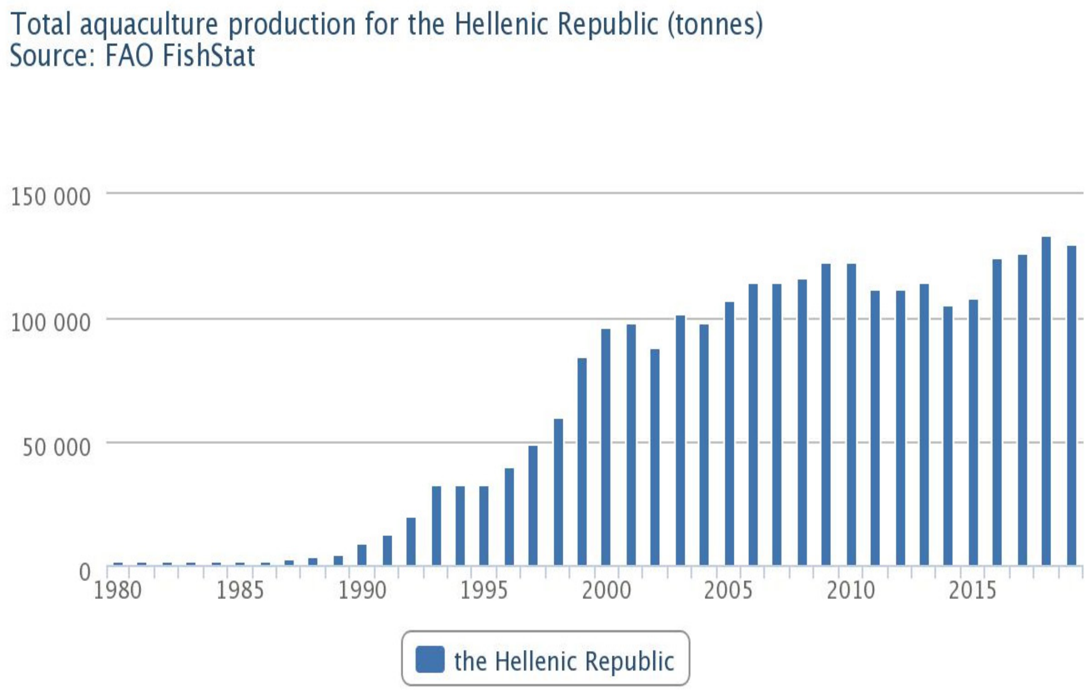

Figure 7. Total aquaculture production for the Hellenic Republic

V.3.1. Environmental impacts of marine aquaculture operations

A large amount of infrastructure and operations relating to marine aquaculture can, for example, affect scenic rural areas. A large quantity of effluent from fish production is generated, including waste feed, medications, and pesticides, which can have detrimental effects on the environment. There may also be unwanted effects on wild populations, such as genetic interactions between escaped farmed fish and wild fish, disease transfer by escaped fish or through ingestion of contaminated waste by wild fish and effects on the wider ecosystem. Considerations of the sustainability of aquaculture include, importantly, the ecological resources required to sustain the industry, namely, fish food for farmed species and environmental capacity to assimilate waste (Read and Fernandes, 2003).

V.4. Shipping, cruising, and pleasure boating

Maritime ports of Greece. The busiest maritime ports for passenger transport are given by table follows.

Table 2. Maritime ports of Greece

The busiest maritime ports for passenger transport	The busiest maritime ports for goods transport
Aegina Antirrio Corfu Heraklion Igoumenitsa Keramoti Kyllini Mykonos Paloukia (Salamis) Paros Patras Perama Piraeus Rafina Rio Souda Bay (Crete) Thasos Thira (Santorini) Tinos Zakynthos	Agioi Theodoroi Aliveri (Euboea) Amaliapoli/Almyros Antikyra Antirrio Eleusis Heraklion Igoumenitsa Kavala Larymna Megara Milos Paloukia (Salamis) Patras Perama Piraeus Rio Thessaloniki Volos

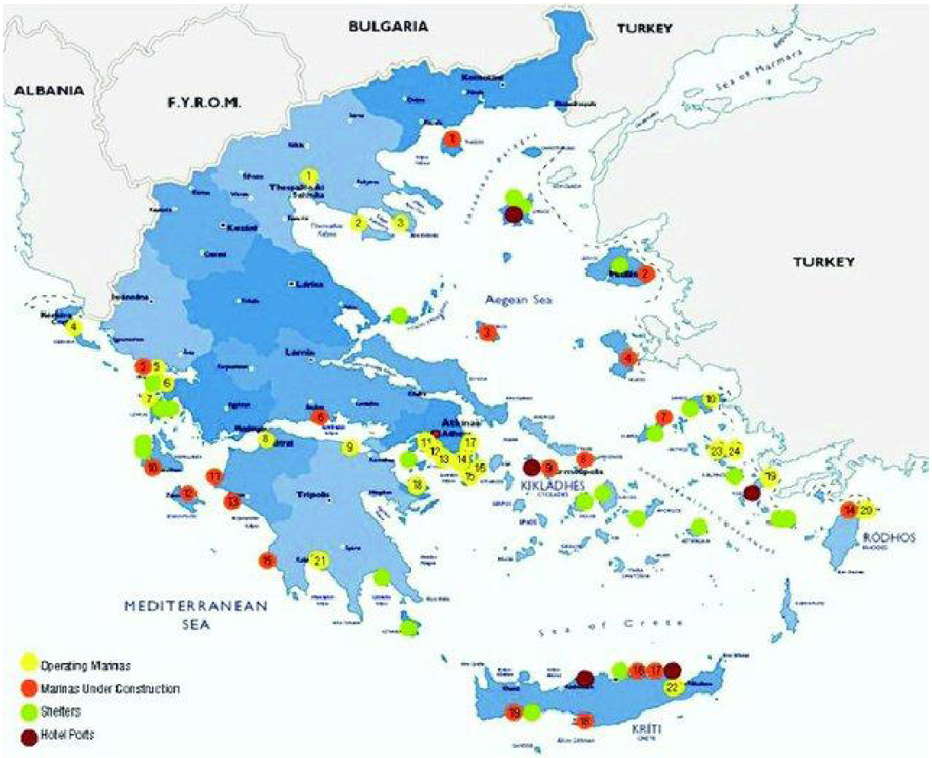

Figure 8. Location of marinas in Greece (Papadimitriou, 2009)

V.4.1. The case of Piraeus

The Port of Piraeus, which welcomed more than one million cruise passengers in 2015, is one of the largest cruise ports in the Mediterranean. More than two-thirds of the passengers are transit passengers, staying on average less than half a day in the region. Although the number of cruise passengers has doubled since 2001, the evolution rate in Piraeus lags the average in Mediterranean cruise ports which saw their passenger numbers triple over the same period. Yet the port has extensive dedicated infrastructure for cruise shipping and offers a wide range of services. The presence of several significant tourist attractions within easy reach is also making it an attractive destination for tourist excursions (Pallis, 2015).

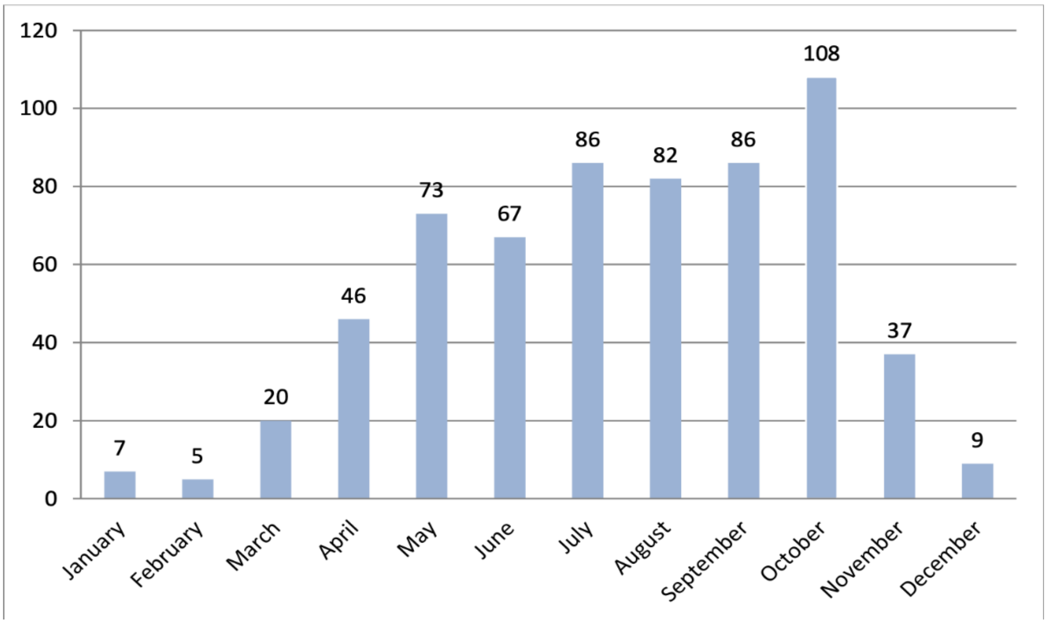

Figure 9. Number of cruises calls in Piraeus per month (2014) (Pallis, 2015)

V.4.2. Environmental impact: Important air emissions and congestion

The negative externalities that port traffic generates reduce overall benefits derived from port activities, in addition to the economic and social advantages. Piraeus is no exception to the rule and traffic density at the port implies that these are significant. Cruises are an important contributor, generating especially air pollution and extra-urban congestion.

Cruise ship air pollution

Piraeus' high traffic density makes coastal passenger ships the biggest emitters, generating about twice the emissions of cruise ships. If cruise ships contribute to less overall air pollution, emissions per cruise passenger are much higher than per coastal passenger. Because cruise ships stay docked for several hours, their engines must be running constantly. This produces a larger number of emissions. It was found that 88.5% of cruise ship generated emissions at Greek ports are due to hoteling mode fuel consumption. The emissions from ships at berth are between three and five times higher than those produced during ship maneuvers.

From May through October, cruise ship emissions are highly concentrated. While coastal shipping emissions occur rather evenly throughout the year, those from cruise ships are concentrated over the six-month period. According to Maragkogianni *et al.* (2016), 58.5% of the year's emissions were produced during the summer while winter contributed only 0.9%. The number of negative emissions attributed to cruise shipping is significant. This is mainly because trucks, buses, and cars used to take passengers into and out of ports (Maragkogianni *et al.* 2016).

VI. Impacts of power, sanitation and desalination stations

Energy production in Greece is dominated by the state-owned Public Power Corporation (known mostly by its acronym ΔΕΗ, or in English DEI). In 2009, DEI supplied 85.6% of all electrical energy demand in Greece, which dropped to 77.3% in 2010. Nearly half (48%) of DEI's electricity production is generated from lignite, down from 51.6% in 2009. 12% of Greek electricity comes from hydroelectric plants and 20% from natural gas. Between 2009 and 2010, energy production by independent companies increased by 56%, from 2,709 Giga watt hours in 2009 to 4,232 GWh in 2010 (Public Power Corporation, 2011).

VI.1. Impacts generated by coastal power stations

There are some of the main impacts generated by this kind of heavy, but strategic installation for the development of the country, particularly at the level of coastal towns with an industrial and tourist vocations:

The main problems that come from power stations in coastal areas are:

- The impact of the installations, such as the turbines, transformers, pumps, suction basins, desalination basins, pipes, drainage channels, and others, of the power plants on the environment and human health
- Noise emissions.
- The discharge of cooling water.
- Water discharge.
- The collection and suction circuit of water from the power plants.
- Atmospheric emissions.
- Solid discharges.

Table 3. Hydroelectric power stations in Greece

Station	Site	Coordinates	Capacity (MW)
Kastraki Dam	Kastraki	38°44′30.69″N 21°21′51.05″E	320
Kremasta Dam	Kremasta Sykias	38.8839511°N 21.4937961°E	437
Ladon Dam	Arcadia	37.7577°N 21.9716°E	50
Plastiras Dam	Karditsa	39.235556°N 21.746389°E	130
Stratos Dam	Stratos	38.6758027°N 21.3258898°E	150
Thisavros Dam	Drama	41.354444°N 24.366944°E	384

Table 4. Thermal power stations in Greece

Name	Location	Coordinates	Fuel	Capacity, MWe	Operational
Agios Dimitrios Power Station	Agios Dimitrios, Kozani	40.394°N 21.925°E	Lignite	1500	
Agios Georgios Power Station	Keratsini	37.95429°N 23.61023°E	natural gas, oil	360	
Aliveri Power Station	Aliveri	38.38953°N 24.05174°E	heavy oil	300	
Amyntaio Power Station	Amyntaio	40.6193112°N 21.6829133°E	Lignite	600	1996
Atherinolakkos Power Station	Atherinolakkos	35.0039°N 26.13916°E	heavy oil	105	2004
Thisvi Power station	Thisvi	38.236243°N 22.949866°E	natural gas	410	2010
Florina Power Station (Melíti Power Station)	Melíti	40.811°N 21.601°E	Lignite	330	2003
Kardia Power Station	Kardia	40.41°N 21.786°E	Lignite	1200	1975
Komotini Power Station	Komotini	41.064°N 25.49°E	Natural gas		
Lavrio Power Station	Lavrio	37.74629°N 24.06688°E	oil, natural gas	450	
Linopermata Power Station	Linopermata	37.74629°N 24.06688°E	distillate oil	111	
Megalapolis Power Station A	Megalopolis	37.418°N 22.109°E	Lignite	850	
Megalapolis Power Station B	Megalopolis	37.416°N 22.067°E	Lignite		
Ptolemaida Power Station	Ptolemaida	40.4808629°N 21.7269015°E	Lignite	495	
Soronis Power Station	Soronis	36.37842°N 28.0184°E	Oil	105	1976

Table 5. Photovoltaic power plants in Greece

Location	Capacity	Description	Constructed
Florina	4.3 MW	Florina industrial zone	2009
Volos	2 MW	Photovoltaic power plant Volos	2009
Thebes	2 MW	Photovoltaic power plant Thebes	2009
Koutsopodi	1.997 MW		2009
Tripoli	1.99 MW		2009
Pournari	1.25 MW		2009
Iliopenditiki	1 MW		2009
Pontoiraklia	944 kW		2009
Kythnos	100 kW		2009
Sifnos	60 kW		1998
Tavros, ILPAP Building	20 kW		2009
Ethel Station	20 kW		2009
Maroussi, Eirini station	20 kW		2009

VI.2. Sanitation stations

There are increasing numbers of coastal towns setting wastewater treatment thresholds. In some areas, the implementation of innovative and tailored technologies for the treatment of urban and industrial wastewater has been very significant, including the development of a National Wastewater Management Scheme, the construction of tertiary treatment facilities, and the introduction of innovative and tailored technologies. The amount of people served by wastewater treatment plants in 1997 was 5,953,000 (55% of the Greek population). The goals scheduled by JMD 5,673/400/97 contain the construction of a sewerage network for all settlements with equivalent inhabitants >2,000 and the treatment of municipal wastewater before disposal to any aquatic receiver.
The General Chemical State Laboratory (GCSL) is involved in a wide range of activities related to environmental monitoring of drinking and surface water, as well as monitoring of food products, oil spills in seawater, and industrial wastes and hazardous materials.

VI.3 The Environmental Impacts of Desalination Plants and Mitigation Strategies

Environmental impacts of desalination plants include the indirect effect of creating a high demand for electricity power. Fossil fuel-powered desalination plants have environmental effects related to the emission of greenhouse gases or other pollutants associated with power generation. This bad impact could be successful if renewable energy sources (RES), such as wind turbines, solar panels, geothermal energy, photovoltaic units, hydrodynamic energy, *etc.*, were used instead of fossil fuels. Luckily, wind and solar energy are usually abundant in the coastal Mediterranean areas. Plants that rely exclusively on RES have already been built and are currently operating successfully in Greece.

The desalination process directly affects seawater by returning hot, concentrated brine to the ocean. The marine environment is said to be vulnerable to salinity for different amounts of time depending on its location. It is measured by the nature of the marine habitat (coral reef, rocky beach, or sandy surfaces) and by the origin of the existing organisms. However, data that document the impacts of the hyper-saline desalination plant flowing are very insufficient, it is now obviously validated that, especially in the Mediterranean region, the Posidonia seagrass (*Posidonia oceanica,* endemic plant in the Mediterranean Sea) habitat is very sensitive to high salinities come from brine discharge. If desalination brine were not disposed of to the sea at all, this impact could be repealed (Laspidou *et al.* 2010).

Chemical cleaning of membranes and pre-treatment cleaning products can adversely affect the marine environment when they are disposed of in the sea. The desalination brine contains all these products. Due to this, if the brine is compiled and moved to salt works, any unfavorable effects from arranging the brine in the sea can be avoided. Naturally, if the salt produced is directed for human consumption, appropriate measures should be taken.

There is also a significant issue of noise pollution generated by desalination plants. Many pumps and systems for recovering energy, like turbines, create a lot of noise, sometimes exceeding 90 decibels. Furthermore, these plants are in coastal areas, which may attract tourists. Thus, the negative impact on land use cannot be underestimated. Recently, a floating autonomous environmentally friendly and efficient desalination unit was developed by researchers of the Aegean University and now operates in the Aegean Sea. These small plants not only depend on RES to function but have the added advantage of not being located on the coast, but floating further out at sea; this way the impact connected to noise pollution and adverse effect of land use could be overcome (Laspidou *et al.* 2010).

VII. Impact of users and tourism on the coastline and coastal fringe

Tourism, building of hotels and leisure homes, and other activities are putting enormous pressure on the coastal environment of Greece. In many areas there are phenomena of degradation of natural resources due to pollution from human activities, as well as depletion of natural resources (aquifers, forests, mineral wealth, agricultural land of high productivity, *etc.*).

In general, pollution comes from fertilizers and pesticides used on agricultural crops, wastewaters in cities and settlements, wastes from industries and processing plants which are transported via waterways, and mining activity and transportation. At the same time, the lack of infrastructure, such as a sewerage network and biological treatment plants, exacerbates pollution problems in the coastal area.

Coastal areas, and the land uses in Greece in general, are described by the Corine program (45 pages). Land use is divided into a variety of categories such as urban construction, industrial areas, tourist attractions, agricultural crops, forest areas, water recipients (rivers, lakes, seas), archaeological sites, mining areas, transport areas, sports facilities, and wastelands.

Problems with residential development (land use conflicts, arbitrary construction in the city plan). The intensity of human activities in the coastal area creates problems of overdevelopment and destruction of the natural environment. The region of Eastern Macedonia - Thrace faces various urban problems at the expense of the natural environment and productive lands. Land use conflicts are observed in Pontolivado (area with the National Park of wetlands Delta Nestos, Lake Vistonida, Lake Iemarida). In the same region, construction rates are high compared to the limited common and public spaces (Kavala). Also, there are no demarcated settlements of the second house except the settlement of Skala Panagia in Kavala, while there is the phenomenon of arbitrary construction for holiday homes in coastal areas and activities off the building plan.

In The development of the coastal zone in central Macedonia (Pieria - Thessaloniki - Halkidiki), the development of tourism and the distribution of housing in the urban area have contributed to the exploitation of natural resources, especially along the coasts of Pieria, Halkidiki and Strymonikos Gulf. In Western Halkidiki and in the wider area of the Thessaloniki Urban Complex we have land conflicts in areas of arbitrary construction and degradation of significant resources such as high productivity agricultural land and forests. The degradation in the north-western area of Thessaloniki is also due to the concentration of industries. In the region of Thessaly, the urban, semi-urban centers, and the most important agglomerations, if they have road plans, present various problems of implementation. Residential pressures from a second home with arbitrary construction are accepted as mentioned above in the mouth of the Delta Pinios River. The coastal zone of Almyros is under pressure from the large concentration of industrial units.

As a result of island character, the wide extent of administrative borders, and the intense seasonality of tourist activity, there are problems related to organizing and operating distribution and production networks in the areas of communications, transport, and energy in the island area (Aggelidis and Oikonomou, 2005).

VIII. Conclusions

Due to the economic activities which are concentrated along the coastline, coastal zone management is of great importance for Greece. Economic growth and stability depend directly on the quality of the coastline. Although continuous effort has been made to improve coastal management, the current policies have failed to meet expectations, while the proposed new policies have proved difficult to implement.

Lacking a spatial and urban plan, as well as an institutional framework, coastal areas suffer from a variety of problems, such as arbitrary construction, traffic problems, and conflicts related to land use.

In the Mediterranean Sea, land-based activities (urbanization, industry, agriculture) contribute primarily to pollution; however, many questions remain about their relative contributions, different fluxes (rivers, atmosphere, non-point sources, *etc.*) and the fate of the pollutants they produce. In the case of urban and industrial pollution, the main problem is the rapid population development along the southern coasts of the Mediterranean, where there are fewer legal instruments and lesser environmental infrastructure investments.

Mediterranean coastal zones are currently experiencing increased pressures due to rapid urbanization, development of touristic infrastructures, aquaculture and efficient exploitation of marine resources. High-diversity coastal ecosystems are more vulnerable to environmental disturbances than low-diversity ones and therefore their effect is assumed to be greater in the Mediterranean than in northern temperate marine ecosystems. Such perturbations may directly or indirectly result from human activities and can be put into the following categories:

- Pollution
- Over-exploitation of marine resources
- Habitat erosion
- Climatic changes (*e.g.*, through the greenhouse effect)
- Introduction of alien species.

Coastal eutrophication, on the other hand, or other environmental degradation could also play a very important role, as these ecosystems play an important role in their productivity and as nurseries for populations that are essential to the overall ecosystem.

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