Water Supply and Depuration

Greece scale

Co-Evolve4BG

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

Water supply and depuration

Greece Scale

REGION OF EASTERN MACEDONIA & THRACE

OVERVIEW

The present document was produced in the framework of **Co-Evolve4BG** project "*Co-evolution of coastal human activities & Med natural systems for sustainable tourism & Blue Growth in the Mediterranean*" in relation to Threats and Enabling Factors for maritime and coastal tourism development on a national scale" Co-funded by ENI CBC Med Programme (Grant Agreement A_B.4.4_0075).

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I. Geographical framework

Greece, officially the Hellenic Republic, is a country located in Southeast Europe (Fig. 1). Its population is approximately 10.81 million as of 2014; Athens is its largest and capital city, followed by Thessaloniki. Situated on the southern tip of the Balkans, Greece is located at the crossroads of Europe, Asia, and Africa. It shares land borders with Albania to the northwest, North Macedonia and Bulgaria to the north, and Turkey to the northeast. The Aegean Sea lies to the east of the mainland, the Ionian Sea to the west, the Cretan Sea and the Mediterranean Sea to the south. Greece has the longest coastline on the Mediterranean Basin and the 11th longest coastline in the world at 13,676 km (8,498 mi) in length, featuring many islands, of which 227 are inhabited. Eighty percent of Greece is mountainous, with Mount Olympus being the highest peak at 2,918 meters (9,573 ft). The country consists of nine traditional geographic regions: Macedonia, Central Greece, the Peloponnese, Thessaly, Epirus, the Aegean Islands (including the Dodecanese and Cyclades), Thrace, Crete, and the Ionian Islands.

Eighty percent of Greece consists of mountains or hills, making the country one of the most mountainous in Europe. Mount Olympus, the mythical abode of the Greek Gods, culminates at Mytikas peak 2,918 meters, the highest in the country. Western Greece contains a number of lakes and wetlands and is dominated by the Pindus Mountain range. The Pindus, a continuation of the Dinaric Alps, reaches a maximum elevation of 2,637 meters at Mt. Smolikas (the second highest in Greece) and historically has been a significant barrier to east–west travel.

The Pindus range continues through the central Peloponnese, crosses the islands of Kythera and Antikythera and finds its way into southwestern Aegean, in the island of Crete where it eventually ends. The islands of the Aegean are peaks of underwater mountains that once constituted an extension of the mainland. Pindus is characterised by its high, steep peaks, often dissected by numerous canyons and a variety of other karstic landscapes. The spectacular Vikos Gorge, part of the Vikos-Aoos National Park in the Pindus range, is listed by the Guinness book of World Records as the deepest gorge in the world. Another notable formation is the Meteora rock pillars, atop which have been built medieval Greek Orthodox monasteries.

North-eastern Greece features another high-altitude mountain range, the Rhodope range, spreading across the region of East Macedonia and Thrace; this area is covered with vast, thick, ancient forests, including the famous Dadia Forest in the Evros regional unit, in the far northeast of the country.

Extensive plains are primarily located in the regions of Thessaly, Central Macedonia, and Thrace. They constitute key economic regions as they are among the few arable places in the country.

Greece comprises a large number of islands - between 1,200 and 6,000, depending on the definition, of which 227 are inhabited - and is considered a non-contiguous transcontinental country. Crete is the largest and most populated island; Euboea, separated from the mainland by the 60 m-wide Euripus Strait, is the second largest, followed by Lesbos and Rhodes.

The Greek islands are traditionally grouped into the following clusters: the Argo-Saronic Islands in the Saronic gulf near Athens, the Cyclades, a large but dense collection occupying the central part of the Aegean Sea, the North Aegean islands, a loose grouping off the west coast of Turkey, the Dodecanese, another loose collection in the Southeast between Crete and Turkey, the Sporades, a small tight group off the coast of northeast Euboea, and the Ionian Islands, located to the west of the mainland in the Ionian Sea.

II. The influence of human geography

II.1. Population

The resident population of Greece is 10,816,286, of which 5,303,223 male (49%) and 5,513,063 female (51%) according to the official 2011 Population - Housing Census revision of 20/3/2014 (Table 1).

Table 1. Resident population by gender and region in Greece, 2014

Description	Totals			Percent share	
	Total	Male	Female	Male	Female
GREECE, TOTAL	**10,816,286**	**5,303,223**	**5,513,063**	**49**	**51**
REGION OF EASTERN MAKEDONIA, THRAKI	608,182	299,643	308,539	49.3	50.7
REGION OF CENTRAL MAKEDONIA	1,882,108	912,693	308,539	48.5	51.5
REGION OF WESTERN MAKEDONIA	283,689	141,779	141,910	50.0	50.0
REGION OF IPIROS	336,856	165,775	171,081	49.2	50.8
REGION OF THESSALIA	732,762	362,194	370,568	49.4	50.6
REGION OF CENTRAL GREECE	547,390	277,475	269,915	50.7	49.3
REGION OF IONIAN ISLANDS	207,855	102,400	105,455	49.3	50.7
REGION OF WESTERN ISLANDS	679,796	339,310	340,486	49.9	50.1
REGION OF PELOPONNISOS	577,903	291,777	286,126	55.5	49.5
REGION OF ATTIKI	3,282,434	1,845,663	1,982,771	48.2	51.8
REGION OF NORTHERN EGEO	199,231	99,984	99,247	50.2	49.8
REGION OF SOUTHERN EGEO	309,015	155,865	153,150	50.4	46.6
REGION OF KRITI	623,065	308,665	314,400	49.5	50.5

Most of the population (almost 80%) lives in urban areas. Athens, the capital and Thessaloniki, the second largest city have more than 50% of the total population.

The age groups and the percentage share by gender for each one is presented in Figure 2, above.In 2020, urban population for Greece was 79.7% (Fig. 3). Urban population of Greece increased from 65% in 1971 to 79.7% in 2020 growing at an average annual rate of 0.42%.

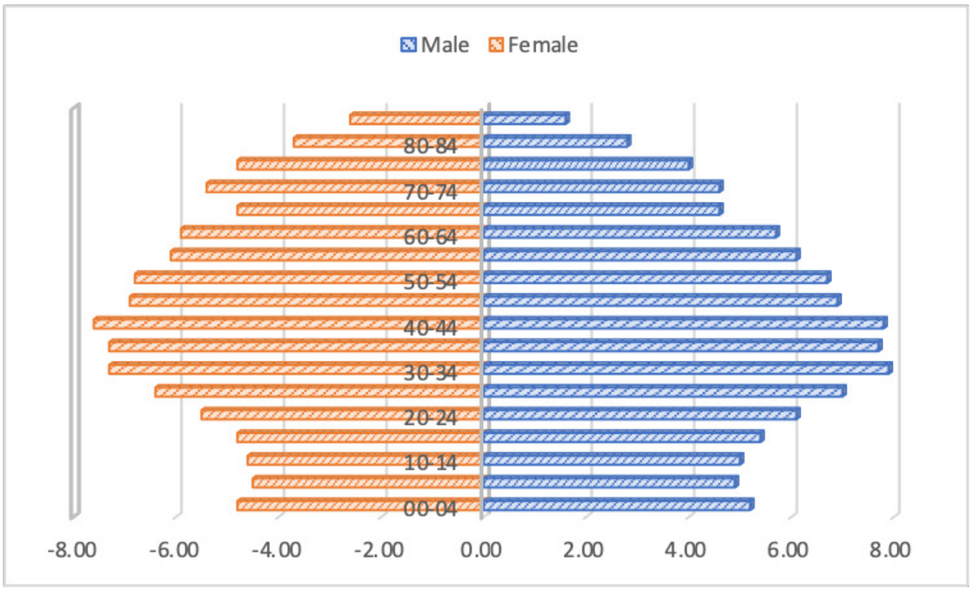

Figure 1. Age groups and percentage share by gender

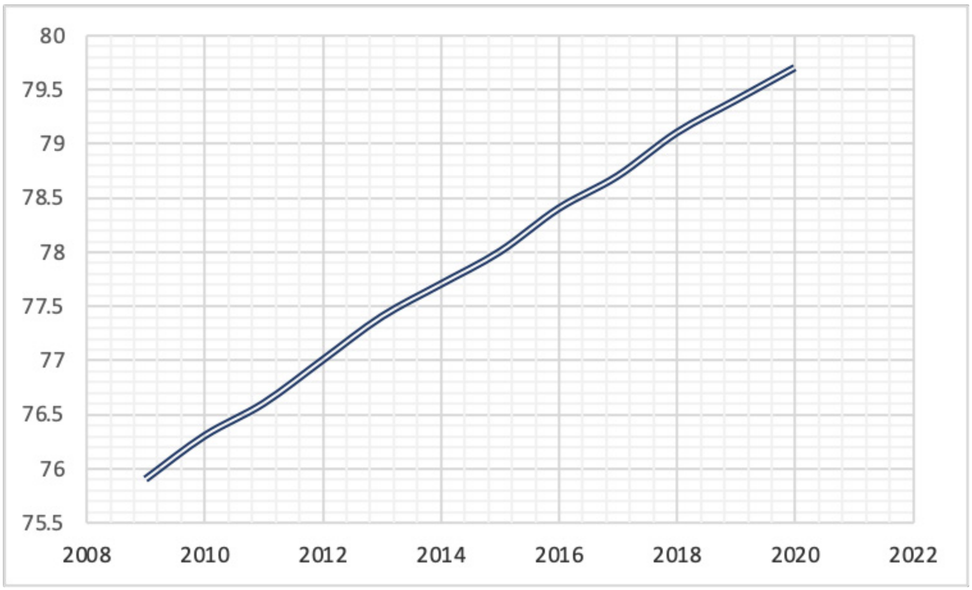

Figure 2. Urban population as a per cent of total population

II.2. Environmental footprint

Environmental (Ecological) footprint (EF) is a measure of the demands made by a person or group of people on global natural resources. It has become one of the most widely used measures of humanity's effect upon the environment and has been used to highlight both the apparent unsustainability of current practices and the inequalities in resource consumption between and within countries (Gikas and Tchobanoglous, 2009a). EF calculations have questioned the sustainability and equity of current consumption and production practices. The Global Footprint Network (GFN), a nonprofit organization that partnered with hundreds of cities, businesses, and other entities to advance the EF as a metric of sustainability that calculates the per capita global footprint. In 2014 the per capita global footprint was 2.8 global hectares (g.ha). Since the global biocapacity that year was 1.7g.ha per person, the EF of humanity overshot Earth's biocapacity by 1.1 g.ha. In other words, 1.7 "Earths" would be needed to sustain current resource demands or, alternatively, it takes Earth more than one year and eight months to regenerate what is used in one year. The implication of such "ecological overshot", which began in the mid-1970s, is that life-supporting biological resources, such as fisheries, forest resources, rangeland, and agricultural land, are being depleted.

From 1961 to 2010, the Mediterranean's per person EF increased by 54%, while per person biocapacity in the region decreased 21%. The average Mediterranean resident now has an EF of 3.0 g.ha, slightly higher than the world-average footprint: 2.7 g.ha and more than double the 1.2 g.ha of biocapacity available per person in the region. In nearly 50 years, the growing gap in supply and demand created a more than three-fold increase in the region's ecological deficit (in Figure 4, represented by the shaded area on the right) (Lofrano and Brown, 2010). In 1961, the needs of the Mediterranean region already exceeded its ecosystems' capacity to produce resources and services. By 2010, only 41 % of the region's EF was met by local ecological assets. The deficit has been met by depleting local stocks and overloading global carbon sinks (29% of the footprint) and by importing resources such as food and energy from outside the region (30% of the footprint). As shown in Figure 4, the EF per person of the Mediterranean region (red line) has increased, while the biocapacity (green line) per capita has decreased. The population (blue line) has more than doubled, from about 240 million in 1961 to nearly 490 million in 2010.

The widening gap between demand and supply makes the stability of the region highly dependent on the availability of resources from international markets, as well as the region's ability to pay for accessing them (Chapagain and Hoekstra, 2008).

Figure 5 shows the Environmental footprint, biocapacity and population in Greece per EF person (red line) have increased, while biocapacity (green line) per capita has slightly decreased.

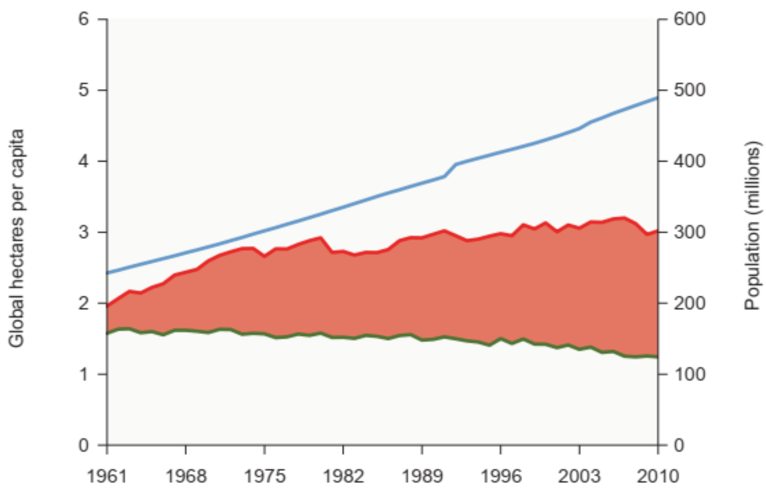

Figure 3. Environmental footprint, biocapacity, and population in the Mediterranean (Mediterranean Initiative - Global Footprint Network, 2015)

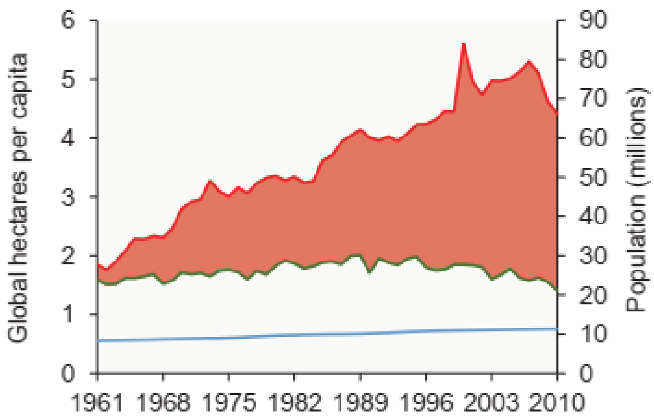

Figure 4. Environmental footprint, biocapacity, and population in Greece (Mediterranean Initiative - Global Footprint Network, 2015)

Every country in the Mediterranean region is running an ecological deficit, with its EF exceeding its biocapacity (according to 2010 data). Moreover, approximately 90% of people in the Mediterranean region live in countries whose EF is higher than the world-average biocapacity available per person. Figure 6, below, shows the EF and biocapacity by different land types for each country in the Mediterranean in 2010. The countries with the highest incomes currently have the highest resource demands in terms of EF. The carbon footprint varies mainly between countries and increases with higher per capita income levels. Greece is in fifth place with nearly 4.4 g.ha while its biocapacity does not exceed 1.5 g.ha. Figure 7 shows the Greenhouse gas emissions by sector for Greece (2016), which are measured in tons of carbon dioxide-equivalents (CO_2e). Figure 8 shows the EF of the country's two major cities Athens and Thessaloniki.

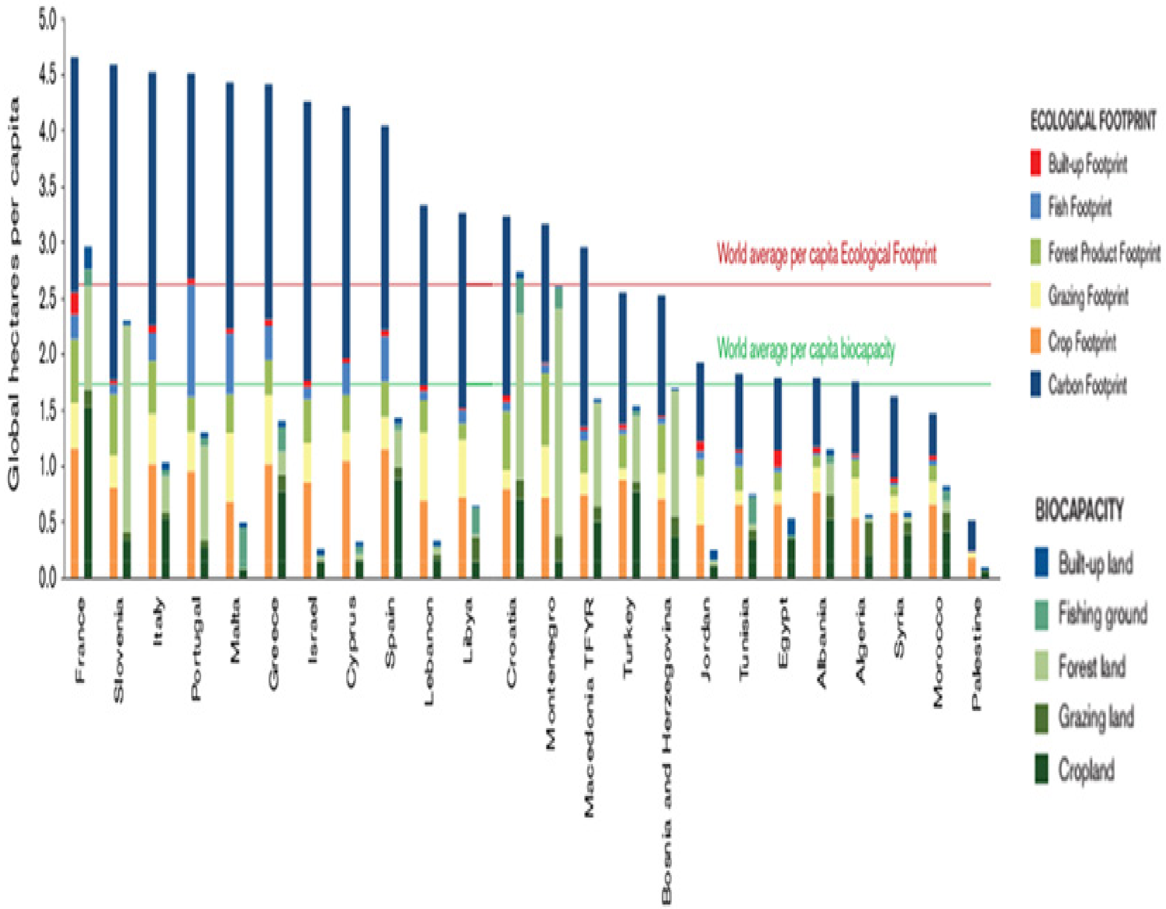

Figure 5. EF and biocapacity by different land types

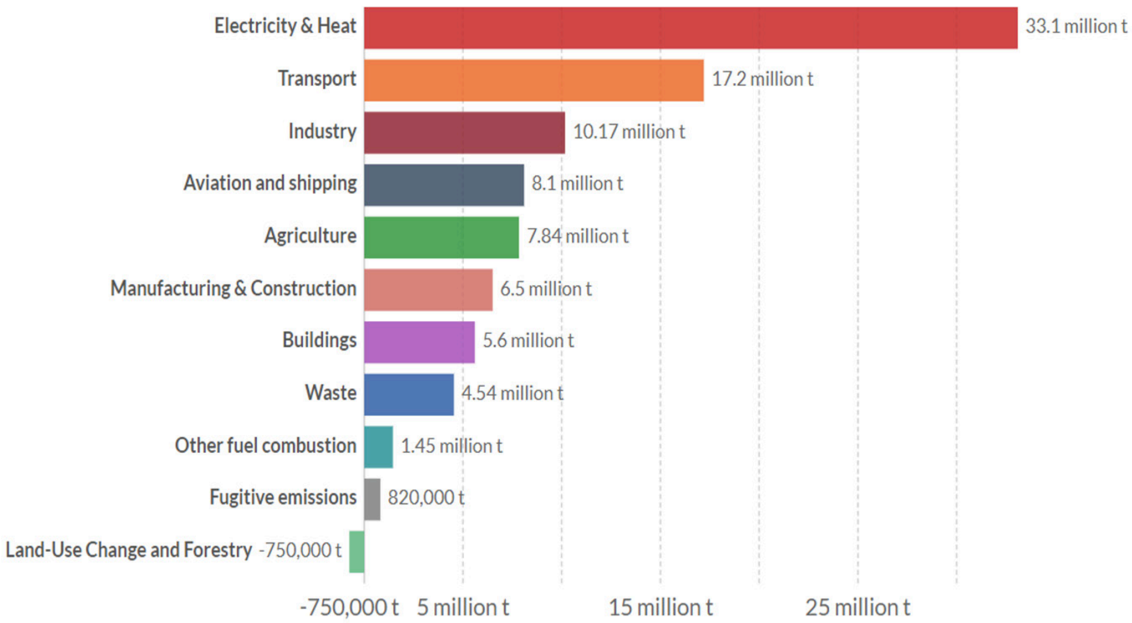

Figure 6. Greenhouse gas emissions by sector, Greece, 2016 - measured in tons of carbon dioxide-equivalents (CO_2e) (Climate Data for Action | Climate Watch | Emissions and Policies, 2017)

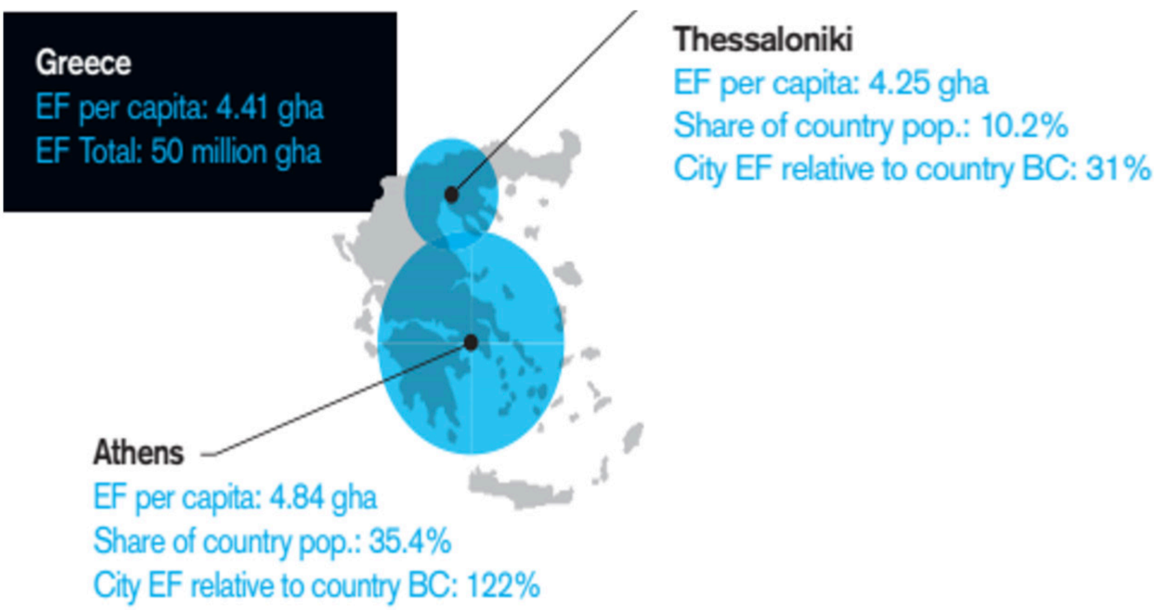

Figure 7. EF of the country's two major cities Athens and Thessaloniki (Mediterranean Initiative - Global Footprint Network, 2015)

II.3. The environmental pressure caused by tourism

Many studies have shown that a tourist service or product is a blend of ecological, social, and economic sub-systems, operable in the area of interest. Carrying capacity assessment has become an indispensable tool for formulating policy and strategies in the tourist industry worldwide. It is well known that Greece depends heavily on the tourist trade. For the Greek coastal tourist industry, the environment, both natural and man-made, plays a leading role in the sustainable development of this economic activity. It is the purpose of this article to apply new environmental protection tools to estimate the impacts inflicted by the tourism industry on local fauna and flora, as well as the overall well-being of the physical environment. The concept of sustainable tourism is used in the context of achieving economic growth without damaging the natural and built environment as well as conserving the culture of local communities (Downward and Taylor, 2007). The World Tourism Organization (WTO) defines carrying capacity as: "The maximum number of people that may visit a tourist destination at the same time, without causing destruction to the physical, economic, socio-cultural environment and an unacceptable decrease in the quality of visitors' satisfaction".

Tourism can generate both positive and negative environmental impacts, depending on how well development is planned and controlled.

Since the mid-1980s, major efforts have been made to restore urban centers, improve urban amenities, and limit urban pollution. For instance, Athenians and visitors to Athens now enjoy good air quality, improved water and waste management services, large pedestrian areas (archeological, green, shopping, or residential zones), a subway system and modernized public transport, renovated historical buildings and improved urban amenities. The 2004 Olympic Games provided a new opportunity for the improvement of the urban environment in Athens. Major investments in municipal wastewater treatment plants will soon result in better coastal water quality. Greece has passed framework legislation on the control of development in urban areas; and land use plans have been elaborated for nearly all major urban areas. Development of a long needed national cadaster is well under way, and priority is properly being given to the registration of lands at high risk of illegal development. Important responsibilities for implementing urban and coastal land use regulations have been devolved to municipal and prefectural authorities. Architectural committees are an example of how local initiatives can function to control the quality of the built environment through consensus. Some island areas have fostered balanced development based on tourism, farming and fishing, preserving cultural and natural assets.

However, the concentration of population and economic activities in coastal areas, as well as the resulting pressures, have increased significantly and will continue to do so, creating new challenges for these areas. Enforcement of land use regulations and building codes remains very weak, leading to problems such as widespread illegal construction of vacation homes and marinas in coastal areas near major cities and tourist destinations. Co-ordination between development and conservation goals in the coastal zone needs improvement. The recent legislative framework for integrated management of coastal areas must be further developed. Nor is there systematic monitoring of the land use, ecological or landscape quality of coastal areas (Gikas and Tsihrintzis, 2014). Preparation for the management of environmental catastrophes, including flood and earthquake, should be further improved, especially in high-density urban and coastal areas.

III. Primary and industrial activities

III.1. Agriculture, fertilizers, and pesticides

The agricultural sector consumes around 75% of water withdrawals in Greece with the surface of irrigated areas rising in recent years. Farmers are not charged for irrigation water supplied by individual projects, but they pay only a small fee per hectare of cultivated area served by collective irrigation projects to the Local Land Reclamation Board (TOEV). Water provided by the Public Power Corporation (PPC S.A.) to farmers from large dams to cover irrigational needs is not charged.

High nutrient concentrations, phosphorus concentrations slightly exceeding thresholds, as well as heavy metals are found in certain lakes, mainly in the northern part of the country, indicating human influence (from agricultural run-off, municipal and industrial wastewater discharges) leading, in certain cases, to eutrophication. Groundwater quality, even though generally good, is threatened by uncontrolled wastewater disposal and salinization caused from over-extraction due to seawater intrusion at coastal areas (Angelakis and Spyridakis, 1996). High concentrations of nitrates, deriving from nitrogenous fertilizers and the use of livestock manure, as well as pesticide residues have been detected in northern and western parts of the country but do not always exceed maximum permissible values (Andreadakis *et al.* 1993).

III.2. Aquaculture

Greek aquaculture is dominated by the farming of marine finfish in offshore cages, specifically of gilthead sea bream and European sea bass with the combined production capacity of about 110,000 tons in 2015. This is followed by the culture of Mediterranean mussels with an annual production capacity up to 35,000 to 40,000 tons in 2015. After several crises mainly because of imbalance between supply and demand, the marine fish sector has been restructured, with the aim of doubling its production by 2030. To meet this objective, targeted research, development and innovations strategies to optimize production; product diversification; and relevant marketing actions through the development of new schemes, such as producer organizations, are under consideration. Freshwater species and extensive lagoon aquaculture have a limited growth potential mainly because of the lack of natural resources (water, wild stocks) availability. Marine fish is the number one exported Greek animal product and accounts for approximately 11% of the total national agricultural exports (which together account for 19% of the total Greek exports).

Modern aquaculture in Greece is dominated by Mediterranean marine species such as European seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*) and Mediterranean mussels (*Mytilus galloprovinicalis*). Marine fish farming was established in the early 1980s with strong European Union (EU) support in establishing pilot-scale farms, and through the transfer of cage technology and knowledge from salmon industries, especially those in Scotland, and breading technology from France and Spain. In the early 1990s, mass production was achieved after the major zoo-technical problems for breading these species had been solved. Therefore, there was exponential growth in the industry, with several crisis periods (1999–2002 and 2007–2008) inducing extended periods of low prices mainly because of uncontrolled production, which reached 140,000 tons at the beginning of the Greek financial crisis (2008), and the lack of adequate efficient marketing support. As of 2015, the industry entered a phase of restructuring and consolidation, with 63 companies and a production of around 110,000 tons. Mussel farming, after its mechanization in the 1990s, increased its production volume in the following decade but remained below the upper limits of farming capacity (35,000 to 40,000 tons gross weight). The growth of the sector is dependent on the availability of suitable space, which is limited. Traditional lagoon aquaculture and freshwater culture both have a limited potential capacity for expansion. Lagoon aquaculture, as a capture-based activity, is exposed to the vulnerability of the wild stocks of fry and juveniles, and natural conditions. Freshwater aquaculture is less suitable because of lack of freshwater sources.

Marine fish farming in Greece provides 12,000 jobs (scientific, technical, workers) mainly in remote and isolated areas. In several cases, it is the major employer, and the wealth of the local society strongly depends on its activities. An additional 5,000 jobs exist in the value chain and peripheral activities. Within the aquaculture sector, marine finfish and mussels account for 85% of the direct labor employment, with 7% in the freshwater and 8% in the lagoon aquaculture activities. In contrast with the high levels of national unemployment, which rose to 26% in 2014, the total employment in aquaculture decreased by only 8% in 2011.

III.2.1. Marine fish farming

Land-based breeding stations provide fry to the on growing facilities, which are mostly fish cages located in areas protected from severe weather. Large cages of about 120 m in perimeter, suitable for holding up to 250 to 300 tons of finfish, are available to escalate production and move the industry further offshore to avoid environmental problems. Fish reach marketable size (350 to 450 g) in 12 to 24 months, depending on the local water temperature which varies between sites.

III.2.2. Mussel farming

Traditionally, mussel farming was carried out in hanging parks located in shallow waters close to estuaries in the northern part of Greece. The use of single longline floating ropes provided an opportunity to expand further offshore and mechanize the production process as much as possible.

III.2.3. Lagoon aquaculture

Extensive aquaculture is carried out 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.

III.2.4. Freshwater aquaculture

Freshwater aquaculture is limited to the few areas where rivers are available and are usually focused on trout and limited quantities of carp in raceways. There are a few niche businesses with closed recirculation systems to grow eels, but these have a limited capacity. More recently, some installations produce spirulina (a high-value cyanobacterium of the genus *Arthrospira*). Most of these businesses are vertically integrated and directly provide products for the nutraceutical industry. Five land-based installations with a total surface of 4.8 ha are used for spirulina farming with a yearly production of 12 tons at a value of EUR 0.51 million (USD 0.58 million).

III.2.5. Number of Installations

In Greece in 2012–13, there were 1,045 aquaculture facilities, of which 57% were mussel farms, 36% were marine fish farming sites including hatcheries and the remaining 7% were inland facilities. In the mussel farming sector, there were 595 farm sites, most of them in northern Greece. In the marine finfish sector, there were 63 companies with 336 farm sites spread around the country and 36 land-based hatcheries. Marine on growing farms can be categorized according to their annual production into small (<300 tons), medium (300 to 1,200 tons) and large (>1,200 tons). The large category is often made up of groups and producer organizations of individual companies. In Greece, most of the producers are small to medium-sized family businesses. There were 78 farms focusing on freshwater aquaculture on the mainland. There were 72 organizations working with lagoon aquaculture, mostly working as cooperatives, which occupied 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.

The recently established cultivation of spirulina microalgae is significant because despite its small production volume (12.6 tons in 2014) it had a significant value. It is oriented to the nutraceutical industry and is a promising sector of freshwater aquaculture.

The diversification of aquaculture species, including meagre, sharpsnout seabream and red porgy, has recently experienced an increase in production. Greece was the leading European producer, exceeding 120,000 tons, before the beginning of the Greek crisis in 2008. Even since the crisis, Greece is a significant world producer with yearly production of 110,000 tons of fish, even though the sector is operating below the existing capacity of the farms. A similar trend characterizes the fingerling production, which is estimated to have reached 421 million fries in 2014, of which 98% were

European seabass and gilthead seabream and 2% were the species of secondary importance (red porgy, meagre, sharpsnout seabream). The sales price of European seabass and gilthead seabream, per fry, is EUR 0.21 (USD 0.24). The cost per fry of sharpsnout seabream is EUR 0.26 (USD 0.29), red porgy is EUR 0.28 (USD 0.32), and meagre EUR 0.40 (USD 0.45).

III.3. Industry

Services are the cornerstone of the Greek economy. Manufacturing contributes 9.9% of the total value added (EU average 15.5% in 2011), specializing mainly in food processing (the manufacture of vegetable oils, and the processing and preservation of fruit and vegetables). Other important sectors are metal, chemicals, cement, and textile.

III.4. Shipping traffic

Greece is a maritime nation by tradition, as shipping is arguably the oldest form of occupation of the Greeks and has been a key element of Greek economic activity since ancient times. Today, shipping is the country's most important industry and is worth 21.9 billion dollars in 2018. If related businesses are added, the figure jumps to 23.7 billion dollars, employs about 392 000 people (14% of the workforce), and shipping revenue accounts for about 1/3 of the country's trade deficit. In 2018, the Greek Merchant Navy controlled the world's largest merchant fleet, in terms of tonnage, with a total Deadweight Tonnage (DWT) of 834,649,089 tons and a fleet of 5,626 Greek-owned vessels, according to Lloyd's List. Greece is also ranked in the top for all kinds of ships, including first for tankers and bulk carriers.

The Port of Piraeus is the chief seaport of Athens, Greece, located on the Saronic Gulf on the western coasts of the Aegean Sea, the largest port in Greece and one of the largest in Europe. With about 18.6 million passengers Piraeus was the busiest passenger port in Europe in 2014. Since its privatization in 2009 the port's container handling has grown rapidly. Piraeus handled 5.65 million twenty-foot equivalent units (EU) in 2019 according to Lloyd's list for top 100 container ports in 2015 Piraeus ranked 8th in Europe and 3rd in the Mediterranean. The port of Piraeus is expected to become the busiest port of the Mediterranean in terms of container traffic by 2019. Piraeus handled 4.9 million TEUs in 2018, an increase of 19.4% compared with 2017 climbing to the number two position of all Mediterranean ports. In April 2016, the port ranked 39th in the world in terms of container capacity. In 2007 the Port of Piraeus handled 20,121,916 tons of cargo and 1,373,138 TEU's making it the busiest cargo port in Greece and the largest container port in the country and the East Mediterranean Sea Basin.

III.5. Offshore drilling

Offshore drillings in Greece are present only near the island of Thasos in Northern Greece. The Prinos oil field is an oil field located in the northern Aegean Sea, between the island of Thasos and city of Kavala on the mainland. It was discovered in 1971 by the Oceanic Exploration Company of Denver. The field was developed by Energean Oil

& Gas. It began production in 1974. It was named after the village of Prinos on Thasos, the nearest inhabited place. The total proven reserves of the Prinos oil field were estimated at around 90 million barrels (12×10^6 tonnes), and production is centered on 1,900 barrels per day (300 m^3/d). However, by 2020 it has delivered some 120 million barrels of crude, exceeding the original estimate.

IV. Water and its use

IV.1. Water Resources

Most of the countries of the Mediterranean region are characterized by a strong seasonal distribution of precipitation, which may be one of the main reasons for the water scarcity problems that they are facing.

Although Greece has one of the greatest water resources potentials per capita in the Mediterranean area and should theoretically have ample water for its population and traditional water uses, water is not evenly distributed in space and time. The maximum precipitation is recorded in the western parts, where the available water resources are consequently plentiful, while in other regions of the country precipitation is much lower and available water resources are insufficient to meet the demand. Due to this inequality in water distribution, both in space and in time, some areas of Greece such as Attica and the Aegean Islands are facing long-term water shortage problems.

Greece is generously endowed with freshwater resources (Fig. 9). Mean annual precipitation in Greece is about 700 mm, nearly half of which is lost to evapotranspiration. However, freshwater resources are unevenly distributed throughout the country, due to the climatic conditions and the rugged geographic relief of Greece. Precipitation ranges from around 400 mm in the Aegean islands and Athens to more than 900 mm in the North-West and the Ionian islands with the island of Kerkyra presenting maximum precipitation levels. On the contrary, parts of the southern and central mainland, the Aegean islands and Crete are in danger of desertification (Gikas and Tchobanoglous, 2009b). Water distribution is also uneven in time. Peak periods for water demand and consumption are reported during the summer dry period when the population in certain areas (mainly coastal) is multiple due to tourist arrivals. During the dry period, water demand is also maximized for irrigational purposes. Therefore, water is not always available where and when it is most demanded. Water redistribution, storage and saving and a sound demand side management are therefore indispensable priorities for water policy in Greece. The mean annual surface runoff of Greece's mainland rivers is 35 billion cubic meters. More than 80% of surface runoff comes from eight major river basins: the Acheloos (Central Greece), Axios, Strimonas and Aliakmonas (Macedonia), Evros and Nestos (Thrace) and Arachtos and Kalamas (Epirus). Nine rivers flow over 100 kilometers within Greece: Aliakmonas, Acheloos, Pinios, Evros, Nestos, Srimonas, Kalamas, Alfios and Arachtos. Four major rivers originate in neighbouring countries: Evros (Turkey), Nestos and Strymonas (Bulgaria) and Axios (North Macedonia); total inflow from upstream neighboring countries amounts to 12 billion cubic meters.

Forty-one (41) natural lakes (19 with an area over 5 km^2) occupy more than 600,000 hectares or 0.5% of the country's total area. The largest lakes are Trichonida, Volvi and Vegoritida. Lake Prespa is on the borders with Albania and North Macedonia. The number of Greek wetlands rises to about 400 with 10 of them designated as Ramsar wetlands of international importance. The 14 artificial lakes (10 with an area over 5 km^2) occupy 26,000 hectares.

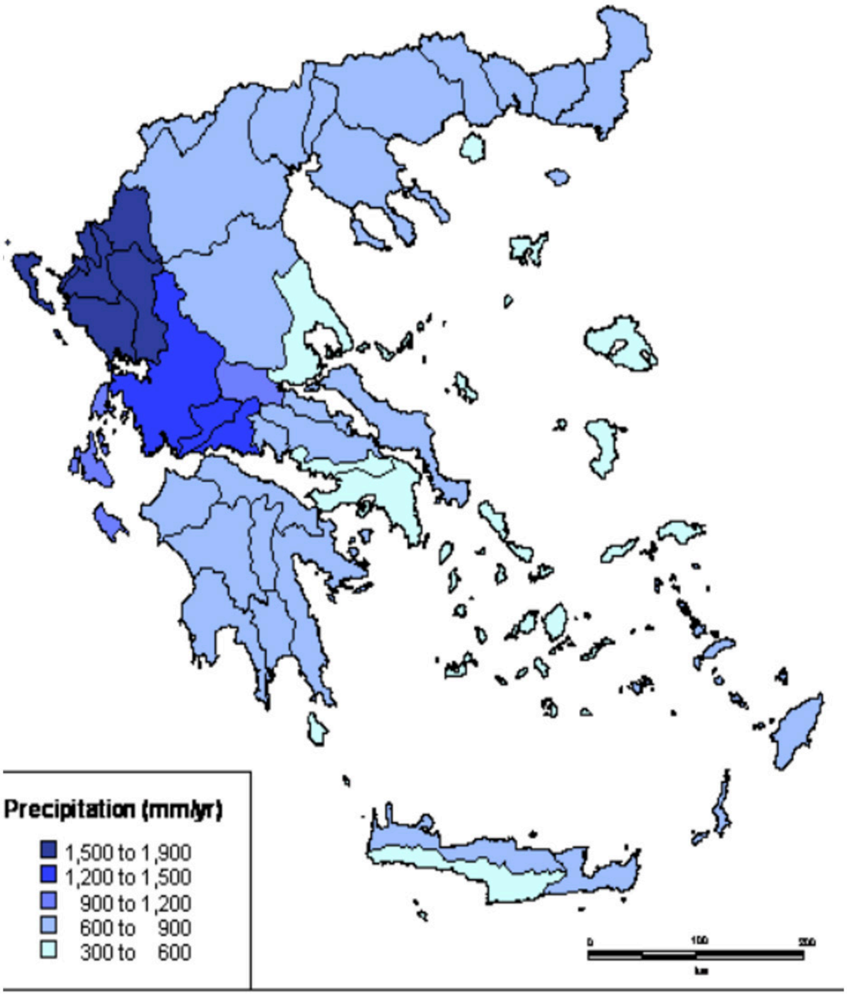

Figure 8. Precipitation in Greece (Papasozomenou, 2018)

Almost 80 of freshwater resources are in the form of surface water and the rest are groundwater. Per capita consumption of water is around 830 m^3 with peaks of over 1,000 m^3 recorded during heat wave days and days of intensive snow fall (EYDAP, 2014). Around 75% of total freshwater withdrawals are for agriculture with irrigated areas representing a third of total cultivated areas. The uneven distribution of rainfall leads to scarcity of water resources during the peak period for irrigation, a time that is equally crucial for other uses such as tourism. Therefore, about half of irrigation water is pumped from aquifers. A considerable portion of irrigation water comes from large multi-purpose reservoirs owned by PPC S.A. Households account for about 10 to 15% of total freshwater withdrawals. Water supply to the Metropolitan area of Athens is provided mainly from surface water stored in dams several hundred kilometres away and transferred to the city.

Other big coastal cities usually extract groundwater, even though salinization problems have caused other solutions to be sought such as spring and surface water collection in reservoirs.

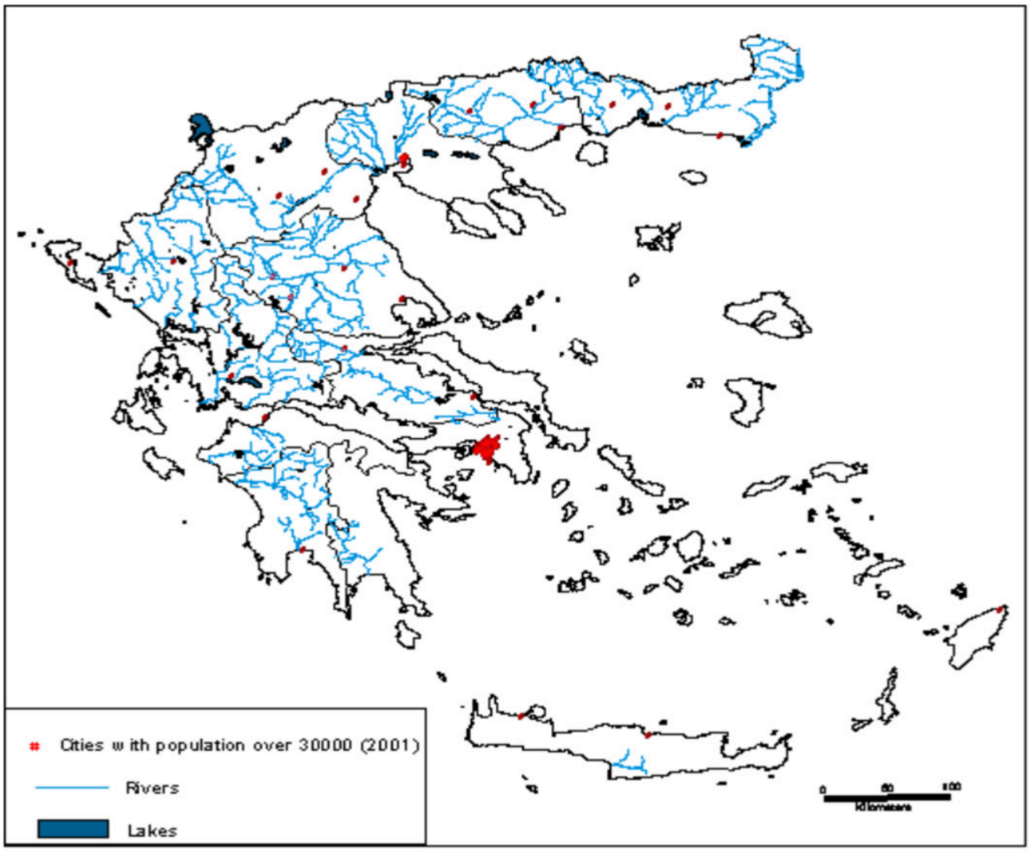

Figure 9. Surface waters in Greece (Circumstances in Greece, 2001)

The national water quality standards for various uses (drinking, aquatic life etc) have been harmonized with the relevant legislation (Directives) of the EU (European Environmental Agency, 2017). Human economic and industrial activity in Greece is concentrated in river basins where additional pressures occur due to agricultural activity. Surface runoff and wastewater discharges create intense point pressures on the quality of water resources. However, the situation has been enhanced over recent years due to the massive construction of municipal wastewater treatment plants for most of the country's human settlements.

Greek rivers are generally of very good quality (Fig. 10). They host some 78 indigenous fish species halves of which are endemic. The average annual nutrient concentration, as well as the heavy metals concentrations, is low and in most cases below the maximum allowable limits for drinking water. Only in some cases in downstream river locations, in urban areas or in areas of intensive agricultural and industrial activity, the levels of phosphorus, nitrites, ammonium and dissolved solids might be rather higher than the standards. High nutrient concentrations, phosphorus concentrations slightly exceeding thresholds, as well as heavy metals are found in certain lakes, mainly in the northern part of the country, indicating human influence (from agricultural runoff, municipal and industrial wastewater discharges) leading, in certain cases, to eutrophication (Kotsovinos *et al.* 2004). Groundwater quality, even though generally good, is threatened by uncontrolled wastewater disposal and salinization caused from over-extraction due to seawater intrusion in coastal areas. High concentrations of nitrates, deriving from nitrogenous fertilizers and the use of livestock manure, as well as pesticide residues have been detected in northern and western parts of the country but do not always exceed maximum permissible values.

The implementation of the recent Law 3199/2003 for the protection and management of water resources has given gave new impetus to sustainable and integrated water management in Greece, emphasizing the ecological function of water and introducing an integrated water resources management (IWRM) approach at the river basin level as well as a pricing policy so that it reflects the full costs of water. The 14 water districts of Greece are presented in Figure 11, which follows.

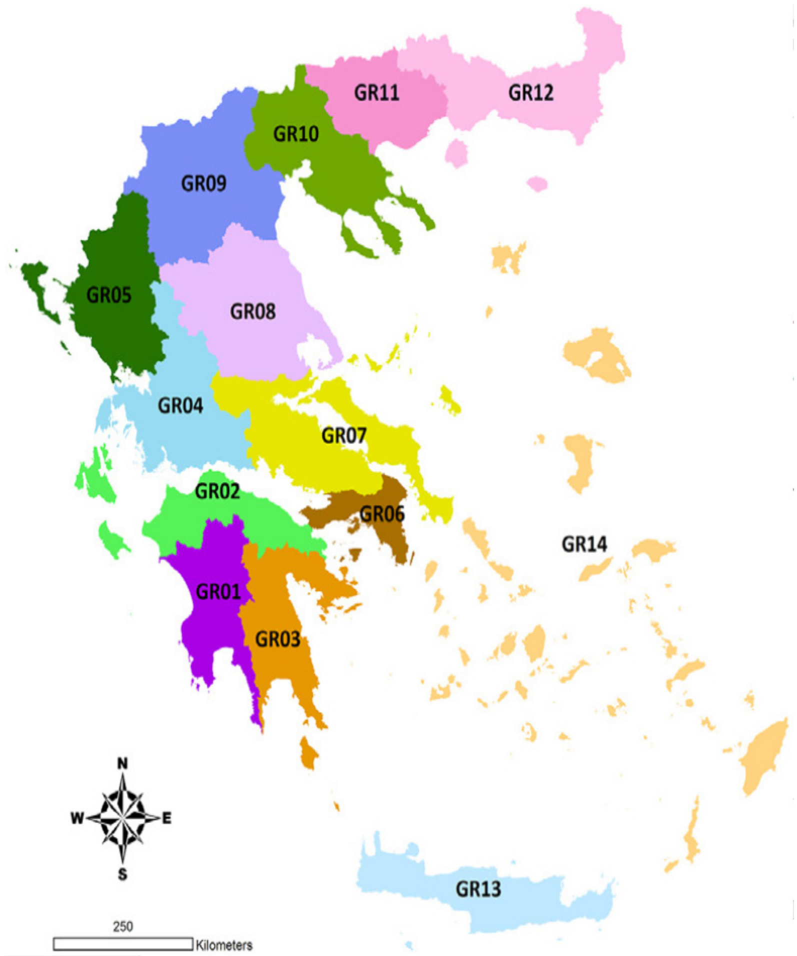

Figure 10. The 14 water districts of Greece (Kourgialas, 2021)

IV.2. Conventional water resources mobilisation

Greece has 46 River Basins (RB), 565 Ground Water Bodies (GWB) and 1785 Surface Water Bodies (SWB). The last one is divided into 1415 River Water Bodies (RWB), 73 Lake Water Bodies (LWB), 47 Transitional Water Bodies (TWB), and 250 Coastal Water Bodies.

Table 2 presents the areas of each water district in Greece. The largest area is occupied by the water district of Western Macedonia with a value of 13,616 km^2, while the smallest area corresponds to the water district of Attica with a value equal to 3,187 km^2. Table 2 also shows the number of water bodies as well as their type for each of the water districts. A distinction was made between Surface, River, Lake, Coastal, Transitional and Groundwater systems. As can be seen from this table, most of the water bodies belong to the Aegean Islands River basin district, their number being equal to 293. Nevertheless, this water district faces problems concerning the lack of exploitable water, due to the small area of water bodies and the rapid transfer of water to the sea, as well as the climate (little rainfall and high temperatures per year; Philandras *et al.* 2013). The permanent population of each water district, according to the Hellenic Statistical Authority, is presented in Figure 12A. It is obvious that the largest number of residents appears in the water district of Attica, although the area of the district is the smallest compared to the rest. Following the river basin district of Attica is the population of the river basin district of Central Macedonia. On the contrary, the water district of the Western Peloponnese has the smallest number of permanent residents. Regarding the distribution of land use in Greece, the highest percentage is covered by forests and pastures with percentages between 37% and 74% of the total area for each river basin district. However, there are exceptions in which the largest area is occupied by agricultural areas, such as the water district of Eastern Macedonia with a percentage that reaches 56.74% of its total area, followed by the water district of Thessaly (43.26%), Crete (42.38%), North Peloponnese (39.52%), and East Macedonia (38.17%), with the lowest presentence of agricultural land occurring in the water district of Epirus with 14.78%. For all water districts, the smallest area corresponds to urban uses with very small percentages from values close to 0% to a maximum of about 11%. Figure 12B represents the percentage of the distribution of different land uses for each water district. Figure 12C depicts the water consumption for each water district and per category of use. The percentages of water consumption related to agriculture range between 11 and 92% per water district, with an average value of all the water districts equal to 74%, indicating that agriculture is the largest water consumer in Greece. The only exception is the water district of Attica, as it is the district with the largest number of inhabitants and 83% of its water consumption is related to urban water use. Industry seems to be particularly developed in Thrace, as it requires very large quantities of water to meet its needs compared to the other water districts. Regarding livestock, in all the districts the quantities of water that meet the needs of this sector are very small with percentages from 0.25 to 2.30% of the total.

Table 2. Areas of each water district in Greece

Water Bodies in Greece

Code	Water Districts	Area (km^2)	River Water Bodies	Lake Water Bodies	Coastal Water Bodies	Transitional Water Bodies	Ground Water Bodies	Total
			Number	Number	Number	Number	Number	
GR01	West Peloponnese	7235	110	2	11	3	27	153
GR02	North Peloponnese	7397	62	5	19	5	26	117
GR03	East Peloponnese	8442	80	1	13	5	34	133
GR04	West Central Greece	10,499	95	12	9	4	26	146
GR05	Epirus	9979	82	4	13	7	27	133
GR06	Attiki	3187	15	1	14	0	21	51
GR07	East Central Greece	12,279	81	3	19	1	41	145
GR08	Thessaly	13,140	72	3	7	0	33	115
GR09	West Macedonia	13,616	150	14	2	2	52	220
GR10	Central Macedonia	10,163	104	6	11	3	37	161
GR11	East Macedonia	7319	83	2	4	1	15	105
GR12	Thrace	11,240	176	6	12	5	18	217
GR13	Crete	8327	123	6	25	4	91	249
GR14	Aegean Islands	9105	81	9	87	0	116	293

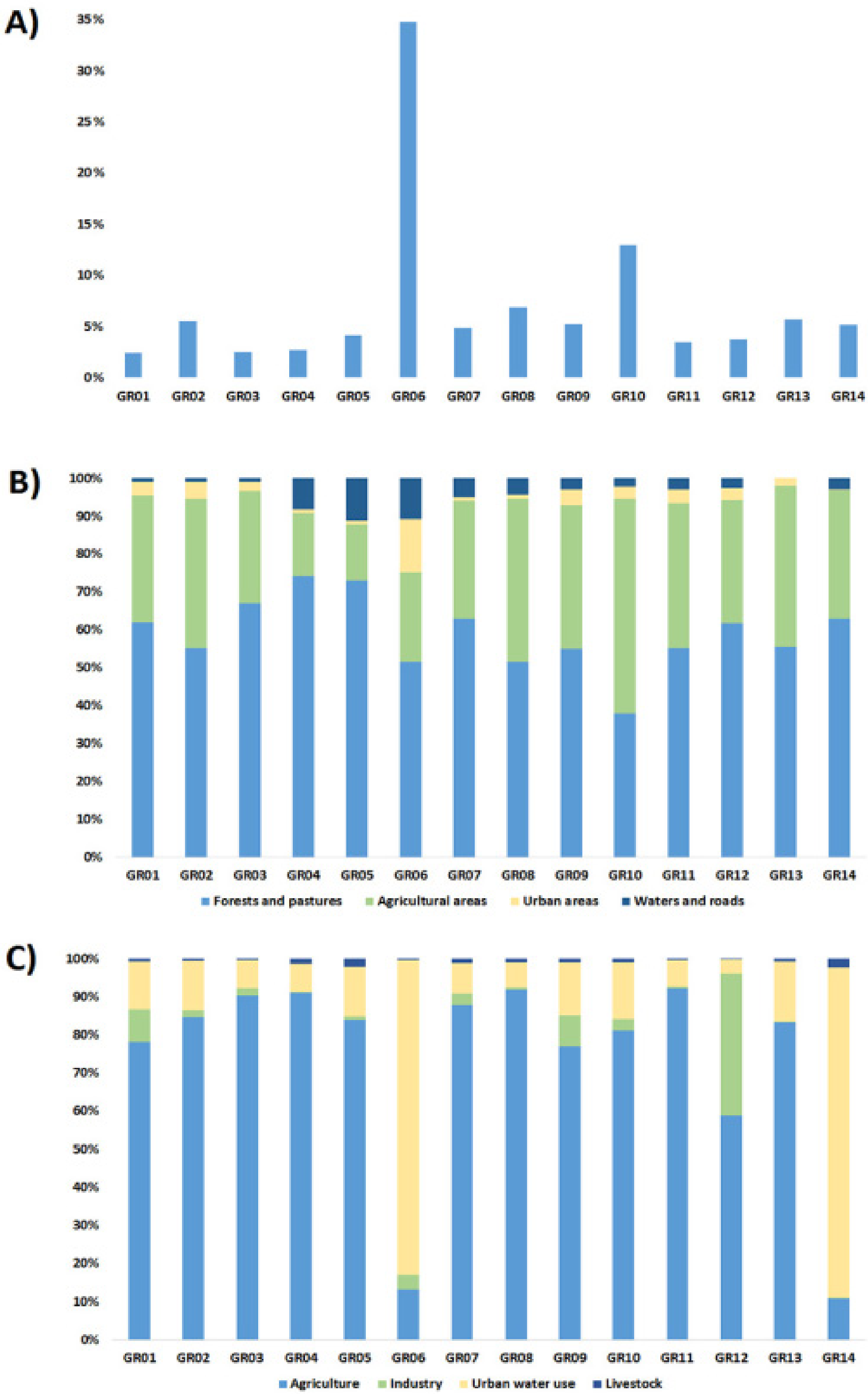

Figure 12. Distribution of population, land uses and water consumption per water district in Greece, reference period 2010-2020 (Kourgialas, 2021)

The above water consumptions are covered by both surface water and groundwater. Specifically, Figure 12 shows the percentage distribution of water extraction between surface and groundwater bodies. For the majority of water districts (10 out of 14), water extractions come from groundwater at a range from 97% in the case of East Peloponnese to 60% in Central Macedonia. Only in the cases of west central Greece, Epirus and East Macedonia extraction from surface water sources prevail in percentage over groundwater extraction sources. An almost equal percentage between surface and groundwater extractions has been observed for the water district of Thrace.

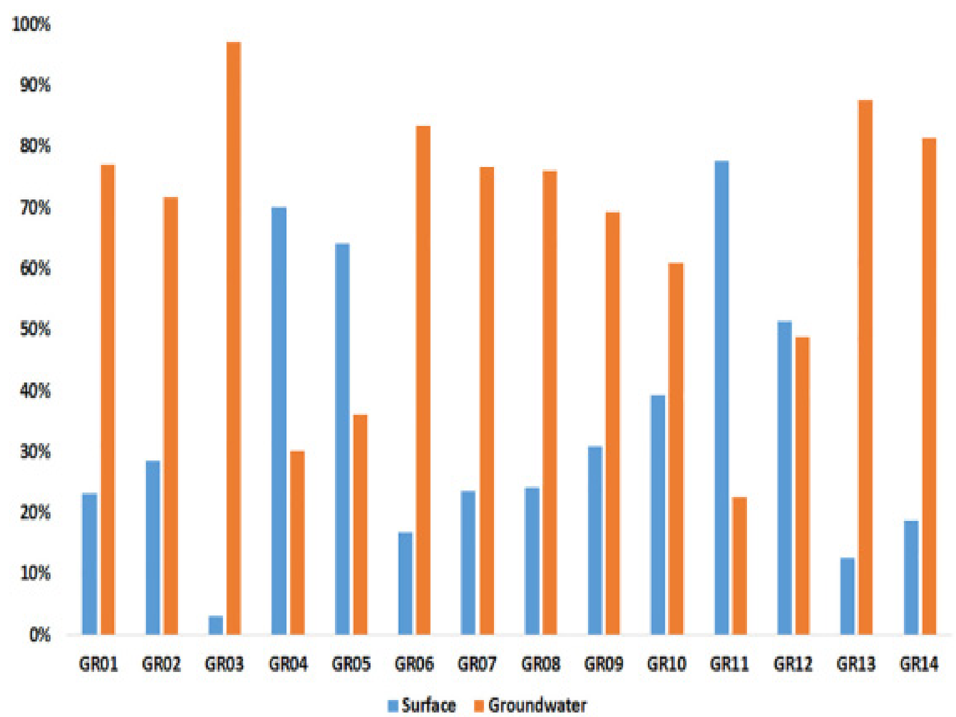

Figure 12. Distribution of water extraction between surface and ground water bodies, reference period 2010-2020 (Kourgialas, 2021)

IV.3. Non-conventional water resources mobilization

In Greece there is a network of 254 urban wastewater treatment plants. Over 80% of treated wastewater is discharged into the environment (directly or via outlets) and re-enter the hydrological cycle. Almost 12.5% of the treated wastewater is reused for agricultural irrigation. These percentages need major improvement in order to achieve water sustainability (Tsagarakis *et al.* 2000).

In the Islands there is a network of Rain Water Harvesting (RWH), which provides essential water resources to the local population.

Moreover, in certain islands there are desalination units that provide water resources, especially during the summer months when the need for water use increases dramatically due to tourism (Hafez and El-Manharawy, 2003). Desalination might currently be the most widely considered option to enhance water resources, but it increases energy consumption and, in many areas not connected to the national grid, the dependence on imports of fuels to run generators, leading to considerable additional emissions of greenhouse gases (Bermudez-Contreras *et al.* 2008). Desalination is also costly, and can involve energy use of 3 to 12.5 kWh of electricity, corresponding to emissions of 1 to 10 kg CO_2 per m^3 of water, with lower values referring to state-of-the-art desalination plants (Gude *et al.* 2010).

IV.4. Water losses

Water losses can be defined as the difference between water pumped into the system and billed water. Water loss occurs in every water distribution system during its overall operational lifetime. It causes not only additional operating costs but also negative ecological and social impacts.

In Greece there is a gross estimation that 25 to 50% of all distributed water is lost due to:

- Evaporation
- Leakages
- Deteriorating Infrastructure
- Incorrect water pressure management
- Inaccurate metering
- Illegal Connections

IV.5. Water Demand per sector

The shortage of water (drought) in a region is not only related to the availability of the water resources, but also to the water utilization. Unfortunately, as previously mentioned, the major users of water in Greece are mainly located in the Eastern and Southern regions of the country, which is rather disadvantageous as compared to the natural enrichment.

Greece does not present a balanced scheme of water uses, as the rural usage takes the lion's share of 86% (Fig. 14). More specifically, 96% of the rural consumption is allocated to irrigation -80% of which is wasted in the hydrologic circle or other losses.

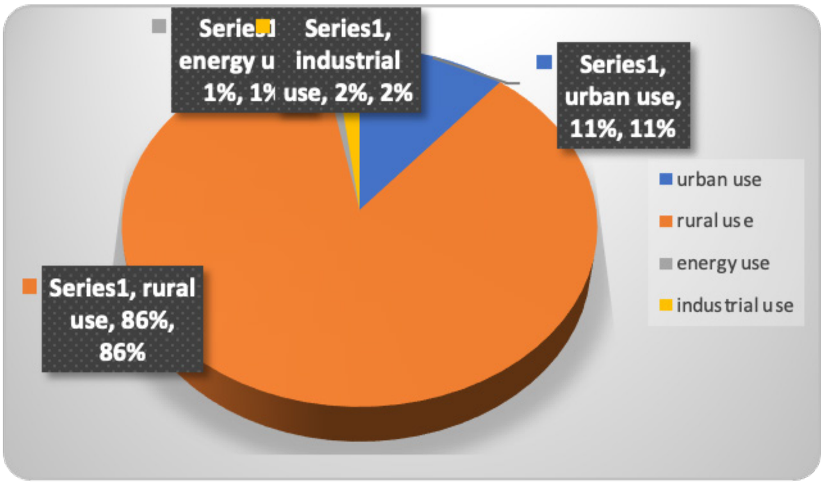

Figure 13. Estimates of water consumption by sector in Greece

IV.6. Strategies to mitigate the consequences of water scarcity

Since December 2003, a new legislative and institutional framework has been put into force in the country. It consists of Law 3199/9-12-2003 (OJG 280A/2003) on "water protection and the sustainable management of the water resources" with which the EU Water Framework Directive (WFD) (2000/60/EC) is transposed into the national legislation (EC, 2000). This new framework law foresees a radical reorientation of the respective administrative capacities in Greece and introduces an innovative and holistic approach concerning water management that recognizes explicitly the ecological function of water. It also lays emphasis on the management of water based on river basins as well as on the water pricing so that it reflects its full costs. In more detail, the main objectives of the new law include: the long-term protection of water resources, the prevention of deterioration and the protection and restoration/remediation of degraded water resources and wetlands, the reduction and, in cases, the gradual elimination of harmful and polluting discharges, the reduction of groundwater pollution and the prevention of its further deterioration as well as the mitigation of the effects of floods and droughts. The 3199/03 law also incorporates the 'polluter pays principle' and the objective of maintaining or reaching a 'good ecological status' for all water resources by imposing pollution control using threshold levels and standards. It also introduces innovative approaches concerning the protection of water quantity and the transnational cooperation for the protection of transboundary water courses and lakes. The new legislation for the protection and the sustainable management of the water resources in Greece provides a detailed identification of 13 River Basin Districts (RBDs) according to the administrative units of the country, the competent authorities and their respective responsibilities in water management in Greece. In this context, regional water directories and councils will be established within each RBD / water region (RBDs) and they will have the responsibility for organizing and coordinating water policy activities (including water pricing) and specific water programs and action plans with specific measures for each RBD. They will be in charge of implementing the WFD in the RBDs of the country and they will be supervised by the national water agency, a governmental authority with the overall responsibility for establishing water policy. In the new legislation there is also consideration about the most effective options for setting up legal coordination mechanisms relating to the designation and management of the RB that cross the water region borders. The appointment of the new authorities will be legally binding once it is integrated into the new legislation.

The 3199/03 law also integrates the public participation requirements of the WFD. The active involvement of the interested parties is ensured by their representation at the national and regional water councils that will be developed as a part of the new administrative framework. To complete the transposition of the WFD, besides this new law, further instruments, presidential decrees and Joint Ministerial Decisions (JMD) are under preparation, for the incorporation of the technical provisions of the directives. Before this new law on water was put into force, the legislative framework of the country on this issue included law 1739/1987 on water resources management, establishing the institutional framework for the management of water resources in Greece and the environmental protection law 1650/1986 for the protection of surface and groundwater quality, including control of effluent discharges. The 1987 law also provided for the design and implementation of water resources policies as a prerequisite for development that would enhance the results of production processes, balance the various competitive uses for water and contribute to the renewal-replenishment of water resources as well as to the protection of the environment through participatory processes. Despite the innovative and integrated approach introduced by this law, its complexity made its full implementation in practice quite difficult. The existing legal framework for water resources management in Greece, apart from the above mentioned new law 3199/9-12-2003, also includes JMD such as JMD 46399/1352/1986 and JMD A5/288/1986 for the harmonization of the Greek legislation with EU Directives 75/440, 76/659, 76/160 and Directives 78/659, 79/869 and 80/778 respectively, as well as JMD 18186/271/1988 for measures and restrictions for the protection of the aquatic environment: determination of limit values for dangerous substances in wastewater. It also includes Council of Ministers' Decisions (CMD) such as CMD 144/1987 for the protection of the aquatic environment from pollution caused by dangerous substances. Moreover, concerning drinking water quality, the sanitary regulatory decision A5/288/86 (Official Journal of the Government - OJG 53B, 379B) about "Drinking water quality" (which refers to the qualitative characteristics of drinking water, to the frequency of sampling and the obligations of the responsible persons), in harmonization with Directive 80/778/EEC, was valid until December 25th 2003,when the new JMD Y2/2600/01 (OJG 892/B/11/11-7-01), in harmonization with EU Directive 98/83 for the quality of water for human consumption, came into force (EC, 1998). Management of protected areas including wetlands, was defined in 1999 (law 2742/99) through the establishment of administrative units (Management Bodies) and the competence of NATURA 2000 Committee, whereas in 2002, through law 3044/02, 25 Management Bodies were established, additionally to the existing two ones. Management of the most important protected wetland sites in Greece, designated as Ramsar wetlands of international importance, is attained through the establishment of these Bodies (which are financially supported, for the time being, from the state), that will collaborate with the respective regional services to be established according to law 3199/03, with the mandate to develop and implement regional water management plans. Concerning the protection of the quality of water resources and of vulnerable zones, in years 2001 and 2002 the existing legislative framework was complemented by various JMDs determining protection measures for vulnerable water resources as well as threshold levels for polluting substances from various anthropogenic sources, according to relative EU Directives (described in detail in European Commission, 2020). Finally, in 2003, a new Forest Act (3208/03) was adopted, concerning the protection and management of forest resources with emphasis on the protection of forests and their hydrological role.

The main targets of the National Strategy for Sustainable Development (NSSD) (2002), regarding the management of water resources, are set out in the National Strategy for Water Resources (NSWR) (2002) and aim at the sustainable use of water resources, the efficient protection of water ecosystems and the attainment of high-quality standards for all surface and ground water bodies by the year 2025. The NSWR also incorporates the water targets, in line with the Johannesburg plan of implementation, for water supply and sanitation as well as for integrated water management and water efficiency plans.

The basic sectors of action of the NSWR are:

- Integrated approach for water management: development of management plans on river basin level including transboundary water courses, based on water quality and quantity considerations and the interaction between surface and ground waters.
- Decentralization of water management authorities-bodies: establishment of water managing bodies the transposition of competencies to the regional and local levels. These bodies will also be responsible for the elaboration of crises management plans, for extreme events *e.g.*, floods and droughts.
- Upgrading and expansion of infrastructure: this includes the promotion of specific measures and actions for meeting the demand for water supply through the expansion of existing networks as well as through the decrease of losses, the construction of new and the upgrading of existing wastewater treatment plants with emphasis on recycling, the construction of new multi-purpose reservoirs and finally, the establishment of more effective mechanisms for monitoring water quality and quantity with focus on creating an updated database.

- Incorporation of socio-economic considerations in water management: this includes measures to reinforce public participation in water management efforts as well as adaptation of pricing policies to include 'the social cost' in water services' provision.
- Protection from harmful substances: setting of new maximum permissible levels of harmful substances' concentrations in water resources as the basis of a sound system for liabilities, water protection and promotion of remedial measures, where appropriate.

More specifically, the NSWR contains a wide series of projects, programs and actions, according to the requirements of the WFD that will allow meeting set targets at national, EU and international levels, by fully implementing the WFD and law 3199/03, such as:

- Participation in the process of testing the guiding and supporting documents on key aspects of the WFD (technical guidance documents) in several pilot river basins across Europe (integrated testing in pilot river basins). The overall objective of this integrated testing project is to contribute to the implementation of the WFD in selected pilot river basins, leading in the long-term to the development of river basin management plans. The specificity of the testing versus the real implementation is that the testing is a front-runner of the actual implementation. Greece is participating in this project with Pinios pilot river basin (Thessaly RBD).
- Update of the national database of hydrological and meteorological information and of the national environmental information network.
- Identification and characterization of the individual river basins and identification of the respective competent authorities.
- Development of a new monitoring network for inland surface, transitional, coastal, and ground waters, including the development of monitoring programs for biological quality parameters and the assessment of their ecological quality.
- Intercalibration exercise in several water bodies, as a part of the intercalibration network within the EU.
- Designation of heavily modified and artificial water bodies.
- Development of water pricing policies that enhance the sustainability of water resources.
- Continuation of construction of wastewater treatment plants.
- Analysis of the role of local authorities and citizens in securing long-term water resources conservation.
- Development of management plans in water districts for each river basin of the country.

V. Water and tourism in the Mediterranean

V.1. Tourism impact on the environment

Tourism can generate both positive and negative environmental impacts, depending on the quality of development planning and control. Global tourism is closely linked to climate change (Hall, 2006). Tourism involves the movement of people from their homes to other destinations and accounts for about 50% of traffic movements; rapidly expanding air traffic contributes about 2.5% of CO_2 production (Auernheimer *et al.* 2003). Tourism is thus a significant contributor to the increasing concentrations of greenhouse gases in the atmosphere. Air travel itself is a major contributor to the greenhouse effect. Passenger jets are the fastest growing source of greenhouse gas emissions. The number of international travelers is expected to increase from 594 million in 1996 to 1.6 billion by 2020, adding greatly to the problem unless steps are taken to reduce emissions. Tourism contributes more than 5% of global greenhouse gas emissions, with transport accounting for 90% of emissions. By 2030, a 25% increase in CO_2-emissions is expected from tourism, as compared to 2016; with an increase from 1,597 to 1,998 million tons (Arnell, 2004).

V.1.1 Depletion of natural resources

Water, and especially fresh water, is one of the most critical natural resources. The tourism industry generally overuses water resources for hotels, swimming pools, golf courses and personal use of water by tourists (Bohdanowicz and Martinac, 2007). This can result in water shortages and degradation of water supplies, as well as generating a greater volume of wastewater. In dry and hot regions like the Mediterranean, the issue of water scarcity is of particular concern. Because of the hot climate and the tendency of tourists to consume more water when on holiday than they do at home, the amount used can run up to 440 liters a day (Chenoweth *et al.* 2011). This is almost double what the inhabitants of an average Greek city use. Golf course maintenance can also deplete freshwater resources. In recent years golf tourism has increased in popularity and the number of golf courses has grown rapidly. Golf courses require an enormous amount of water every day and as with other causes of excessive extraction of water, this can result in water scarcity (Balogh and Walker, 2020). If the water comes from wells, over-pumping can cause saline intrusion into groundwater. Golf resorts are more and more often situated in or near protected areas or areas where resources are limited.

Tourism can create great pressure on local resources like energy, food, and other raw materials that may already be in short supply. Greater extraction and transport of these resources exacerbates physical impacts associated with their exploitation. Because of the seasonal character of the industry, many destinations have ten times more inhabitants in the high season than in the low season. High demand is placed upon these resources to meet the high expectations tourists often have (proper heating, hot water, *etc.*; Essex *et al.* 2004).

Important land resources include minerals, fossil fuels, fertile soil, forests, wetland and wildlife (Eurostat, 2009). Increased construction of tourism and recreational facilities has increased pressure on these resources and on scenic landscapes. Direct impact on natural resources, both renewable and non-renewable, in the provision of tourist facilities can be caused using land for accommodation and other infrastructure provision, and the use of building materials. Forests often suffer negative impacts of tourism in the form of deforestation caused by fuel wood collection and land clearing (Gössling *et al.* 2012).

V.1.2. Pollution

Tourism can cause the same forms of pollution as any other industry: air emissions, noise, solid waste and littering, releases of sewage, oil and chemicals, even architectural/ visual pollution. Transport by air, road, and rail is continuously increasing in response to the rising number of tourists and their greater mobility. One consequence of increase in air transport is that tourism now accounts for more than 60% of air travel and is therefore responsible for an important share of air emissions. One study estimated that a single transatlantic return flight emits almost half the CO emissions produced by all other sources (lighting, 2 heating, car use, *etc*.) consumed by an average person per year (ICAO, 2001). Transport emissions and emissions from energy production and use are linked to acid rain, global warming, and photochemical pollution. Air pollution from tourist transportation has impacts on global level, especially from CO2 emissions related to transportation energy use. And it can contribute to severe local air pollution. Some of these impacts are quite specific to tourist activities. For example, especially in very hot or cold countries, tour buses often leave their motors running for hours while the tourists go out for an excursion because they want to return to a comfortably air-conditioned bus.

In areas with high concentrations of tourist activities and appealing natural attractions, waste disposal is a serious problem and improper disposal can be a major despoiler of the natural environment, rivers, scenic areas, and roadsides.

Construction of hotels, recreation and other facilities often leads to increased sewage pollution. Wastewater pollutes seas and lakes surrounding tourist attractions, damaging the flora and fauna (Chan, 2005). Sewage runoff causes serious damage to coral reefs because it contains lots of nutrients and it stimulates the growth of algae, which cover the filter-feeding corals, hindering their ability to survive. Changes in salinity and transparency can have wide-ranging impacts on coastal environments. And sewage pollution can threaten the health of humans and animals (Ferronato and Torretta, 2019).

Often tourism fails to integrate its structures with the natural features and indigenous architecture of the destination. Large resorts of disparate design may look out of place in a natural environment and may clash with the indigenous structural design. A lack of land-use planning and building regulations in many destinations has facilitated sprawling developments along coastlines, valleys, and scenic routes. The sprawl includes tourism facilities themselves and supporting infrastructure such as roads, employee housing, parking, service areas, and waste disposal.

V.1.3 Physical Impacts

Attractive landscape sites, such as sandy beaches, lakes, riversides, and mountaintops and slopes, are often transitional zones, characterized by species-rich ecosystems. Typical physical impacts include the degradation of such ecosystems. An ecosystem is a geographic area including all the living organisms (people, plants, animals, and microorganisms), their physical surroundings (such as soil, water, and air), and the natural cycles that sustain them. The ecosystems most threatened with degradation are ecologically fragile areas such as wetlands, mangroves, coral reefs, and sea grass beds. Threats to and pressures on these ecosystems are often severe because such places are very attractive to both tourists and developers (Blakemore and Williams, 2008).

Physical impacts are caused not only by tourism-related land clearing and construction, but by continuing tourist activities and long-term changes in local economies and ecologies (Sato *et al.* 2013). Construction activities and infrastructure development: The development of tourism facilities such as accommodation, water supplies, restaurants and recreation facilities can involve sand mining, beach and sand erosion, soil erosion and extensive paving. In addition, road and airport construction can lead to land degradation and loss of wildlife habitats and deterioration of scenery.

V.1.4 Deforestation and intensified or unsustainable use of land

Coastal wetlands are often drained and filled due to lack of more suitable sites for construction of tourism facilities and infrastructure. These activities can cause severe disturbance and erosion of the local ecosystem, even destruction in the long term. Development of marinas and breakwaters can cause changes in currents and coastlines (Fortuny *et al.* 2008). Furthermore, extraction of building materials such as sand affects coral reefs, mangroves, and hinterland forests, leading to erosion and destruction of habitats. Overbuilding and extensive paving of shorelines can result in destruction of habitats and disruption of land-sea connections (such as sea-turtle nesting spots; Englebert *et al.* 2008).

V.2. Water and tourism key issues

The issue of water use by the tourism industry has been attracting attention in recent years, exemplified by the fact that the theme for this year's UN World Tourism Day (September 27th, 2013) was "Tourism and Water". Research and management efforts have so far concentrated on tourist facilities such as hotels, golf courses and swimming pools which directly use large amounts of water (Deng and Burnett, 2002).

For the average consumer, it is estimated that 86% of the daily water footprint comes from products originating in the agricultural sector. This realization is of immediate relevance to tourism, where approximately one-third of all tourist expenditure is used to purchase food. Tourism may consequently have a much more substantial impact on water consumption than previously thought, particularly on the percentage that is commonly associated with agriculture (Gössling *et al.* 2011).

Tourism is one of the world's largest industries, supporting one in eleven jobs worldwide and generating more than 9% of global GDP in 2012 (WTTC, 2013). Tourism is also one of the world's fastest-growing industries, with new destinations constantly emerging and tourism arrivals worldwide expected to increase by an average of 3.3% per annum from 2010 to 2030 (UNWTO, 2013). Given tourism's undeniable role in generating economic output, any efforts to conserve water must be geared towards maintaining or even increasing (where possible) industry profits. An element which adds a degree of complexity is that tourism is highly diverse, offering a plethora of products that cater for different tastes and budgets at different times of the year. These products differ in terms of the revenue generated but also in terms of their demand for water.

In Greece, tourism is mainly located into coastal areas and in the Greek islands, sites where water scarcity is more intense. Globally, direct water use in tourism is suggested to be between 80 and 2000 liters per tourist per day, with a tendency for larger resort style hotels to use significantly more water than smaller, less luxurious establishments.

All tourist facilities can save substantial amounts of water. For instance, it is estimated that hotels can reduce indoor water consumption by 30% by installing water-efficient fixtures. There is even greater potential to reduce outdoor water demand.

Several specific measures as discussed in the literature are presented in the following.

V.2.1 Gardens

Where irrigation is an important factor in water use, landscaping can considerably reduce irrigation needs. For instance, minimizing water consumption in landscaping can conserve 30% to 50% of water. Measure includes installation of water meters to monitor water use, selection of drought resistant plants and grasses, mulching of garden beds to reduce evaporation, installation of drip irrigation systems with electronic controllers and moisture sensors, and the use of rain or grey water for irrigation (Ilias *et al.* 2014). In many locations use of indigenous plants for landscaping purposes along with appropriate garden designs may reduce the need to irrigate altogether.

V.2.2 Pools

Pools can be responsible for considerable water consumption, and the most important measure is consequently to reduce their size and to avoid large pool landscapes when designing hotels. Likewise, fountains, waterfalls or other features increasing evaporation should be avoided. Pool night covers can reduce evaporation in hot climates, while drainage barriers can collect overflows and direct them back to the pool.

V.2.3 Guest rooms

In tourism facilities and accommodation guest rooms, toilets, showerheads, and faucet flow restrictors can be replaced with efficient ones. Given the proportion of water use related to toilet flushing, the use of dual flush, reduced flush and dry composting toilets can significantly reduce water usage. For instance, the most efficient toilets can use as little as 1 liter for a “mini flush”, compared to up to 12 liters for older models. It is also possible to use recycled water to flush toilets and urinals. Efficient and low flow showerheads can use less than 7 liters per minute, compared to 13 liters per minute used by older ones. Faucet flow restrictors can halve water consumption to 2.5 liters per minute. Usually, these changes will be highly economical.

V.2.4 Kitchens

Kitchens use water for washing and preparing food, thawing food and cleaning dishes. Changing cooking practices, use of efficient dishwashers and pre-rinse spray valves with smaller nozzles to achieve higher water velocity, use of boilers without steamers and efficient ice cream makers, as well as flow control regulators at sinks and basins can significantly reduce water use while being highly economical (Smith and Costello, 2009).

VI. Water supply and depuration parameters

Today, Greece has a population of approximately 10.8 million inhabitants, according to the last official census of 2011. The main management model for water and wastewater services in Greece is delegated public management, although more recently some public-private management schemes have been also started to be implemented. In the two biggest cities of Greece (Athens and Thessaloniki), the Greek state delegated two public companies (by a majority) named E.YD.A.P for Athens and E.Y.A.TH. for Thessaloniki. These companies have been listed also in the Greek stock market already for more than 15 years and the Greek state is the main shareholder and, therefore, the president of the board of directors and the CEO of both companies are appointed by the government. For cities with more than 10,000 inhabitants, the national law regulating the role and the foundation of municipal water and sewerage companies was published in 1980. Currently, there are 130 municipality-owned companies, named D.E.Y.A. In cities with fewer than 10,000 inhabitants, the management model is usually the direct urbanity public management.

According to article 17 of the urban wastewater treatment Directive 91/271/EEC (EC, 1991), each member state has to prepare every two years the respective Implementation Report, describing the collection, treatment, and disposal of the relevant wastewater data. Based on the most recent report of 2017, which refers to the year 2014, 91% of the country's population is connected to 254 urban wastewater treatment plants, treating almost 1.74×10^6 m^3/day. These plants provide secondary biological treatment, with 83% providing biological nitrogen removal, 57% providing (additionally) biological phosphorus removal, and 93% providing (tertiary) wastewater disinfection.

In 2012, a national database was created by the Specific Secretariat for Water (SSW) of the Greek ministry of environment and energy, with the initiative and the support of the European Commission Directorate-General for Regional and Urban Policy. This database has been upgraded and enriched ever since, presenting all the relevant information content in an advanced Geographical Information System (GIS), easily accessed by everyone interested via the respective webpage ("SSW—Wastewater Treatment Plants"). Within the database, specific information regarding the location, capacity, performance, means of disposal, or reuse of wastewater and of sludge, as well as the Environmental Terms of each WWTP are stored and are easily publicly accessible.

WWTPs follow the requirements of the directive 91/271/EEC, as indicated by blue dots (which represent the majority, *i.e.*, 168 out of 254). Figure 15 presents WWTPs that are not still compliant with the directive, either because they do not collect enough samples per year, or because the effluent is outside of the respective limits as set by the directive, which are indicated by red dots. Each dot size is logarithmically related to the capacity of each WWTP of municipal water and sewerage companies.

As shown in Figure 16, urban wastewater treatment plants in Greece have been increasing since the 1990s. Greece's wastewater sector has achieved undoubtable progress in terms of infrastructure, technology, and policy implementation, providing a solid ground for its future development. However, to be sustainable in this future, providing that wastewater quantity will continue to increase further and that water shortages will become more common, specific focus should be provided to the following main objectives:

- Treated wastewater reuse.
- Sludge disposal.
- Energy efficiency.
- Reducing greenhouse emissions.
- Management of wastewaters from small settlements that still use quite extensively the septic tanks option.
- Management and monitoring and control of wastewater from hotel and tourism infrastructure.

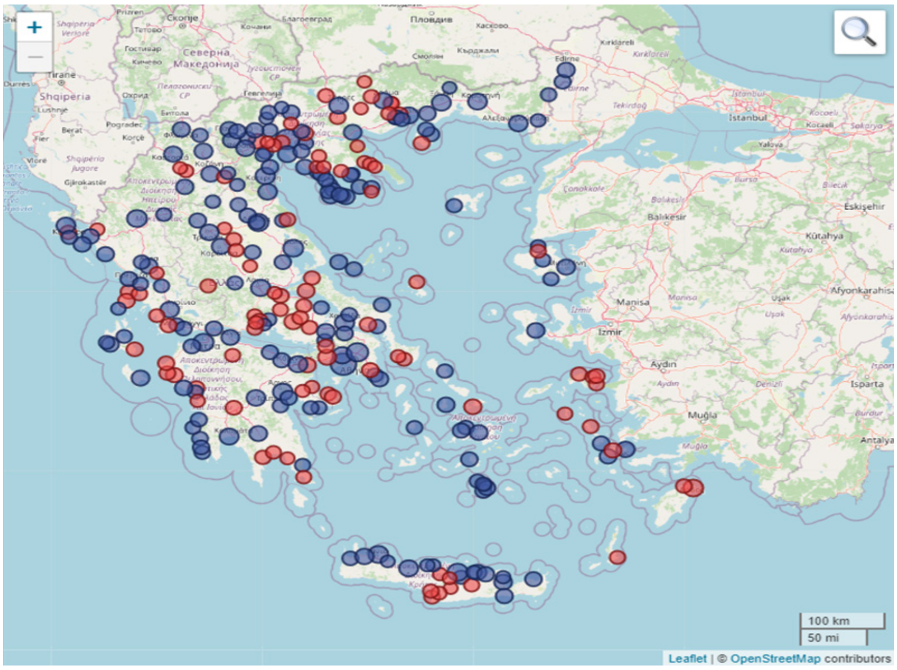

Figure 14. Map of Greece's WWTPs (Babunski *et al.* 2020)

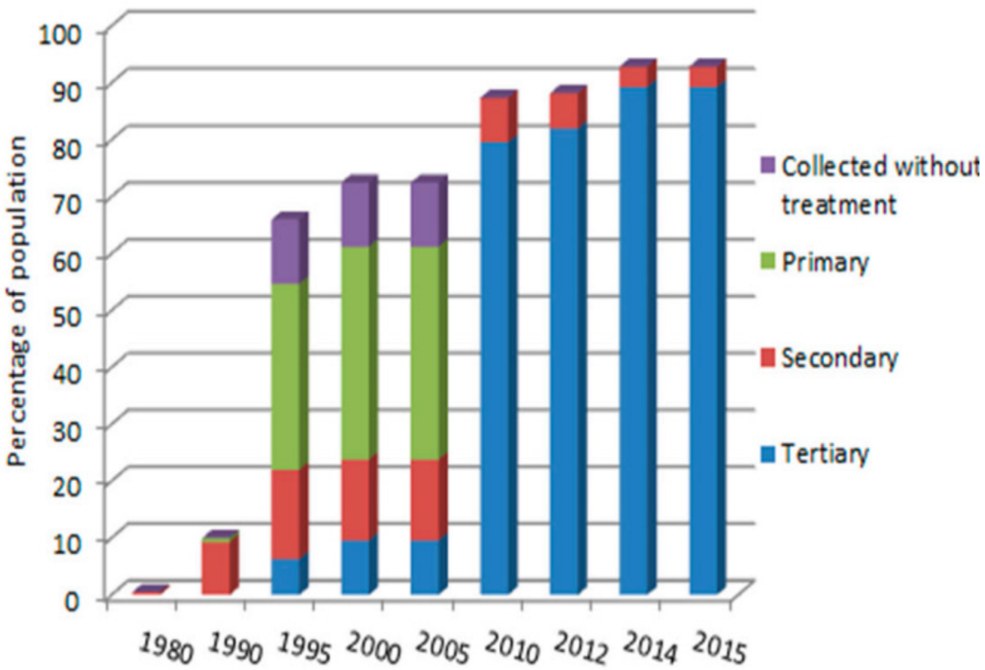

Figure 15. Increase of urban wastewater treatment plants (WWTPs) in Greece (1980-2015)

VIII. Conclusions

Tourism depends to a considerable degree on water, which is both a resource needed to provide services related to basic human needs, such as hygiene or food, as well as a precondition for fuel production, and an asset essential for a wide range of tourist activities, such as swimming in lakes or pools, or golf and winter sports. Furthermore, water is a central element of tourism landscapes in various forms, from irrigated hotel gardens to white winter landscapes, to lakes and streams embedded in park landscapes. Limited water availability, poor water quality or media portrayal of a water crisis can consequently do great harm to the image of tourism destinations.

Compared to water use in other economic sectors, tourism is generally less relevant, as in virtually every country in the world, agriculture eclipses tourism-related water consumption. However, in some countries, as well as regionally, tourism can be the main factor in water consumption. In such areas, it can increase direct pressure on already diminished water resources and compete with other economic sectors as well as the subsistence needs of local populations. In addition, tourism can also contribute to a decline in downstream or destination water quality and potable water supplies because of poor or no treatment of wastewater, which then enters aquifers and the water system. Significantly, in several increasingly water-scarce regions such as the Mediterranean, the concentration of tourism in time and space as a result of seasonal tourist demand can place enormous pressures on domestic and industrial water supplies as well as wastewater infrastructure, often at a period when they are least able to cope. Such situations also highlight the importance of analyzing tourism's water demands at an appropriate temporal and spatial scale rather than just relying on assessments conducted on an annual or national basis.

Numerous studies suggest that direct water use in tourism is 80 to 2,000 liters per tourist per day, with a tendency for larger resort-style hotels to use significantly more water than smaller and less luxurious establishments. Depending on geographical location and environmental and/or climate conditions, the main water-consuming factors are irrigated gardens, swimming pools, spa and wellness facilities, as well as golf courses, followed by cooling towers (if applicable), guest rooms and kitchens.

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