

Greece in the Eastern Mediterranean: Challenges of Climate Change and Key Opportunities

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Abstract

Climate change presents both challenges and opportunities for Greece in the Eastern Mediterranean region. In addition to environmental concerns, it directly impacts the country's development model, production sectors and ecosystems, requiring appropriate adaptation strategies to support economic growth. The tourism industry, vital to the Greek economy, is vulnerable to rising temperatures and extreme weather events. Biodiversity and forests are threatened, requiring reforestation efforts and international cooperation to combat wildfires. The agricultural sector, though declining, is still important, requiring adaptation measures and knowledge exchange. Energy infrastructure is also under threat, with extreme weather conditions affecting both renewable energy sources and networks. Despite the challenges, Greece can turn them into opportunities through collaboration, innovation, and sustainable development. Strengthening multilateral cooperation, knowledge sharing, and investing in resilient infrastructure will mitigate climate change's adverse effects and unlock Greece's potential for a prosperous future in the Eastern Mediterranean.

Introduction

Climate change and its severe consequences are not just another environmental problem simply linked to rising temperatures or more frequent occurrence of extreme weather events, as is often and incorrectly approached in the media and the public. On the contrary, it is an issue that is directly related to the development model of a country, or a region, as societies, entire productive sectors, and ecosystems are significantly affected by climate change. In order to maintain the economic and socio-economic momentum, adequate adaptation strategies are needed.

Therefore, a timely, reliable, spatial, and temporal assessment of the impacts of climate change can strengthen the protection of crucial sectors of a country and its economy. Consequently, such an assessment will affect the labor market, facilitate the development of new sectors, identify new business opportunities and "train" the state in long-term strategic planning. This serves to protect the country's social capital, along with its Gross Domestic Product.

All of the above become even more important if the country considered is on an economic recovery path, such as many countries in the Mediterranean and most notably Greece. The Greek development model is based on industries/sectors, particularly tourism, that are increasingly affected by climate change (Karountzou and Soileme, 2019).

About Greece

Greece comprises a total area of 131.957 km² and occupies the southernmost extension of the Balkan Peninsula. The mainland accounts for 80% of the land area, with the remaining 20% divided among nearly 3000 islands. The Greek landscape, with its extensive coastline, exceeding 15.000 km in length, is closely linked with the sea and coastal plains along the seashore of the country, which cover approximately 25% of it is lowland. Forestland accounts for 26.2% of the total area of the country, while grassland, rangeland and pasture with vegetation covers an additional 40.3%. Agricultural land comprises 25.1% and settlements, developed land including transportation infrastructure and human settlements of any size, account for 4.1% of the total area (Climate ADAPT, 2021; Hellenic Republic, 2018).

Greece has a Mediterranean climate, with mild and wet winters in the southern lowlands and island regions and cold winters with abundant snowfall in the mountainous areas in the central and northern regions and hot, dry summers. The mean temperature during summer is approximately 24°C in Athens and southern Greece, while lower in the North. Generally, temperatures are higher in the southern part of the country. Except for a few thunderstorms, rainfall is rare from June to August, where sunny and dry days dominate (World Bank Group, 2021).

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Greece contributes minimally to global climate change with greenhouse gas emissions amounting to no more than 0,18% of global emissions, but is significantly affected by it. This notwithstanding, the Greek governments have supported all the European and international treaties that have been pledged and institutions that have been formed in recent decades to protect the environment and tackle climate change. This includes, e.g., the United Nations Environment Programme, IRENA and the UNFCCC Paris Agreement of 2015 (Kartalis, 2021).

In this regard, one of the most important initiatives that Greece has taken in the context of European cooperation was the "Athens Declaration on Climate Change and the Mediterranean Environment" (*The Prime Minister, 2021*). The leaders of France, Greece, Spain, Italy, Croatia, Malta, Cyprus, Portugal and Slovenia adopted the Declaration at the EUMED 9 Summit in 2021. The Declaration calls for actions with specific measures to tackle climate change, the conservation of biodiversity and forests, the protection of the marine environment and closer cooperation of civil protection agencies among the participant countries (*Mitsotakis, 2021*).

Thus, in order to better identify the opportunities and synergies that may lead to meaningful cooperation in all the countries of the Mediterranean Basin, one should consider the driving forces of climate change that result in the most critical impacts in the Mediterranean, in general, and in Greece, in particular.

Biodiversity and Forests

Greece, as a Mediterranean country is characterized by a substantial diversity of plant and animal species (*Legakis et al., 2018*). The flora of Greece is, in relation to its area, is one of the richest in Europe, with more than 6 000 species and subspecies of plants, of which 300 are considered rare and endangered, according to the latest Red Data Book of Rare and Endangered Plants of Greece (*Phitos et al., 2009a,b*). Greece's significant geomorphology and the influences it entails, as well as the historical factors have allowed the country to comprise, in addition to a wealth of species, a high degree of endemism (*Phitos et al., 2009a,b*).

At the same time, forest ecosystems occupy over 65% of the land area of Greece, providing a variety of material goods, such as wood biomass, grazing material, natural products and contribute to the provision of quality water and air by capturing atmospheric CO₂.

The Natura 2000 Network is a central element of EU nature and biodiversity policy and consists of two categories of protected areas:

1. **Special Areas of Conservation (SACs)** designated by the Member States in accordance with the provisions of the Habitats Directive on the conservation of natural habitats, and of wild flora and fauna and
2. **Special Protection Areas (SPAs)** as they are established for the conservation of birds (in accordance with the provisions of Directive on the conservation of wild birds).

The Natura 2000 network in Greece consists of 443 Natura 2000 areas (241 SACs & 202 SPAs), covering 27.2% of the land and 6.1% of the territorial waters. The impacts of climate change, which have serious implications for biodiversity and environmental integrity have already been observed in these ecosystems and have been summarized in *Georgakopoulos (2017)*:

- a. the natural progression of processes such as reproduction and migration of species is modified,
- b. the duration of the germination period is altered,
- c. changes in migratory bird communities have been observed,
- d. most species of amphibians and reptiles are in danger of not having suitable habitats by 2050.

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If we take the effects of human activities, along with the spread of fires, in addition to the usual environmental factors, such as temperature, solar radiation, available water, into considerations, it becomes apparent that the situation is even more complex and multifaceted.

In Greece, fires are very common, degrading the structure, composition and function of forest ecosystems and limiting their beneficial effects. In the years 1990-2000 there were 18,545 fires that burned 519 745 hectares of land, of which 49% were productive forests. For the years 2000-2020, 115,433 fires were observed, of which about 1% (1.022 incidents) are responsible for 80% of the burned areas reported (*Greek Fire Service, 2021*).

According to the data of the European Forest Fire Information System for 2021, although the number of forest fires increased by 43% compared to the average of previous years in Greece, the burned areas show an even greater increase of about 500% compared to the same figure in 2020. This increase alone is sufficient to place Greece first among the 15 Mediterranean countries participating in this system (*JRC-EFFIS, 2022*).

Forecasts for the future are ominous as the frequency of high fire risk days will increase from 15% to 70% by 2050 on a European level and especially for Greece this period will be extended from 2 to 6 weeks (*Climate Change Impacts Study Committee, 2011*).

In order to adapt to the new challenges that prevail, the Greek Government created the General Secretariat of Forests in December 2021 and announced at the same period the largest reforestation program ever carried out in Greece, its costs amounting to 310 million Euros (approved to be funded by the Recovery & Resilience Fund; Ministry of Environment and Energy, 2020).

These two very important initiatives, i.e., the initiation of a General Secretariat for Forestry and the reforestation program clearly show the country's strategic orientation. However, this will also enable the utilization of more extensive synergies and collaborations with countries more advanced in this field in order to become a reality. It also entails the transfer of know-how in forest management, best practices in firefighting, transnational agreements for joint action, research on reforestation and a better understanding of the interconnectedness of systems for joint monitoring and forest fire prevention.

The opportunities for cooperation on a regional level with regard to the observation and prevention of fires, are particularly promising. This is due to the fact that the National Reforestation Plan of Greece includes the installation and systematic operation of protection mechanisms, the conservation of forests and its rich biodiversity, along with the monitoring of reforestation and of changes in land use that have a bearing on environmental quality and integrity.

In addition, the transnational cooperation between the countries of Central Europe and those of the Mediterranean in the field of Civil Protection is a matter of high importance and a field of common opportunities. Greece frequently requests the assistance of foreign countries in firefighting during summer and flood management during winter and autumn, as a consequence of forest damage, which reduces the ability of tree roots to retain precipitation.

Agriculture

The agricultural sector is traditionally one of the most important sectors of the Greek economy and one of the most prominent contributors to Greek exports. Despite the gradual decline of the sector's contribution to the country's total GDP over the last decades (currently 3.9%) (*O'Neill, 2023*), its importance for the economic development and social cohesion of the country became apparent again during the recent economic crisis. The declining importance of agriculture for the country's GDP is mainly caused by an increase in land requirements for the growing urbanization in the country, which leads to decreasing volumes of agricultural products. This notwithstanding, it is important to note that the agricultural sector

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of the Greek economy constitutes 17% of the total Greek exports, while it employs about 12% of the total workforce of Greece, a percentage that significantly exceeds the corresponding EU average (*Mavros, 2022*).

In the upcoming decades, agriculture is estimated to be affected adversely by climate change, as production is at risk due to the decline in precipitation, the loss of arable land, shorter growing seasons and uncertainty about the type of crops suitable for the altered climate conditions. Consequently, the overall GDP of European countries is expected to be reduced by 1% by 2050, however, varying from country to country (*Georgiopoulou, 2021*). Climate change will result in less copious and lower-quality crops and higher production costs for farmers. More specifically in Southern Europe, the cultivation of wheat, corn and sugar beets may be reduced by up to 50% by 2050, as a consequence of reduced precipitation for irrigation (*Georgakopoulos, 2017*). Moreover, climate change is expected to affect the soil, reducing its organic components and its water content in a given region. It will bring about changes in crop management, in the composition of products (some species may not be able to thrive where they were cultivated previously, while others may appear in areas that until recently were unsuitable for them) and in the spatial organization of agricultural production. Relocation within rural farmlands will probably be faced with already uninhabitable areas or spaces unsuitable for agriculture. These facts underline the conclusion that the agricultural sector of the Mediterranean Basin, and similarly of Greece, will be significantly affected by climate change.

In this ever-changing environment, it is important to highlight the importance of transferring expertise on good practices in plant and fruit growing from countries with currently suitable conditions, to those that were previously unsuitable for such products but may gradually become more appropriate for them. A typical example is the olive oil sector. While previously representing a highly competitive product in the countries of southern Europe and those of the Middle East and North Africa, these countries should engage in increased cooperation in order to sufficiently meet global needs.

This appears to be appropriate because the European Union is the largest producer, consumer and exporter of olive oil, producing about 67% of the world's olive oil. More specifically, Spain, Italy and Greece are the three largest producers of olive oil, followed by Tunisia, Turkey, Morocco and Syria (*European Commission, 2021*). These facts underline the need for enhanced cooperation between the above-mentioned countries.

At the same time, we should also take into consideration the synergies stemming from the combination of current trends in agricultural technology and new energy production technologies. Two of the most innovative solutions are the combination of CHP units (Cogeneration of Heat & Power) with hydroponic cultivation in greenhouses, which is accompanied by high economic rewards for both sectors. The second example is related to Agri-Photovoltaics, i.e., the installation and use of photovoltaic panels on top of agricultural land to produce electricity and simultaneously provide shading for agricultural crops, thereby increasing the economic yield per unit area.

Finally, soil degradation creates the need for cooperation in the field of fertilizers and food security, enabling joint research and development programs between Greece and the MENA region. This applies most importantly to Morocco, which holds the 75% of the world's phosphate deposits (*Tanchum, 2022*).

Energy

Global climate change is already affecting both our daily needs and the spatial and temporal distribution of (electrical) energy. As temperature rises, so does the demand for cooling energy during the summer, while the energy demand for heating decreases during the cold season. The large fluctuations in loads that result from these changes affect the needs for new generating units and increase the cost of electricity generation, as shown by recent developments in Europe (*Zachariadis and Hadjinicolaou, 2014*).

In addition, energy infrastructure and more specifically energy transmission infrastructure are considered very vulnerable to the effects of climate change, as extreme weather events can damage crucial

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components. Moreover, the daily intermittency and the seasonally varying production of renewable energy, particularly solar- and wind energy, create volatility for the availability of electricity. This can lead to a rapid loss in voltage or overloading of networks and may result in blackouts that affect end users as well as network transmission and distribution operators. Last but not least, flash floods and rainstorms, which have become more common and severe in recent years as a result of climate change pose a significant risk that is likely to have an impact on all types of energy facilities.

The most crucial areas of energy infrastructure, that Greece has observe when planning for a sustainable path to energy security comprise (*Georgakopoulos, 2017*):

- a. The productivity of hydropower plants, which are one of the most critical backups of the electricity system of Greece, is affected by the availability of water resources. These plants have been designed years ago and have been based on historical data of climatic parameters (particularly with regard to precipitation), which were significantly different to the new climate conditions.
- b. Electricity transmission and distribution networks, as well as high voltage centers, are infrastructures particularly vulnerable to extreme weather events and floods. Also, the constant rise in sea level affects Greece's near coastal network infrastructure, as well as underwater interconnections.
- c. Wind farms are vulnerable to extreme weather events, due to the change of the wind potential of an area. High wind speeds may cause damage to wind turbines, which were designed for different climatic standards, while low wind speeds threaten the viability of wind farms.
- d. Changes in the water vapor content of the atmosphere and the characteristics of clouds affect the atmospheric transmissivity and consequently the energy production from photovoltaic installations. These changes can be positive or negative depending on the specific changes of climatic parameters in a given region.

Changes of climate parameters, particularly an increase in solar irradiation will favor the production of renewable energy from photovoltaics (PV) in Southeastern Europe and in Greece. However, it is shown that the projected temperature increase of 3.5oC will negatively affect PV output. Nevertheless, this will be outweighed by the expected increase in total radiation resulting in an up to 4% increase in energy output (*Panagea et al., 2014*). Therefore, changing climatic conditions will create new opportunities for some forms of energy generation, such as solar energy, and will create difficulties for others, such as wind and hydroelectric power production.

One of the most important areas of common interest in the energy sector among countries of the Mediterranean lies in multilateral cooperation in developing interconnection and energy transmission infrastructure. It should be noted that at present, Greece is engaged in advanced talks on a new Greek-Egyptian power cable, a project that could significantly reduce energy costs in both countries, reduce carbon dioxide emissions and reduce the dependence on imported fossil fuels. This cable, apart from exporting green electricity from Egypt to EU through Greece, can play the role of a regional central dispatch system, working complimentary with the renewable energy produced in SE Europe.

In addition, Greece, within the framework of the European Target Model, has already established a coupling of electricity markets with those of Italy (*ADMIE, 2021*) and Bulgaria (*SDAC, 2021*). The development of cable infrastructure such as the above can create the conditions for further coupling of energy markets across the Mediterranean basin with the central European energy market, with countries such as that of Egypt, Cyprus, Israel, etc.

Another important initiative that Greece is heavily involved in, which highlights the possibilities of interregional cooperation is the "GR-eco Islands Initiative" (*European Commission, 2022*), an initiative that aims to transform Greek islands into sustainable islets that will produce on the spot "green" energy. The inhabitants will use solely "green" transportation, both on land and at sea by electric cars and boats. In

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addition, innovative waste management technics will be implemented in order to reduce the island's carbon footprint to zero. The Greek government is already implementing its plans at the islands of Chalki, Tilos and Astipalea, with the support of German, French and other European energy, and automotive companies.

Finally, Greece has a significant asset in the Mediterranean through the Greek merchant fleet. The "Greeks" have the largest share internationally of the Liquefied Natural Gas (LNG) vessels, while playing a leading role in the Liquefied Petroleum Gas (LPG) industry. According to the latest report of the Hellenic Ship-owners' Association, 15.58% of the global LNG/LPG fleet belongs to Greek companies (*Georgiou, 2022*). The significant presence of LNG/LPG vessels, which may in the future be accompanied by hydrogen transport vessels that Greece is planning to build, can be both an excellent alternative to energy pipelines and a reliable partner for the safe and uninterrupted supply of energy to third countries.

Tourism and Cultural Heritage

Tourism is another highly important sector of the Greek economy, as Greece is one of the top tourist destinations in the world. The number of tourists has been growing steadily since 2004 (14.2 million visitors) until today (over 20 million visitors) and the benefits from the services to the Greek economy sums up to 16% of GDP and 18% of employment.

However, the effects of climate change significantly threaten Greece's tourism industry. This includes the drastic increase in summer temperatures, the occurrence of heat waves, increasing energy requirements for refrigeration and space cooling and the reduction of water resources, especially on the islands. These are most crucial factors that can completely alter the composition of the local population and the sustainability of local enterprises.

It is expected that tourist traffic maybe be reduced during the summer, although this does not necessarily mean a reduction in tourist traffic on an annual basis, if appropriate support measures are implemented in order to shift visitor arrivals to spring or autumn months. Higher temperatures allow tourists to stay in coastal areas longer into autumn and earlier in spring, however, this can still not be counted as an outright gain (*Elafros, 2021*).

The above-mentioned shift in the extended tourist seasons can be extremely beneficial for the Greek tourism industry if we consider the recent trends and changes in the behavior of tourists. New, more environmentally conscious and nature-oriented forms of tourism are developing and can become a significant field of cooperation among the countries of the Mediterranean Basin. Ecotourism, winter tourism, gastronomic tourism, digital nomads, etc., are just some of the areas that will flourish in the coming years and countries of the Mediterranean can gain significant mutual benefit from these developments.

Apart from the rising opportunities, however, one of the most important issues that both the Greek tourism industry and the Greek governments need to address is the effects of climate change on cultural monuments. Cultural heritage is a concept directly related to the strengthening of social capital, economic and tourism development of any country. This applies in particular to Greece, whose monuments and history are internationally recognized. Floods, fires, strong winds and the long-term effects of adverse climatic conditions threaten, in whole or in part, cultural heritage monuments, which are located throughout Greece.

The Greek government has already drafted a National Action Plan for Cultural Heritage and Climate Change starting in October 2019. One of the most important results of this plan is to recognize its adequacy and achievability by the EU institutions, with Greece securing financial resources of € 32Million from the Recovery & Resilience Fund for actions related to monitoring, digitalization, and systematic monitoring of the environmental effects, on its most important archeological sites (*Koulouvaris, 2021*).

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Apart from the domestic policy planning, Greece has taken an initiative at the UN level to “protect the world cultural heritage from climate change. G. Kremlis, advisor to the Greek Prime Minister on energy, climate, environment and circular economy and President of the initiative, recently told the Greek media that “already 100 states support this initiative, and the number is constantly growing” (*HuffPost Greece, 2021*).

All of the above issues comprise an environment in which Greece has the opportunity to take the lead in this crucial issue of climate change on a global level and to expand diplomatic cooperation by transferring knowledge and experience gained so far to other Mediterranean countries.

Conclusions

The impact of climate change on Greece's economy, environment and society is undeniable. This paper has highlighted the challenges and significant opportunities facing Greece in the Eastern Mediterranean in relation to climate change. Climate change is not just an environmental issue. It directly affects the country's development model, production sector and ecosystem. To ensure sustainable economic and socio-economic growth, Greece needs to put in place appropriate adjustment strategies. Assessing the spatio-temporal impacts of climate change is important to protect a country's key economic sectors. It helps identify new business opportunities, leads to the development of new areas of economic activity and drives long-term strategic planning. Greece's focus on industries such as tourism makes it particularly vulnerable to climate change. Rising temperatures, changing precipitation patterns, and increasing frequency of extreme weather events pose significant challenges in these sectors.

The paper also emphasizes the importance of biodiversity and forests in Greece. Greece, like most of the Mediterranean countries, has a rich variety of flora and fauna. Forest ecosystems cover a significant portion of Greece's land area and provide various material goods, contribute to water and air quality, and capture atmospheric CO₂. However, climate change and human activities, including the spread of fires, pose serious threats to these ecosystems. An increase in the frequency and intensity of forest fires has already been observed in Greece, necessitating the implementation of reforestation programs and collaboration with other countries for joint monitoring and prevention.

The agricultural sector, while declining in its contribution to Greece's GDP, remains a vital sector for the country's economy and employment. However, climate change presents risks to agricultural production, including reduced precipitation, loss of arable land, and shorter growing seasons. Adaptation measures and knowledge exchange between countries with suitable conditions for certain crops are crucial to ensure sustainable agricultural practices. Especially, enhanced cooperation between olive oil-producing countries in the Mediterranean Basin can help meet global demands.

Energy infrastructure is also vulnerable to climate change. Extreme weather events, intermittency of renewable energy sources (solar, wind), and increased demand for heating and cooling are only some of the most important challenges facing this sector. Advancements in electricity transmission and distribution networks along with the creation of maintenance and creation of gas and hydrogen pipelines are a key issue in addressing Europe's energy needs. In this regard, developing resilient energy infrastructure and ensuring energy security in the face of climate change are important priorities for Greece.

In summary, Greece faces major challenges from climate change, especially in areas such as tourism, biodiversity and forestry, agriculture and energy. However, these challenges also offer opportunities for collaboration, innovation and sustainable development. Strengthening multilateral cooperation, promoting knowledge sharing and investing in resilient infrastructure will reduce the adverse impacts of climate change and increase Greece's potential for a sustainable and prosperous future in the Eastern Mediterranean.

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Agis Digkas serves as Executive Vice President of Greece's Renewable Energy Sources Operator. The company is the largest shareholder in the Hellenic Energy Exchange (HEnEx) and the auctioneer of the CO2 Emissions Allowances in Greece. In this capacity, he oversees and coordinates the strategic development of Greece's Renewable Energy Market, increasing penetration and ensuring sustainability of existing and new RES & CHP investments. He represents the company to European & International Institutions, strengthening government's effort to tackle climate change and its consequences. Prior to this, Agis worked as an energy consultant with a demonstrated history in both private and public sector. He studied Mechanical Engineering at National Technical University of Athens and holds an MBA and a PhD in "Decision Support Systems & Systemic Risk Analysis" from University of Athens.

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