Preface and summary of the findings of the Report

The studies included in this publication of the Bank of Greece were conducted by a large number of researchers from a wide range of scientific disciplines. When the Governor and the General Council of the Bank asked my colleague at the Academy of Athens, Professor Constantinos Drakatos, and me to set up a Climate Change Impacts Study Committee, we were fully aware of the fact that producing a comprehensive report on the environmental, economic and social impacts of anthropogenic climate change in Greece would be a particularly demanding task, but also that such an endeavour would help fill an important gap in both the Greek and the international literature on the subject. Indeed, in the course of preparing the respective studies, we realised how much needed to be done and how much more would have to be done in the future.

The individual studies highlight the wealth of Greece's natural resources, but also the *dangers* to the country's natural and human environment. Greece has an extremely long coastline of some 16,300 km (equivalent to roughly one-third of the Earth's circumference), of which around 1,000 km correspond to areas highly vulnerable to climate change, due to the risk of a *rise in mean level of Greece's seas* by an estimated 0.2 m to 2 m by the year 2100. The vulnerability of our coasts is determined not only by the risk of a mean sea level rise and extreme wave events, but also by local factors (tectonics, geomorphology, etc.). About 20% of Greece's total coastline is ranked as being of moderate-to-high vulnerability to developments likely to arise on the basis of projections. Both the long-term change in sea level and extreme, transitory events will affect many sectors of the economy, including tourism, land use and transportation. The total cost of anthropogenic contribution to sea level rise will come to tens of million of euros each year, as discussed in detail in the relevant chapters.

Greece's environment, apart from its distinctive geography featuring an extensive coastline, is also characterised by great biodiversity and a variety of climates, due to the interaction between the weather systems and the country's complex topography and the distribution of land and sea areas from East to West and North to South. Thus, within just a few dozen kilometres, the climate can change from coastal Mediterranean to practically alpine in the country's central and northern regions. The varied topography combined with the trajectories of the weather systems separate Greece into a western windward area and an eastern leeward (or rain shadow) area. The country receives enough *rainfall* to meet all its needs, but unfortunately these water resources are mismanaged. The total annual volume of precipitation averages 115 billion m^3, which puts Greece at least on a par with many other European countries. However, some regions of Greece are affected by a water deficit, especially in the country's rain shadow, where the decline in water supply is, in addition to water resource mismanagement, further exacerbated by extreme climate situations, such as the one that occurred in 1989-90, when precipitation levels dropped by around 40%. On the plus side of the equation, many of these water-deficit regions have higher biogenic emissions of aromatic compounds, which, to the delight of scores of visitors, release their fragrances into the atmosphere.

Available measurements show that, in the course of the past century, *precipitation* decreased by around 20% in Western Greece and by 10% in Eastern Greece. These lower levels of precipitation have typically been attributed to natural factors, for the simple reason that the anthropogenic impact only became quantifiable in recent decades thanks to the development of high-standard climate models requiring the use of advanced computers. Based on the models used to calculate the anthropogenic component of climate change under the two extreme climate change scenarios (B2 and A2) discussed in the relevant sections of the study, it is expected that by the end of the 21st century, the decrease in precipitation levels due to anthropogenic factors will range between 5% and roughly 19% countrywide, depending on the scenario, while *air temperature* will increase by between 3.0ºC and 4.5ºC, respectively. The simulations point to significant changes in several climate parametres, such as *humidity, cloud cover*, etc. Interestingly, with regard to the future use of Renewable Energy Sources (RES), *average solar irradiation is expected to increase* (by between 2.3 W/m^2 and 4.5 W/m^2) at a national level, while *the force of the etesian winds is expected to increase* by 10% by the end of the 21st century.

As shown by one of the studies in this Report, it is estimated that, even under the intermediate scenario A1B, the Greek mainland in 2071-2100 would, compared to now, have some 35-40 more days *with a maximum daily temperature of 35ºC or more*, while even greater would be the increase (by around 50 at the national level) in the number of tropical nights (when minimum temperatures do not fall below 20ºC). At the other end of the spectrum, the number of nights with frost is expected to drop significantly, especially in Northern Greece (by as many as 40). Moreover, the rise in average temperature will *prolong the vegetation period* by 15-35 days.

One of the major impacts of global warming is that *the demand for electricity for cooling* in the summer months *will increase*. More specifically, the low-lying areas of continental Greece will have increased needs for cooling for up to an extra 40 days per year during the period 2071-2100, while the increase in needs will be smaller in the island and mountain areas. A positive aspect of climate change is that *energy needs for heating* in wintertime *will decrease*.

Changes are also expected in *precipitation extremes*. In Eastern Central Greece and NW Macedonia, the maximum amount of precipitation occurring within 3-day periods is expected to increase by as much as 30%, whereas in Western Greece it is expected to decrease by as much as 20%. By contrast, the greatest increases in drought periods are projected for the eastern part of the mainland and for Northern Crete, where 20 more *drought* days are expected per year in 2021-2050 and up to 40 more drought days are expected in 2071-2100. As a result of climate pattern changes, the number of days with a very high *risk of fire* is expected to increase significantly by 40 in 2071-2100 across Eastern Greece (from Thrace down to the Peloponnese), while smaller increases are expected in Western Greece.

On a general note, the impact of climate change on all sectors of the economy that were examined was found to be negative and, in several cases, extremely so. The impact, for instance, on fir, beech and pine *forests* would be considerable, while fire-fighting costs are expected to shoot up on account of the increasing number of *forest fires* and area affected by them. Meanwhile, species abundance and *biodiversity* are expected to decline. Furthermore, climate change, as measured by its projected impact on the tourism climatic index (TCI) by the end of the century, is expected to have serious repercussions on *Greek tourism* – mainly on the seasonal and geographical patterns of tourist arrivals. Receipts from tourism will therefore be affected. Given that tourism is such a crucial source of revenue for Greece, this Report proposes that long-term strategic planning is needed in order to upgrade the country's tourism product in the context of ongoing human-induced climate change. The consequences of climate change on the *built environment, transportation, health, mining* and other sectors are also important and are discussed in the present publication. All of the studies in the Report clearly point to the need for a well-specified adaptation policy that would cover all sectors. A foreign policy that would be revised on aspects of particular relevance for Greece should also be part of the overall adaptation policy.

With regard to *economic impact assessments*, specific studies were carried out using three different scenarios: the worst-case scenario in terms of greenhouse gas emission intensity, called the **Inaction Scenario**, corresponds to no action being taken to reduce anthropogenic greenhouse gas emissions. It was estimated that, under this scenario, Greece's GDP would drop by an annual 2% in 2050 and 6% in 2100, and that the total cumulative cost for the Greek economy over the period extending till 2100, expressed as GDP loss relative to base year GDP, would amount to €701 billion (at constant prices of 2008). The second scenario, called the **Mitigation Scenario**, presumed that Greece would achieve a consistent and drastic reduction in greenhouse gas emissions within a broader global effort and that, as a result, the average global temperature would not increase by more than 2ºC. The total cumulative cost of the Mitigation Scenario for the entire period till 2100, expressed in terms of GDP loss, comes to €436 billion (at constant prices of 2008). In other words, the total cost for the economy under the Mitigation Scenario is €265 billion less than under the Inaction Scenario, meaning that the mitigation policy would reduce the cost of inaction by 40%. Finally, given that an adaptation policy is also necessary in order to reduce the damage from climate change, an **Adaptation Scenario** was examined. Under this scenario, Greek GDP would drop by 2.3% and 3.7%, respectively, in 2050 and 2100, while the cost of adaptation policies would total €67 billion. It must, however, be stressed – as discussed in the relevant sections of the Report – that the adaptation measures do not eliminate all the damage from climate change, but simply contain it. Thus, the cumulative cost for the Greek economy of the (now reduced) damage from climate change was estimated at €510 billion (at constant prices of 2008) over the period till 2100. As a result, the total cost for the Greek economy under the Adaptation Scenario is the sum of, first, the cost incurred by the economy on account of the adaptation measures and, second, the cost of the (reduced) damage from climate change; this sum (the total cumulative cost through 2100) was estimated at €577 billion (at constant prices of 2008).

Finally, it should be noted that the estimates of the economic cost of human-induced effects on the environment, as derived at various stages of the study, all correspond to the lowest expected cost and, as such, must be taken as simply indicative of the order of magnitude. One of the important factors affecting Greece's strategic planning and adaptation policy formulation will be the issue of *poverty* and the *social problems* that human-induced climate change exacerbates. Obviously, understanding and addressing such a host of issues would require better calculations, more data, but also the formulation of domestic and foreign policies which – drawing on the indicative findings of this Report – would shield the country from things to come. Let us not forget the tenet of Hippocrates and his school *"Κάλλιον το προλαμβάνειν ή το θεραπεύειν"* ("It is better to prevent than to treat"), which is echoed in the term *'Precautionary principle'*, now of standard usage after its introduction by former Prime Minister of Norway, Bro Harlem Brundtland.

On behalf of the Climate Change Impacts Study Committee, I would like to ask our readers to excuse any errors, oversights or omissions in this Report, to be corrected in a future edition. The Study Committee would like to thank the Governor of the Bank of Greece, Mr. George Provopoulos, as well as the members of the Bank's General Council, and all those who have contributed to the success of this first, but big, effort to better prepare our country for the environmental challenges ahead.

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