MUSEUM
OF THE BANK
OF GREECE

Exhibition Catalogue

BANK OF GREECE
EUROSYSTEM

CENTRE FOR CULTURE
RESEARCH AND DOCUMENTATION


ΚΛΙΜΑΤΙΚΗ ΑΛΛΑΓΗ
ΟΙΚΟΝΟΜΙΑ & ΚΛΙΜΑ
HANDLE WITH CARE
ΚΕΝΤΡΙΚΗ ΤΡΑΠΕΖΑ

MUSEUM
OF THE BANK
OF GREECE

EXHIBITION CATALOGUE

CLIMATE CHANGE

ECONOMY & CLIMATE
HANDLE WITH CARE

CENTRAL BANK

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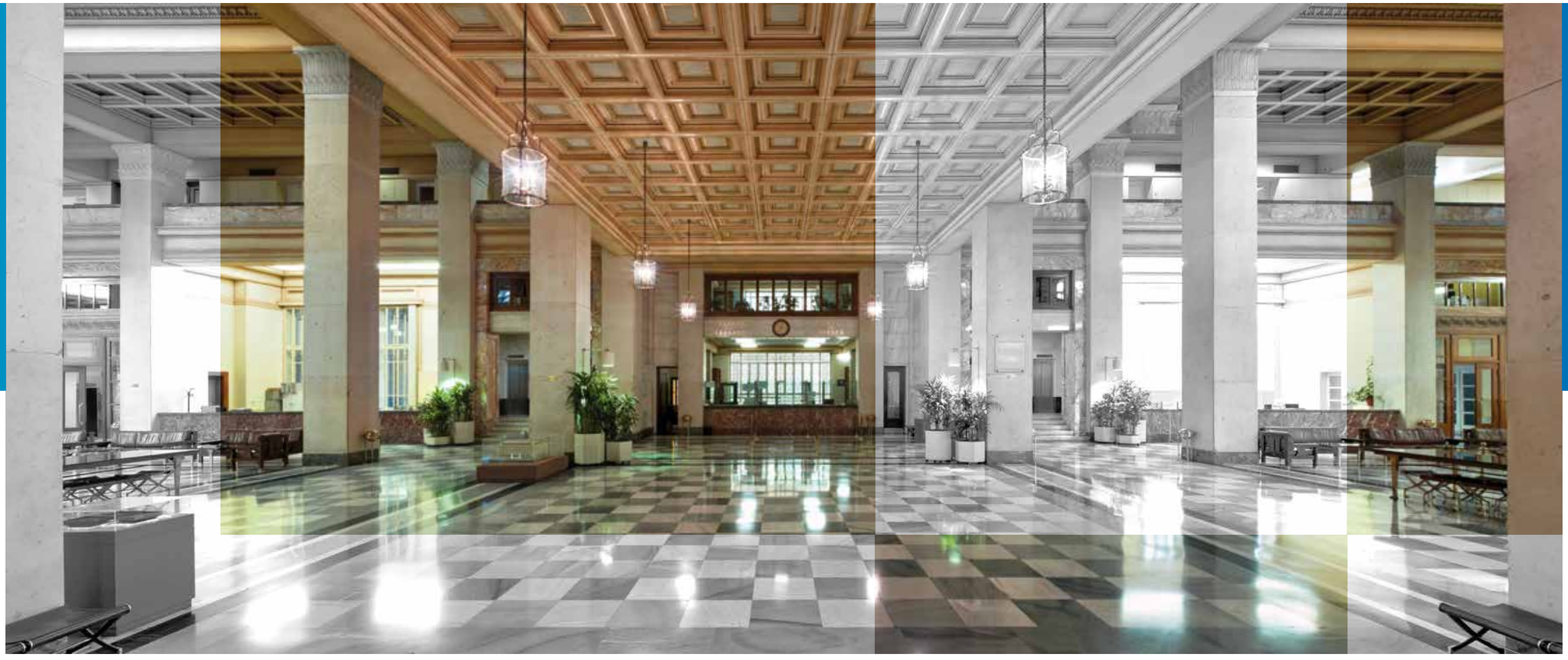
Foreword

The Bank of Greece is one of the first central banks in the world to have recognised the significance of addressing the risks arising from climate change. It systematically studies the impacts of climate change in Greece, having set up the Climate Change Impacts Study Committee (CCISC) in 2009, and takes actions in this regard, including its participation in the Central Banks and Supervisors Network for Greening the Financial System (NGFS) and its decision to set up the Climate Change and Sustainability Center in 2021.

In addition, the Bank of Greece is actively involved in the ongoing efforts within the Eurosystem to address the impacts of climate change. These efforts include an ambitious action plan with a detailed roadmap towards sustainability.

In this context, the new temporary exhibition "Economy and climate: Handle with care" at the Bank's Museum aspires to raise awareness of the risks and opportunities arising from climate change, which has become a key consideration in the design of environmental, social and economic policies. The exhibition describes the phenomenon of climate change and analyses its economic consequences, with a focus on Greece. Furthermore, it highlights the role of central banks in addressing the impacts of climate change within their mandate. This project would not have been possible without the crucial contribution of the Bank's specialised economists and other experts. The exhibition will be accompanied by several cultural and educational events,



reaching out to broader audiences, in particular the young generation, engaging them to join the global effort to tackle the climate emergency.

The current COVID-19 pandemic has posed a huge challenge to economies and societies worldwide. At the same time, however, it has revealed the need to prioritise people and social welfare over and beyond economic prosperity. The global effort to reduce physical risks, global warming and environmental deterioration of the planet, but also risks arising from the transition to a low-carbon economy, needs not only to be continued, but also to be stepped up – and the time to do this is now. The 26th UN Climate Change Conference (COP 26) in Glasgow last November provided an important opportunity for action to protect the climate and the future of our planet. Global coordination of efforts is essential if we want to achieve a green, sustainable recovery geared evenly towards societal, environmental and economic development.

Yannis Stournaras

Governor

Acknowledgements

The Bank of Greece, one of the first central banks in the world to deal with the issues of climate change and sustainability, has implemented numerous activities in this regard. Its various business areas involved in these activities have worked together for two years to prepare this exhibition, entitled "Economy and Climate: Handle with care". This makes them effectively co-hosts of this exhibition along with the Centre for Culture, Research and Documentation.

These business areas are: the Economic Analysis and Research Department; the Climate Change and Sustainability Centre; the Banking Supervision Department; the Financial Operations Department; the Department of Private Insurance Supervision; the Printing Works Department; the Technical and Administrative Support Department; and the CCISC. We would like to warmly thank all of them for their invaluable contribution of facts and figures as well as texts.

Special thanks go to the expert editorial team, comprising Director Ms. D. Papadopoulou, Director Ms. T. Antonakaki and Special Advisor Mr. I. Sampethai.

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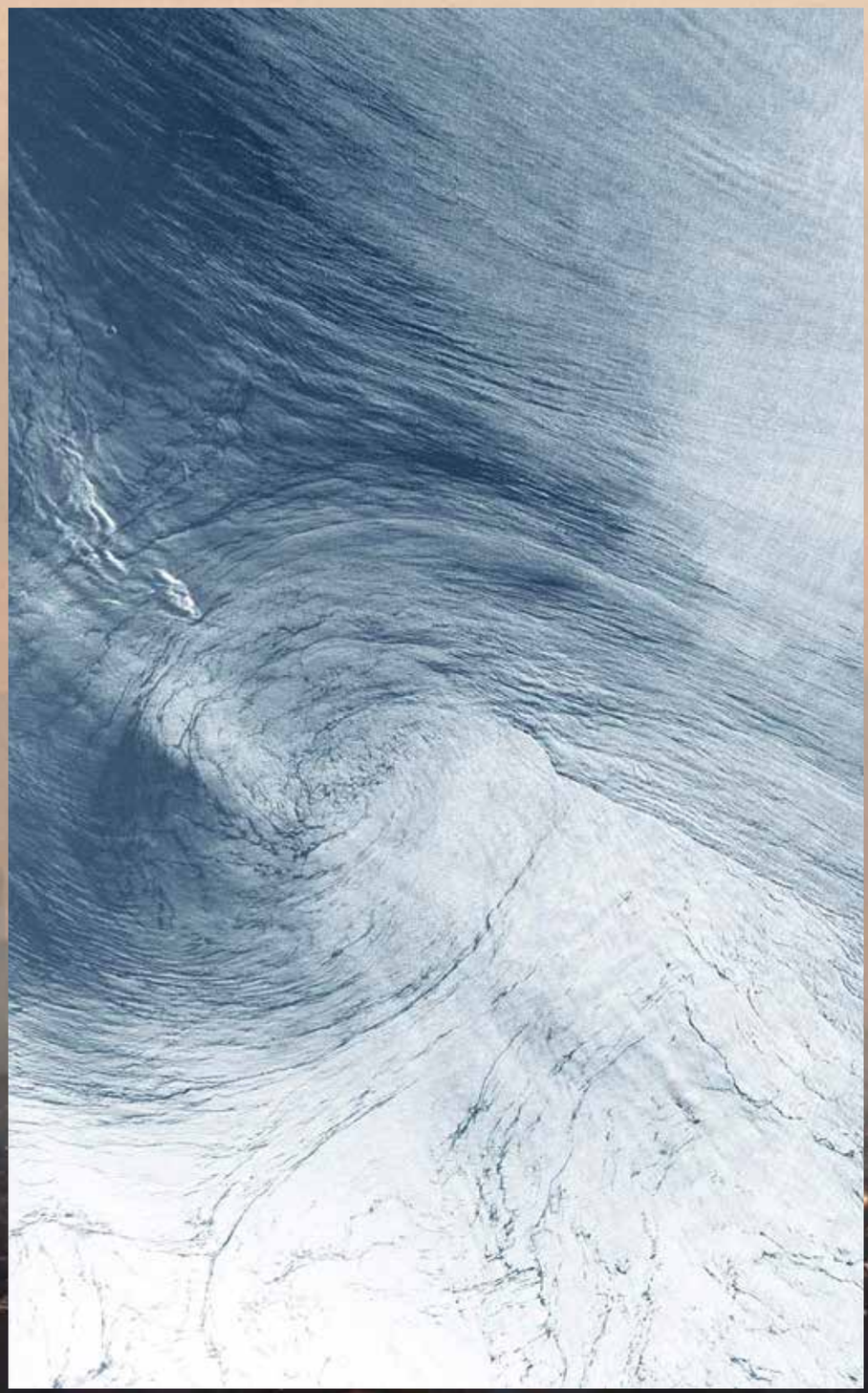
- NASA for the Vital Signs of the Planet and the Earth Now exhibits;
- Articulate for kindly providing photographs;
- the Bank's Information Systems Department and Tamasenco for the development of the "Handle with Care" game and the operation of digital exhibits;
- the WBGU and the Verlagshaus Jacoby & Stuart for permission to publish a Greek version of the comic *Die grosse Transformation: Klima – Kriegen wir die Kurve?* (The Great Transformation: Climate – Can we beat the heat?).

The translation of the comic from German was done by the Publications and Translation Section of the Economic Analysis and Research Department and is gratefully acknowledged. The comic is also available free of charge, in hard copy from the Museum of the Bank and in online format on the Bank of Greece website. Targeting younger audiences, in particular high-school and university students, the comic is intended to enhance their understanding of the ins and outs of climate change and its impacts.

We warmly thank the Printing Works Department for printing this catalogue, the comic and other material and for designing and producing the commemorative medal of the exhibition. We thank G. Iliopoulos-V. Pouli & Co. for the bookbinding of the comic.

Last, but not least, we would like to express our deep gratitude to Ms. D. Papadopoulou, Ms. T. Antonakaki, Ms. I. Seliniotaki, Mr. V. Spiliotopoulos, Mr. A. Kakkos, Mr. N. Nikolaou, Ms. S. Papadopoulou, Ms. M. Albani, Ms. Z. Kotsioni, Mr. N. Dougekos, Mr. Y. Seferlis, Ms. C. Linardaki, Ms. K. Theodosiou, Mr. I. Chatzivasiloglou, Ms. K. Paisiou, Ms. F. Patrikiou, Mr. A. Stylos, Ms. I. Marmarou, Ms. T. Aslani, Ms. K. Vallianatou, Ms. I. Skotida, Ms. E. Argyri, Ms. P. Tsalaporta, Ms. S. Anyfantaki, Ms. M. Karvounopoulou, Ms. K. Margeti, Ms. V. Roussou, Mr. P. Sempos and Mr. C. Malliarakis for their dedicated work and invaluable contributions all along the preparation of the exhibition.

Manos Kordakis
Deputy Director
Centre for Culture, Research and Documentation



1. Introduction
Economy and climate

By “climate change” we describe the changes in global climate, as manifested by a number of very worrying phenomena, including higher average global temperatures, rising sea levels and more frequent weather extremes (heat waves, storms, floods). Such phenomena are expected to have a huge impact on the global economy in coming decades. The effects of climate change could be particularly severe for Mediterranean countries like Greece.

Tackling climate change is a pressing challenge for the future of Europe and the entire world. In order to halt or mitigate it, we need to urgently take drastic action to minimise greenhouse gas (GHG) emissions and shift to clean energy. Especially in the current critical circumstances, financing recovery from the pandemic through fiscal and monetary policy packages can provide a unique opportunity to speed up the green transition.

1.1. Why is the Bank of Greece interested in climate change?

Although it is governments that have the primary responsibility and the most effective tools to tackle climate change, central banks can make a substantial contribution towards this effort. The Bank of Greece, one of the first central banks in the world to address the issues of climate change and sustainability, is at the forefront of the fight against climate change and has already taken action in many areas.

Tackling climate change is a pressing challenge for our future

- In 2009, the Bank of Greece set up the Climate Change Impacts Study Committee (CCISC), which continues to conduct key research, aiming to identify the risks as well as the opportunities arising from climate change, which has become a key consideration in environmental, social and economic policymaking.
- The establishment of the Climate Change and Sustainability Centre in 2021 signals the strategic importance that the Bank of Greece attaches to addressing sustainability issues, tackling the impacts of climate change and ensuring a smooth transition to a low-carbon economy.
- The Bank of Greece, one of the national central banks which, together with the European Central Bank (ECB), comprise the Eurosystem, contributes to the collective efforts[1] to incorporate climate change considerations into Eurosystem policies.
- In close collaboration with national, European and international organisations, the Bank works to raise public awareness and understanding of the impacts of climate change on the economy and the financial system, as well as of policies to address it ("climate literacy").
- The Bank of Greece is increasingly incorporating sustainability criteria across all its functions and strives to reduce its own carbon footprint.

It is telling that in 2019, according to the Official Monetary and Financial Institutions Forum (OMFIF), the Bank of Greece, alongside the ECB and the Bank of England, was named one of the most vocal central banks worldwide on climate change, while Governor Yannis Stournaras is the central banker who has discussed the most the issue of climate change in his public speeches.

1.2. The exhibition "Economy and climate: Handle with care"

This book accompanies the exhibition at the Museum of the Bank of Greece, organised by the Bank's Centre for Culture, Research and Documentation.

The exhibition describes the phenomenon of climate change and its economic impacts, through mostly digital exhibits (videos and interactive applications). Visitors have the opportunity to "feel the pulse" of our planet and understand how human activity affects the climate, but also to watch real-time news feeds and market responses on a terminal connected to Bloomberg.

The exhibition focuses on Greece and provides facts and figures about the estimated losses that could be caused by climate change by region and economic sector in the country. Using an interactive application, visitors can get an idea of how banks and insurance undertakings operate and how they are affected by climate change. Other exhibits illustrate the importance of currency stability and how it could be threatened by climate change; green investments and the opportunities opened up by this momentous shift that mankind needs to make in order to mitigate the consequences as well as to adapt to the new realities of climate change.

Further along their tour, visitors can see why climate change is important for central banks and what are the possible ways to address the associated challenges.

The exhibition builds on the crucial contribution of the Bank's specialised economists and experts and is accompanied by a number of parallel cultural and educational events, aimed to raise awareness and engage the public —especially the new generation— in the global collective efforts to tackle the climate emergency.

For this reason, the Museum of the Bank distributes free of charge this Catalogue and the Greek version of the comic *Die grosse Transformation: Klima – Kriegen wir die Kurve?* (The Great Transformation: Climate – Can we beat the heat?), which is also available online on the Bank of Greece website. On the occasion of the exhibition, a commemorative coloured medal has been designed and produced, also available free of charge at the Bank's Museum.

In a dedicated area of the exhibition, visitors can play the "Handle with Care" game on their mobile devices. The game can also be played outside the Museum and can be downloaded free of charge from AppStore and GooglePlay.

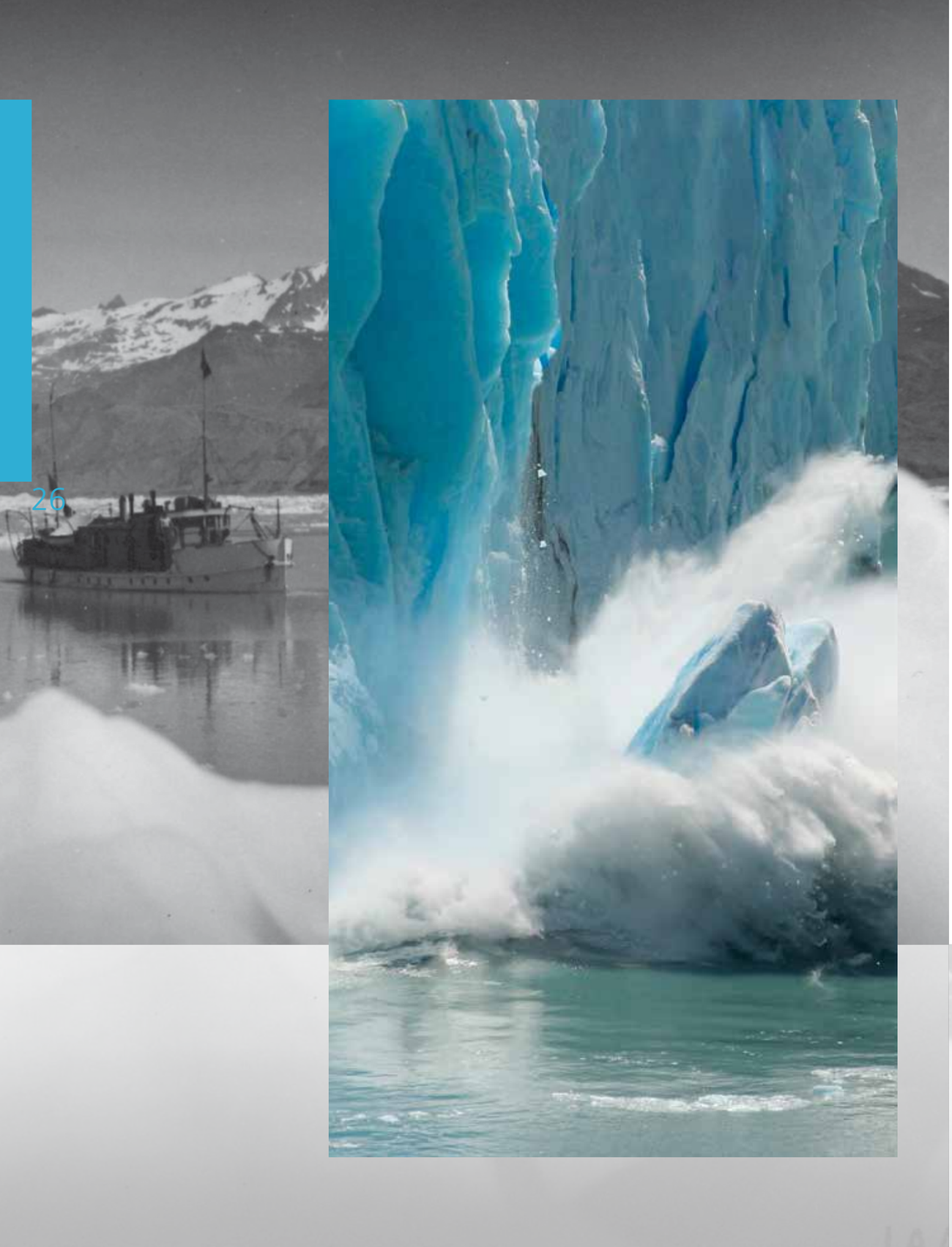
A digital presentation of the exhibition is also available on the Bank of Greece website.

This Catalogue contains texts and scientific evidence based on Bank of Greece studies and *Annual Reports*, as well as CCISC research.

The Bank of Greece is the central bank of the country and an integral part of the Eurosystem, which comprises the euro area national central banks and the European Central Bank. Along with the other Eurosystem members, it participates in the formulation of the single monetary policy in the euro area, with the primary objective of price stability. By doing so, it makes an effective contribution to economic growth and employment.

As a supervisory authority, it ensures the stability and smooth functioning of the financial system (banks, insurance undertakings, etc.).

While remaining institutionally and operationally independent, the Bank is accountable to the Hellenic Parliament.



2. Climate change and policy responses

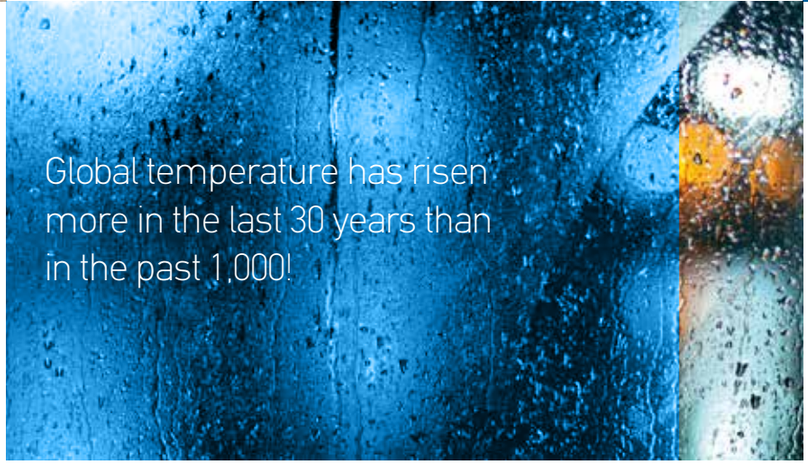
Business as usual?

The Earth's climate, which has remained broadly stable for thousands of years, has been crucial for the development of modern civilisation; its features are unique in our planetary system for supporting life and are essential for the survival of the Earth's ecosystem. Should our climate significantly change, the survival of every form of life would come under a more or less severe threat (CCISC, 2011).[2]

The climate is determined by external factors (such as the Earth's orbital parameters and solar activity) and by internal natural processes such as volcanic activity, glacier mass changes, changes in oceanic circulation and in the natural GHG concentrations in the atmosphere, as well as various anthropogenic factors (i.e. changes caused by human activity).

2.1. The two aspects of anthropogenic impact: economic growth and climate change

After the industrial revolution and especially since the late 19th century, mainly thanks to scientific and technological advances and economic progress, humanity has experienced a huge improvement in overall living standards, albeit with regional disparities. However, this improvement has come at the cost of a change in the composition of the atmosphere and global warming: this effect is called "anthropogenic component of climate change". The term "climate crisis" is also often used to signal the severity of the situation we are facing.



As almost all modern-day human activities (and the respective sectors of the economy) contribute directly or indirectly to the level of CHGs —i.e. carbon dioxide (CO_2), nitrogen oxides (NOx), methane (CH_4), etc.— the consequences for the environment are very serious. In particular, the emitted GHGs trap solar radiation in the atmosphere, thereby increasing global mean temperature; as a result, the global mean temperature in the last 30 years has increased more than in the past thousand! Today, global mean temperature is already 1°C above pre-industrial levels (with a significant part of this increase being attributed to human activity) and continues to rise further.

Global temperature keeps rising

As a result of ongoing global warming, various phenomena are observed, such as:

- melting of sea and land ice and rising sea level;
- extreme weather events;
- disruption of the global water cycle;
- threats to biodiversity, with further significant losses.

All of the above can trigger chain reactions across the entire ecosystem, including human beings.

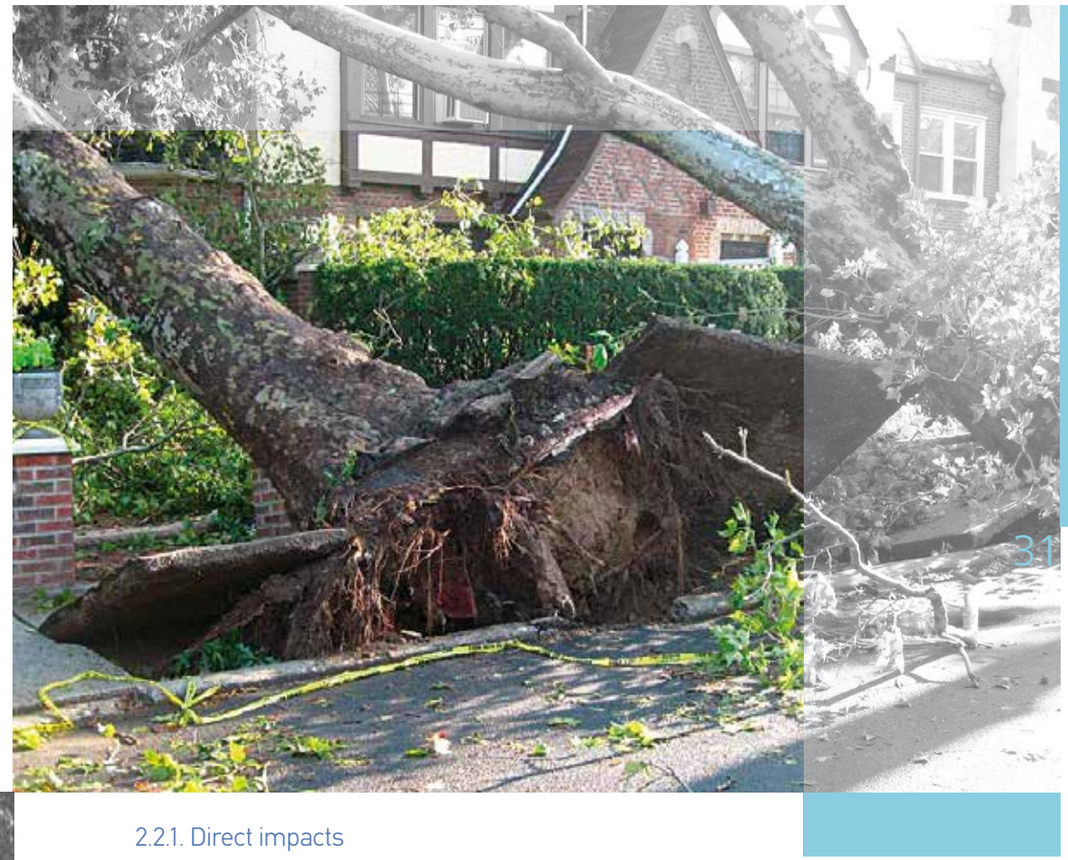
2.2. Impacts on the economy and society

GHG concentrations in the atmosphere have multiple impacts on the entire planetary ecosystem: they affect cloud formation, precipitation patterns, atmospheric circulation (winds), sea level, etc. They also affect crop yields, water reserves, biodiversity, individual ecosystems, even human migration. Thus, the effects of climate change span across all sectors of the economy and society.

Economic impacts can be direct and indirect.

The costs likely to be incurred as a result of climate change are very hard to calculate, not least because goods such as human health and well-being, ecosystems and biodiversity are, literally, priceless. Only estimates are possible, on the basis of the measurable impacts of climate change and available scientific data.

The economic impacts can be distinguished into **direct** and **indirect**.



3.1

2.2.1. Direct impacts

Direct impacts mainly refer to loss of, or lower return on, physical capital (buildings, infrastructure, equipment), but also human capital (i.e. the workforce), lower productivity and higher expenditure to achieve the same level of utility.

Here are some examples:

- Buildings and infrastructures (roads, bridges, ports, etc.) are typically designed to resist extreme weather conditions. However, if, as a result of climate change, buildings are stressed beyond their maximum resistance level, then the cost of construction, repair and/or reconstruction could increase dramatically. Climate change-induced damages to road and railway networks worldwide already exceed USD 22 billion (UNECE 2019).[3]
- Heavy rainfall can cause major damages, creating direct and indirect losses to the economy: e.g. the New York City subway had never flooded in its first 108 years of operation, but the 2012 floods from hurricane Sandy caused damages worth

Climate change-induced damages to road and railway networks worldwide already exceed USD 22 billion

The New York City subway had never flooded in its first 108 years of operation, but the 2012 floods caused by hurricane Sandy led to damages worth several billions of dollars

several billions of dollars (prompting the City to conduct emergency preparedness drills ahead of potential future extreme weather events).[4]

- Melting ice and severe storms lead to a further rise in mean sea level, which entails coastal road erosion, floods, damages to bridges and coastal assets, higher maintenance costs, etc.
- Very serious could also be the potential effects on monuments and archaeological or historical sites, which are threatened by wildfires, soil erosion and/or floods – a very important consideration for countries like Greece with a very rich cultural heritage.

2.2.2. Indirect impacts

Indirect impacts relate to any circumstances that could adversely affect the economy and citizens' living standards (and, inevitably, the financial system), such as:

- Problems in infrastructures, such as electricity outages or supply chain and transportation disruptions (weighing heavily on business activities and trade). These problems would in turn spill over to many other aspects of the economy, thus their impact would be amplified (CCISC 2011).
- Devaluation of residential and commercial properties.
- Decline in household disposable income and corporate profitability, leading to higher bank losses and higher compensation liabilities for insurance undertakings.

Over 7 million people die annually from air pollution. A child born today will live in a world 4°C warmer than the pre-industrial average

In a broader context, however, indirect impacts could also include the following:

- The World Health Organisation considers climate change as the biggest health threat of the 21st century (with an estimated 7 million deaths annually caused by indoor and outdoor air pollution) (WHO 2020).[5] Without action to halt the rise in temperature, a child born today will live for the next 70 years in a world 4°C warmer than the pre-industrial average and will be much more vulnerable to diseases and health-threatening pollutants.
- Global warming and overall environmental deterioration may have economic impacts as well, which should not be underestimated. The consequences of extreme weather events, forest fires, droughts and floods on food production may be very significant (e.g. in the Mediterranean, staple crop yields could fall by between 5% and 25%).
- The blooming period of plants starts earlier in the year, as has been observed in recent years; based on climate model simulations, this could lead to drier soils in the summer all over the northern hemisphere, causing more frequent and severe heat waves and, more generally, a hotter climate with more rain, favouring the growth of pathogens.
- The permanent loss of agricultural land due to protracted droughts and desertification is already threatening the livelihoods of more and more people, forcing them to move to other regions or countries, thereby increasing migration flows and potential tensions between neighbouring populations and/or population groups in the host countries.

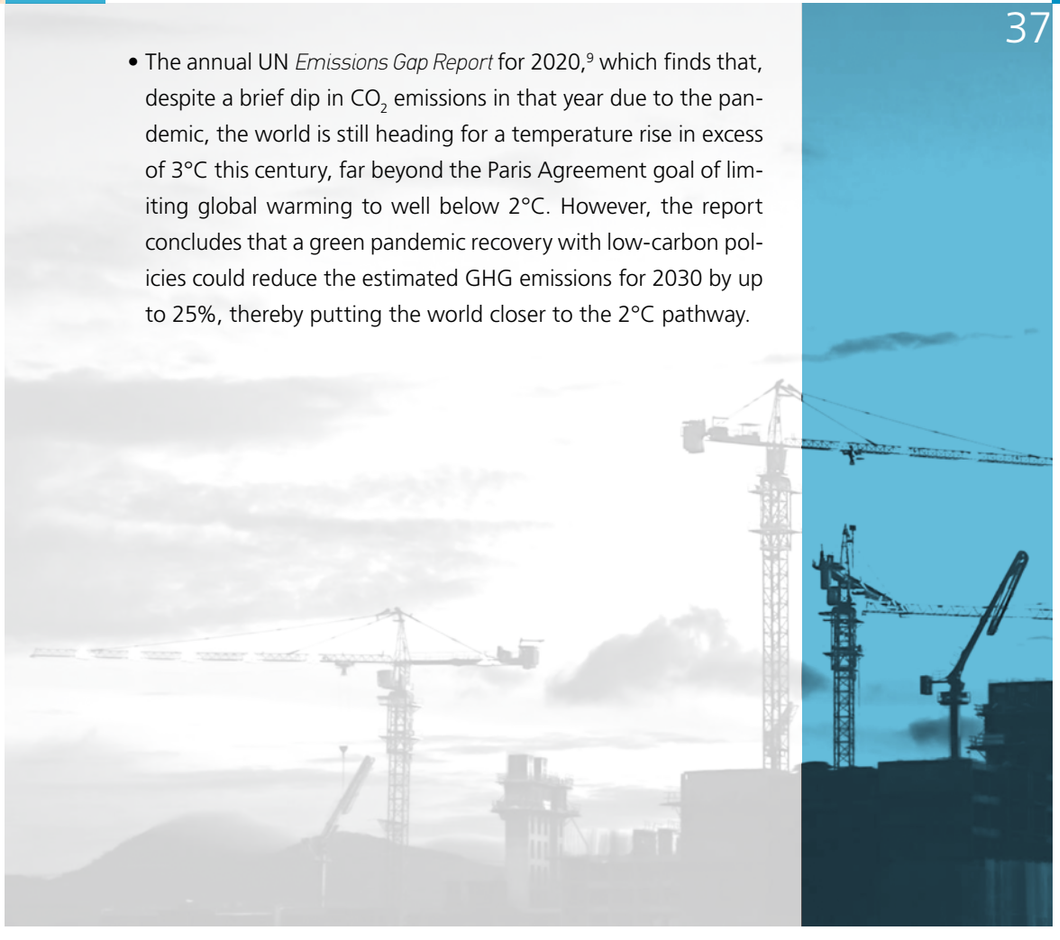
In the Mediterranean region, staple crop yields could fall by 5%-25%

2.2.3. Growing concern over climate change

Climate change developments have been attracting growing attention from academics and policy institutions worldwide, as reflected in numerous relevant publications. Among recent publications, it is worth pointing out the following:

- A joint report by the European Environment Agency and the Swiss Federal Office for the Environment (April 2020),[6] which concluded that Europe has significantly exceeded the limits considered as a safe operating space in terms of three of the four "**Earth life-support systems**" (nitrogen cycle, phosphorus cycle and land system change), while it has not yet exceeded the limit for freshwater use.
- A report prepared by an independent team under Professor Sir Partha Dasgupta on "The Economics of Biodiversity", published by the UK Treasury in early 2021,[7] reviews the interaction of human societies and economies with nature. It also considers concrete policies that are urgently necessary to restore the lost balance in this relationship and to ensure the sustainability of societies and nature alike. The report adopts a holistic economic approach to the major issues relating to addressing climate change and protecting the natural environment and human health, while proposing new methods for measuring the effects of economic activity and wealth (including the notion of natural capital). It also identifies the ways in which humans, as "managers" of natural assets, are transgressing planetary boundaries, which is already affecting productivity growth and threatening the well-being of present and future generations.
- An interdisciplinary study (Kirezci et al. 2020),[8] showing that, without coastal protection and adaptation, coastal flooding would increase by around 50% by 2100, while global population and assets would be at risk of flooding (in coastal areas, two thirds of such flooding are projected to be caused by tide and storm events and one third by sea level rise).

- The annual UN *Emissions Gap Report* for 2020,[9] which finds that, despite a brief dip in CO_2 emissions in that year due to the pandemic, the world is still heading for a temperature rise in excess of 3°C this century, far beyond the Paris Agreement goal of limiting global warming to well below 2°C. However, the report concludes that a green pandemic recovery with low-carbon policies could reduce the estimated GHG emissions for 2030 by up to 25%, thereby putting the world closer to the 2°C pathway.



The impacts of climate change are so far-reaching that no sector of the economy and society remains unaffected

2.3. Uneven distribution of impacts

The impacts of climate change are so far-reaching that no sector of the economy and society remains unaffected. However, the impacts, as well as the costs of climate change *mitigation* and *adaptation* policies, are often distributed unevenly in time and space. This disparity should be taken into account when considering and adopting policy measures.

The poorer regions of the world will be affected more strongly

Future generations will bear the devastating consequences of climate change

- Although future generations will bear the brunt of climate change, it is the present generations who have to take action and bear the cost of policies to tackle the issue.
- The distribution of the costs and benefits is uneven across regions and parts of the population within a region.
- For example, while the majority of current GHG concentrations are the result of cumulative emissions from highly industrialised countries, this has started to change as many developing countries are catching up – the poorer regions of the world will be the ones to suffer the heaviest losses from climate change (CCISC 2011).

- In addition, the effects are much more severe for low-income social groups. Households with lower disposable income and other vulnerable groups (minorities, migrants, etc.) often lack sufficient savings or access to bank credit or subsidised energy efficiency programmes in order to protect themselves from climate change impacts in a timely manner (e.g. improve the insulation and energy efficiency of their homes, shift to solar energy, or even relocate to less vulnerable areas). Therefore, these households are likely to face even more serious problems in their access to basic goods, such as adequate housing, while the pandemic could further exacerbate the existing inequalities.

The effects are much more severe for low-income social groups

This could give rise to a vicious circle at a global level: poverty, implying a lack of access to energy and energy-saving technology (energy poverty), results in limited ability to protect from the impacts of climate change, which in turn exacerbates poverty and so forth. Thus, corrective actions become all the more necessary (Bank of Greece, *Annual Report 2018*, April 2019).

2.4. A global risk that needs to be addressed

According to the World Economic Forum, environmental risks have been increasing in recent years, in terms of both likelihood and impact: in 2021, four of the seven key global risks are associated with climate change (World Economic Forum 2021).[10]

Action to address these risks is therefore necessary: "Research so far confirms that the current and projected implications of climate change pose such threats to society and sustainable development that we cannot continue with a 'business as usual' scenario. We need to address challenges and work on solutions, shifting to a low-carbon economy, managing the risks and adapting to the changing climate" (Stournaras 2019).[11]

2.5. Policy responses

Policies to address climate change mainly include **mitigation** policies (i.e. actions to limit global warming by reducing GHG emissions) and **adaptation** policies (i.e. actions to moderate the negative impact of climate change).

Thus, the economic impacts of climate change do not only refer to the costs entailed by higher average global temperatures, but also to the costs of transition to a low-carbon economy and the costs of adaptation to climate change. The relevant initiatives are primarily the responsibility of governments, through appropriate policies including fiscal, institutional and structural measures. However, businesses and households are also required to adopt behaviours that contribute to addressing climate change.

While discussions currently focus mainly on the economic, environmental and social costs, climate change could also generate a number of opportunities and benefits, largely depending on how the relevant mitigation and adaptation actions will be implemented.

2.5.1. Mitigation

Mitigation refers to actions to reduce GHG emissions. To achieve zero net GHG emissions, anthropogenic emissions (e.g. from vehicles and industrial plants burning fossil fuels) will have to be eliminated or minimised. Any remaining GHG emissions worldwide could be offset by removing an equivalent amount of carbon, e.g. through reforestation or technological innovation. The existing scientific consensus suggests that mitigation policies should preserve conditions for sustainable economic growth (for an overview of the literature on the challenge for economics, see Nordhaus 2019).[12]

European Green Deal:
net zero emissions of GHGs in the EU by 2050

Mitigating the harmful impacts of climate change is a key priority for the European Union (EU), which strives to reduce its GHG emissions, while encouraging other countries and regions to do the same. In December 2019, the European Commission proposed the European Green Deal, "a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy, where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" (European Commission 2019).[13]

In spring 2020, the European Commission presented its proposal for a "**European Climate Law**" that writes into law the goal for Europe to become climate-neutral by 2050. According to EU President Ursula von der Leyen: "[...] I want the European Green Deal to become Europe's hallmark. At the heart of it is our commitment to becoming the world's first climate-neutral continent. It is also a long-term economic imperative: those who act first and fastest will be the ones who grasp the opportunities from the ecological transition. I want Europe to be the front-runner. I want Europe to be the exporter of knowledge, technologies and best practice" (von der Leyen 2019).[14]

In April 2021, the Council and the European Parliament reached a provisional agreement on the relevant Regulation, and its formal adoption followed soon afterwards (June 2021).

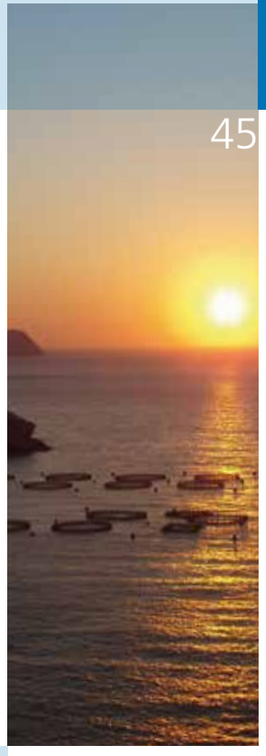
2.5.2. Adaptation

Worldwide, climate change mitigation and adaptation actions should be implemented in tandem, given the complementarities between the two. Thus, the adaptation actions promoted by national or supranational public institutions have indirect positive effects on mitigation (e.g. by protecting against heat, insulation of buildings is an adaptation measure; at the same time, by contributing to energy saving and GHG emission reduction, it also serves as a mitigation measure).

Adaptation is a matter of concern for the private sector as well, with businesses and individuals already taking measures in this direction. Weather conditions affect demand for specific goods and equipment (e.g. water and beverages, air conditioning, insulation), while they also have an impact on businesses' optimal input choice (e.g. farmers adapt to weather changes by changing fertilisers, labour inputs, irrigation methods or type of crop).

However, the adaptation measures implemented by the private sector need to be supported and complemented by similar public sector projects. The adaptation gains to be achieved in this manner mainly take the form of widely consumed public goods (coastal protection, water management, environmental information systems, etc.), and efforts must be made to ensure that such measures are extensive and inclusive. In order to tackle climate change, it is therefore crucial to adopt a strategic approach that takes all the above considerations into account. In this context, in February 2021, the European Commission adopted its new EU strategy on adaptation to climate change, geared towards building a climate-resilient future; the strategy will be supported by a new financial instrument,[15] aiming to make Europe more resilient to climate change.

Climate change mitigation and adaptation actions should be implemented in tandem, given the complementarities between the two



2.6. Three types of climate risks for the economy

The risks for the economy arising from climate change can be classified into physical risks, transition risks and liability risks:

- **Physical risk**s are either acute, typically relating to event-driven hazards (floods, wildfires, heat waves, etc.), or chronic, referring to longer-term shifts in climate patterns (e.g. rising sea level, increased frequency, intensity and/or duration of extreme weather events).
- **Transition risks** are related to the process of adjustment to a carbon-neutral economy. They concern a broad range of potential future developments, actions and events (public policies, technological change, changes in investment preferences, etc.) that could lead to devaluation of assets or obsolescence of well-established technologies.
- **Liability risks** relate mainly to increased compensation claims for losses suffered, including claims on insurers and banks. Such claims could also arise under professional liability insurance contracts, based on failure to take appropriate adaptation or mitigation actions.

2.7. Tools to tackle climate change

A key tool for calculating the risks arising from climate change and its consequences is the carbon budget. This indicates the maximum amount of carbon dioxide (CO_2) emissions permitted over a period of time to keep global warming within a certain threshold (compared with pre-industrial levels).

Based on Member States' existing policies and plans, it is likely that the EU will not achieve its goal to substantially reduce its GHG emissions by 2030 compared to 1990 levels. Nevertheless, the European Council has tightened the goal, aiming at a 55% reduction from 1990 levels by 2030 (European Council conclusions 10-11.12.2020).[16]

Governments and supranational entities, such as the EU, contribute to addressing climate change by ensuring an appropriate institutional framework, but also by using fiscal policy tools;

The carbon budget indicates the maximum amount of GHG emissions permitted

this involves legislative work, as well as the provision of incentives or disincentives, with a view to a policy mix that optimises the desired outcomes and is socially acceptable. Carbon pricing policies (emission trading and carbon taxes),[17] which are key climate change mitigation tools, are central to the design of mitigation actions (CCISC 2011).

Carbon taxes —which are considered the most effective tool for a drastic and rapid reduction of GHG emissions— tend to affect low- or middle-income households the most, and thus, they are controversial. In recent years, proposals have been made to combine them with progressive tax refunds to those who suffer the most (Bank of Greece, *Annual Report 2018*, April 2019). Other important mitigation tools are the following:

- cap-and-trade systems;
- methods to remove carbon from the atmosphere; and
- development of clean energy technologies.

Emissions trading systems (ETS) are becoming an increasingly popular policy tool for controlling GHGs, particularly since the introduction of the EU-ETS, the European emissions trading system. The emission allowances allocated to companies by the regulatory authority can be traded on the market, where their price is determined and they are re-allocated among companies. The trading of allowances ultimately means that these are used by the companies that are willing to pay to emit more.

Other emission reduction methods include:

- **Carbon capture and storage** (CCS), whereby CO_2 released from coal- or gas-fired power plants is captured at the emission point and stored underground.
- **Solar radiation management** (SRM), another tool to contain temperature rise, is being explored, as it still entails uncertainty and implementation risks.
- **Halting deforestation and forest degradation** is also a very important tool for reducing emissions and enhancing the role of forests as natural carbon capture and storage sinks in developing countries. In this context, the UN **REDD+** (Reducing Emissions from Deforestation and Degradation) framework promises large, cost-effective and rapid reductions in global GHG emissions, by providing financial incentives to forest owners and users for more sustainable management.
- In late September 2020, a special issue of the *Journal of Plasma Physics* featured seven papers by researchers of the MIT Plasma Science and Fusion Center, which showed significant progress in addressing the serious problems of constructing a nuclear fusion reactor for **clean energy production** and suggested that such construction may become feasible in the next decade.

2.8. Financing adaptation and mitigation investment

Climate change is a crucial issue of our time. It calls for drastic actions, which need to be taken right now: the more we delay, the more difficult and costlier the future efforts will be.

Climate change is a crucial issue of our time

According to the flagship report by the Global Commission on Adaptation released in September 2019,[18] the investment required to strengthen global resilience and adaptation to climate change is estimated at USD 1.8 trillion, but this could generate USD 7.1 trillion in total net benefits over the next decade. Benefits would arise from the so-called triple dividend: (i) avoided losses, (ii) positive economic benefits through reducing risk, increasing productivity, and driving innovation; and (iii) social and environmental benefits.

Although investment in adaptation actions has clear economic benefits, most often it requires substantial initial financing before it can generate medium- and long-term returns; in the short term, it is not profitable enough to attract private investors.

Funding can be provided by the public sector, the private sector, or a combination of the two:

- Public investment in climate-proofing existing infrastructure (e.g. strengthening forest protection, relocating and enhancing ports, airports and roads) and building new infrastructure (e.g. dams and anti-flood systems to better protect from extreme weather events), in the broader context of adaptation policies.
- Investment in highly energy-efficient buildings and other sustainable infrastructure can have a significant contribution to mitigation as well.
- Strengthening research and development on low-carbon technologies and clean energy through subsidies and appropriate incentives.[19]
- Stepping up public efforts to provide finance and incentives to boost investment in adaptation.
- The private sector, on the other hand, needs to recognise that its own viability depends on the sustainability and resilience of the society and the environment in which it operates.

In January 2020, the European Commission presented the **Sustainable Europe Investment Plan**[20] (which is expected to mobilise at least EUR 1 trillion for sustainable investments over the next decade), as well as a proposal to set up a Just Transition Mechanism (JTM) as a tool to ensure that the transition towards a climate-neutral economy is fair and leaves no one behind (see section 2.9 below).

2.9. Climate change as an opportunity

Climate change poses risks to various parts of the economy, but can also create opportunities for a wide range of economic agents, leading to a reallocation of resources such as human capital, investment and technological innovation.

Existing producers in climate-vulnerable sectors (tourism, agriculture, forestry, fisheries, transport, real estate, etc.) will have to address climate risks (higher costs, losses, disruptions, etc.) by changing their production processes, products and/or services – and perhaps also ultimately their business models and strategies. They could consider relocating to less affected areas or discontinuing certain products and/or services that they will no longer be able to offer due to lack of resources. However, it is very likely that new opportunities and activities will emerge, which may be able to absorb freed up resources.

Consumer preferences will also play a role in the transition to a sustainable economy: they could shift to more energy-efficient and low-emissions technologies and shun goods or services that are harmful to the climate. Increased public awareness of e.g. the impact of meat and dairy production and consumption could shift consumption away from such products and thus adversely affect the relevant producers. On the other hand, it could also lead to new consumption patterns (e.g. increased consumption of other foodstuffs), thereby creating economic growth opportunities.

The implementation of concrete long-term and far-reaching national policies for economic sustainability could influence the strategic decisions of economic agents and the allocation of financial resources. In the EU, for example, the decision has been taken to stop funding fossil fuel or gas infrastructures by 2022, while the European Investment Bank (EIB), which has become **"Europe's climate bank"**, will facilitate the implementation of the Sustainable Europe Investment Plan (SEIP) for climate action and environmentally sustainable investments over the next decade, thereby contributing to achieving the goals for the transition to a climate-neutral economy.

Similarly, **the Just Transition Fund (JTF)** —a new financial instrument being part of the broader EU cohesion policy and a key pillar of the newly-established Just Transition Mechanism (JTM)— aims to support sectors and territories facing serious socioeconomic challenges due to the transition to climate neutrality. The JTF will facilitate the implementation of the European Green Deal in an effective and fair manner, helping regions that rely on fossil fuels (coal, peat, oil shale, etc.) and GHG-intensive industrial processes to shift to new types of economic activity, as it is important to ensure that noone is left behind in the transition to a climate-neutral Europe by 2050.

2.9.1. The role of digital innovation

In the fight against climate change, innovative **Information and Communication Technology (ICT)** —including artificial intelligence, deep learning, neural networks, etc.— is a new approach and a powerful horizontal tool that can support the efforts to remain on a path towards decarbonisation, enhanced biodiversity and ultimately a modern, sustainable, digital growth model, especially in those sectors of the economy and society that are the biggest GHG emitters (energy, cities, transport, agriculture).

Digital technology penetration in societies and economies is a key priority around the world —including for the EU21— as digital transformation and the **4th Industrial Revolution** open up opportunities for dynamic growth (mainly through higher labour productivity), while, for countries that lag behind, the risk of marginalisation and stagnation is visible (see the article "How do digital technologies drive Greece's economic growth? Opportunities and challenges", Bank of Greece, *Economic Bulletin* No. 49).

In 2018, the ICT sector accounted for 2.7% of total employment in the EU[22] and generated more than one-fifth of global GDP, which could reach one-quarter by 2100 (Knickrehm, Berthon and Daugherty 2016).[23] It accounts for 5-9% annually to global energy consumption and 2-3% to global GHG emissions (Bank of Greece, *Annual Report*, April 2021)[24] —thereby being also a big polluter given the heavy environmental footprint of production, use and final disposal in the relevant infrastructure, equipment and materials used in the ICT sector— yet, the possible benefits far outweigh their environmental cost.

New digital ICTs and their applications can mitigate climate change (contributing to a 20% reduction in global carbon emissions) by 2030 (Global Enabling Sustainability Initiative 2020)[25] in various ways, e.g. by enabling resource-saving processes such as cloud computing, videoconferencing, paperless data exchanges, e-commerce, e-payments and e-banking, as well as by offering solutions that improve energy efficiency, inventory management and business efficiency ("green ICT") and progressively reshape people's lifestyles.

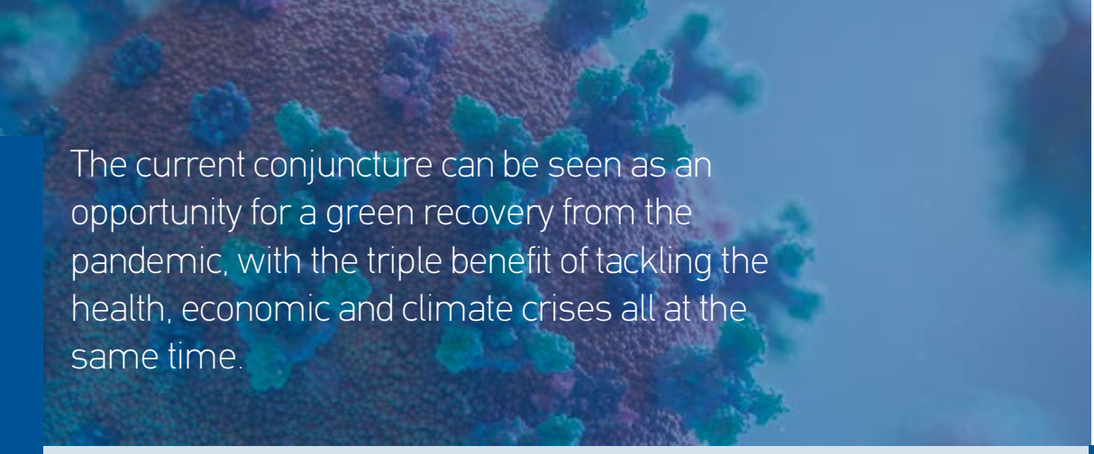
Among the constantly evolving innovative technologies, the following can make a significant contribution to the decarbonisation of the economy:

- "smart grids"[26] and "smart buildings" that increase energy efficiency and help manage renewable energy;
- intelligent mobility systems (for goods and people), such as real-time traffic flow management, telematics for passengers, smart logistics, transport infrastructure diagnostics, etc.;
- "Industry 4.0", using digital technologies such as big data, machine learning, the Internet of Things (IoT) and cloud computing for more connected, efficient and smart manufacturing processes;
- "Agriculture 4.0" and "precision agriculture", which improve efficiency in the use of nitrate fertilisers and in livestock farming, leading to higher productivity and lower GHG emissions.

Greece could become an important technology hub in the future, although it currently has a digital divide, with clear socio-economic differences in the access and use of innovative technologies (due to low digital literacy, insufficient uptake of digital technologies in public services, delays in the assimilation of new technologies in the domestic production structure, the existence of many small-sized and family businesses that cannot afford investing in new technologies, etc.).

This points to a need for a system which entails continuous training and retraining, along with supportive, coherent and forward-looking policies, as well as investments in innovation and infrastructure that will prevent the risk of technological hysteresis. To this end:

- the private sector should lead by taking initiatives and business risks that will generate gains in the long run;
- a reliable, simple and flexible institutional setting should be created to facilitate spin-offs and startups;
- more extensive use should be made of public-private partnerships (PPPs), with each sector contributing according to its type of wealth, resources, know-how and competitive advantages; and
- emphasis should be placed on sectors of high economic, social and environmental value, such as waste management, energy saving and, of course, ICT (which will certainly be a key pillar of the new growth strategy).



2.9.2. COVID-19 pandemic and green recovery

As the pandemic evolved in 2020-2021 into a huge health-related, social and economic challenge for the entire world, it threatened to sideline the planet's other huge challenge, i.e. climate change. However, this conjuncture can be seen as an opportunity for a **green recovery from the pandemic,** with the triple benefit of tackling the health, economic and climate crises all at the same time. To this end, three of the most important lessons learned from the pandemic need to be fully exploited:

- The need to take action is undeniable: the cost of inaction is too high.
- Delay is costly: a rapid, resolute and coordinated response yields the best results;
- Science plays an essential role: decisions should be based strictly on scientific evidence.

As has repeatedly been pointed out, "curbing climate change will not only prevent economic losses and catastrophic events, but also generate additional benefits by reducing the likelihood of new epidemics in future" (Stournaras 2021)[27], given that scientific research shows that "the combination of human transgression into nature and climate change increases the likelihood of epidemics and exacerbates immunodeficiency" (Bank of Greece, *Monetary Policy 2019-2020*, June 2020).

Moreover, an opinion of the European Economic and Social Committee in June 2020[28] called for a comprehensive European economic recovery plan aimed to addressing the consequences of both climate change and the pandemic, stressing that the transition to a low-carbon economy and post-COVID reconstruction must lead to a more just and sustainable EU. Available analyses[29] highlight the role of technology as a key weapon in the dual fight against climate change and the pandemic, and that policies to address the pandemic and climate change will be most successful in the long run if they are closely aligned.[30]

In the EU, total GHG emissions dropped by about 4% in 2019 compared to 2018 and were 28% lower than in 1990. This downward trend reflects the strong and steady growth of **Renewable Energy (RE)** in Europe and the progress towards decarbonisation. Importantly, the 2019 drop took place at a time of economic growth, before the COVID-19 breakout. This highlights the results of effective climate policies implemented across the EU. It also shows that even more ambitious reduction targets can be achieved in the future through additional targeted actions and measures.

For 2020, GHG emissions fell further (by an estimated 11.3% in the EU), but this should be attributed to the extraordinary circumstances of the pandemic and the associated temporary shutdowns across Europe and beyond (European Environment Agency, Report No. 13/2020).[31]

Unquestionably, tackling the health crisis and boosting economies are top priorities. Recovery programmes provide an opportunity to more closely align public policies with climate objectives, helping to shift investment away from carbon-intensive infrastructures towards sustainable ones. Thus, investment can be geared towards sectors and technologies that accelerate energy transition and improve climate resilience and, above all, do not undermine the national efforts to address the pressing environmental challenges.

In this context, the new temporary recovery instrument **NextGenerationEU** will finance investments worth EUR 750 billion in 2021-2026 to help Member States repair the immediate economic and social damages caused by the coronavirus pandemic, as well as assist in the green transition, resource saving, digital transformation in the public sector and the economy in general, and strengthen the healthcare sector.

In the EU, more than one-third of national recovery programmes is expected to be directed towards climate action

Under the EU Sustainable Development Strategy,[32] environmental sustainability, productivity, fairness and macroeconomic stability are the guiding principles underpinning Member States' recovery and resilience plans, as well as their national reforms and investments. Thus, more than one-third of the respective national recovery programmes is expected to be directed to climate action, in line with the principles of the Green Deal and the EU strategic goal of making Europe the first climate-neutral continent by 2050.

The EU, and therefore Greece too, can emerge stronger from the pandemic through green recovery, investing in the circular economy, energy saving, renewables, sustainable transport and clean technology, and creating more green jobs, thus paving the way to a greener, more digital, resilient and future-proof Europe.

Fighting climate change is an urgent challenge for the future

2.9.3. Encouraging signals and positive developments

The visible progress made by various countries and supranational bodies in adopting measures to fight climate change provides reasons for optimism going forward. Some positive developments are the following:

- The first report of the International Renewable Energy Agency (IRENA) shows that decarbonisation of the energy system supports short-term recovery while it creates resilient and inclusive economies and societies (IRENA, press release 20.4.2020).[33]
- The 2020 report of the International Energy Agency (IEA) and the International Monetary Fund (IMF), set out a sustainable recovery plan to boost economic growth, create millions of jobs and put emissions into structural decline (IEA, press release 18.6.2020).[34]
- The 5th report of the Secretariat of the UN Convention on Biological Diversity[35] acknowledged the progress made towards the targets set in 2010, but also stressed the need for radical transformations in a number of transition areas: land and forests, sustainable agriculture; sustainable food systems; sustainable fisheries and oceans; cities and infrastructure; fresh water; climate change; and an all-inclusive "One Health" approach.
- In October 2020, the IMF's biannual review of the global economy (IMF, *World Economic Outlook*, chapter 3), suggested that an initial green investment push combined with steadily rising carbon prices would contribute to achieving climate goals, and that governments can protect those affected the most by climate change mitigation by providing targeted cash transfers financed by carbon revenues.
- As the President of the Hellenic Republic pointed out in a speech in October 2020,[36] "the UN strongly promotes sustainable development, a principle that governs EU law and is enshrined in the Greek Constitution".[37] The President also stressed the importance of the European Green Deal and the issue of poverty before and after the COVID-19 pandemic, recalling that eradication of poverty has been defined by the UN as Goal no. 1 in its 2030 Agenda for Sustainable Development.
- In September 2020, China pledged to become carbon neutral before 2060. In December 2020, President Xi Jinping announced concrete commitments to curb the carbon intensity of the economy (i.e. GHG emissions relative to GDP) by more than 65% by 2030 and vowed to triple the country's wind and solar capacity between 2019 and 2030.

- In a virtual event held in December 2020,[38] Mark Carney, former Governor of the Bank of England, offered important policy proposals addressed to the Financial Stability Board on climate change and finance with a view to supporting the transition to net zero carbon emissions. It should be noted that the Bank of England revised its mandate to explicitly include environmental sustainability and net-zero compatibility.
- In January 2021, on his first day in office, President Biden signed a number of executive orders whereby the United States rejoined the Paris Agreement (officially as from 19.2.2021), reversing its withdrawal in 2020, and US environmental legislation was revised (Bank of Greece, *Annual Report*, April 2021).

Overall, at national, supranational and global level, a trend has been observed lately towards concrete commitments and actions to simultaneously tackle the health-related, economic and climate crises.

2.10. Global cooperation in the 21st century

However, each country negotiates its own terms for joining climate agreements based on its own cost and benefit considerations. The complexity and high uncertainty regarding the impacts of climate change, as well as their uneven distribution across countries, make it difficult to reach commonly accepted agreements, designed in a manner to provide appropriate incentives for countries to join on a voluntary basis.

At global level, since the Kyoto Protocol (December 1997) and the successive Conferences of the Parties (COP 13 to COP 20) that led to the Paris Agreement (April 2016),[39] there have been several important developments, such as:

- the first **green bond,** launched by the EIB in 2007;
- the Climate Bonds Initiative in 2009, aimed to support investment in a low-carbon economy;
- the first meeting of the Sustainable Stock Exchanges (SSE) initiative, a UN partnership organised in 2009 by the UN Conference on Trade and Development (UNCTAD), the UN Global Compact and the UN Environment Programme Finance Initiative (UNEP FI);

The need for global cooperation in addressing climate change is obvious

- the development of the UNEP FI Responsible Investment principles (PRI) and Principles for Responsible Banking (PRBs);
- the introduction of the Green Climate Fund in 2010 to support projects to reduce GHG emissions;
- the launch of the Carbon Disclosure Protocol in 2010, aimed to ensure that businesses, mainly from the private sector, make data on their environmental performance publicly available.

Amid growing awareness of climate change, 195 countries, in their submitted Intended Nationally Determined Contributions (INDCs) towards meeting the goals of the Paris Agreement, have tightened their goal of limiting global warming to "well below 2°C". By providing flexibility to countries to define their own pathways, while remaining legally binding in other aspects, the Paris Agreement has been met with almost universal acceptance, and even the US that had withdrawn from the Agreement for some years rejoined in early 2021.

195 countries have set the goal of limiting global warming to "well below 2°C

Both the results of scientific research and the history of the climate change negotiations suggest that several, flexible pathways to emissions reduction might be more effective. Although so far most of **the efforts are focused on the UN Framework Convention on Climate Change**,[40] there are other actions —either at global level (e.g. discussions at G8 and G20 meetings) or at national or local levels (e.g. carbon markets)— and some important developments led by the private sector.

International meetings and events continued during the pandemic, although they were held online due to the containment measures. Of particular note were the following:

- The online Climate Ambition Summit 2020 took place on 12 December, on the occasion of the 5th anniversary of the Paris Agreement. It brought together more than 70 world leaders and the UN Secretary General and its focus was on reducing GHG emissions. Thanks to the commitments made by major countries, the sentiment was positive (unlike a year earlier), with authoritative commentators now expressing cautious optimism about the ability to achieve the emission and global warming targets.[41]
- The Climate Adaptation Summit (CAS) was held on 25-26 January 2021, as the closing event of the "Action Year for Adaptation", coordinated by the Global Commission on Adaptation. The Summit, which was an important milestone on the way to COP 26, brought together global leaders and other stakeholders, including representatives of cities, regions and international organisations.[42]

3. The impacts of climate change in Greece

Sun and sea

The impacts of climate change in Greece are expected to be particularly severe. Key sectors of the Greek economy and the macroeconomy as a whole will likely be affected by climate disruption. Greece's National Climate Change Adaptation Strategy and National Energy and Climate Plan are important steps towards achieving climate neutrality by 2050.

The "Mediterranean" climate is characterised by typically mild to cool, wet winters and warm to very hot, dry summers

3.1. Expected changes in climate parameters in Greece

The regions around the Mediterranean basin have the so-called "Mediterranean" climate, characterised by typically mild to cool, wet winters and warm to very hot, dry summers. In the Eastern Mediterranean region, one of the most vulnerable to the anthropogenic component of the climate crisis, the annual average temperature is projected to rise by 2°C between 2021 and 2050 and by 4°C between 2071 and 2100, with a decline in total precipitation and a higher frequency of extreme precipitation events.

The Research Centre for Atmospheric Physics and Climatology (RCAPC) of the Academy of Athens has developed model simulation datasets for GHG emission scenarios for Greece, as elaborated in the context of the Fifth Assessment Report of the UN Intergovernmental Panel on Climate Change (IPCC); such datasets are used as a basis for CCISC studies (on which this chapter draws). These scenarios incorporate historical observational data on emissions and concentrations for a complete set of GHGs, aerosols and chemically active gases, as well as land use data. Thus, they are important tools for designing mitigation and adaptation policies and are briefly described below:

- The "**mild scenario**" assumes that global CO_2 emissions peak by 2020 and then drop to almost zero by 2080; oil use is decreasing, but the use of other fossil fuels is increasing and compensated by CO_2 capture and storage; the use of biofuels is high; the use of renewable energy (e.g. solar and wind) is increasing, but remains low.
- The "**baseline scenario**" assumes that the earth-atmosphere energy balance stabilises after 2100, without exceeding the long-term goal; there is a general decrease in energy consumption and use of fossil fuels, as well as higher use of renewable energy sources and nuclear energy.
- The "**worst-case or business-as-usual scenario**" assumes increasing GHG emissions, leading to high concentrations; in the absence of GHG emission reduction policies, methane and nitrous oxide emissions increase rapidly until the end of the century; a growing population leads to more extensive use of land and fossil fuels for energy production and transport.

The two extreme climate change scenarios ("mild" and "worst-case") suggest that, towards the end of the 21st century, Greece would face the following developments:

- **Precipitation** levels will decrease, according to the mild scenario, by up to 10% in Western Greece and will exhibit slight fluctuations in Eastern Greece. By contrast, under the adverse scenario, precipitation will decrease significantly across the country, and most strongly (by up to 30%) in the Peloponnese, Crete and the Dodecanese.
- **Mean air temperature** will increase by 2-5°C (mild and worst-case scenario, respectively). The rise in temperature will be more pronounced in the summer and higher on the mainland than in insular Greece. In the period 2071-2100, the number of days with a maximum temperature above 35°C will be higher than at present on the mainland (15 to 50 more days, depending on the underlying scenario). By contrast, especially in Northern Greece, the number of days with night frost will decrease by 35-80, depending on the scenario.

- The Bank of Greece study (CCISC 2011) highlighted the increased frequency and intensity of **weather extremes** as a crucial aspect of climate change in Greece. Heat waves, in particular, will probably become more frequent, longer and more acute. Cold extremes are likely to become less frequent, but occasional cold spells will continue to occur even after 2050. Summer droughts will increase further, with longer dry periods threatening water reserves in already vulnerable regions. At the same time, heavy rainfall will become more frequent in the next 70 years, with urban areas facing a higher risk of flooding.

Heavy rainfall will become more frequent in the next 70 years, with urban areas facing a higher risk of flooding

3.2. Impact on key sectors of the Greek economy[43]

Greece is characterized by a variety of climates and great biodiversity, due to the interaction of weather systems with its complex topography and the strong presence of the sea element. Simulations based on different scenarios predict significant changes in many climate parameters (temperature, humidity, cloud coverage, etc.) across the country.

There will be a need for cooling for up to an extra 40 days per year in the period 2071-2100

The most noteworthy among these changes include the expected increases in average incoming solar radiation (which will almost double) and in the intensity of Etesian winds (by 10%) towards the end of this century. Rising temperatures will lead to longer growing seasons by 15-35 days, but also to higher energy demand for cooling in the summer. The low-lying areas of continental Greece could face increased needs for up to an extra 40 days per year in the period 2071-2100, while in the island and mountain areas the needs would rise more moderately. On a positive note, however, energy demand for heating in wintertime is projected to weaken.

Precipitation is expected to decrease significantly by the end of the 21st century

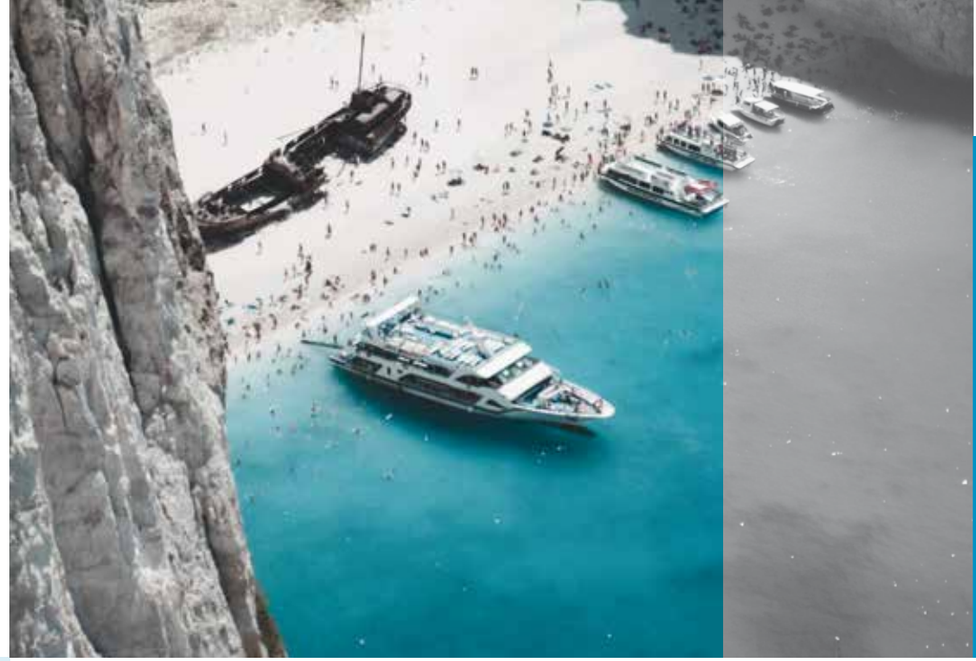
Greece's annual volume of precipitation, at around 115 billion m^3 on average, is comparable to those of other European countries. For the Greek territory as a whole, precipitation volume is expected to significantly decline by the end of the 21st century, with the size of the decline depending on the scenario considered. Changes are also expected in precipitation extremes. In Eastern Central Greece and Northwestern Macedonia, the maximum amount of precipitation occurring within three-day periods is expected to increase by as much as 30%, whereas in Western Greece it is expected to decrease by up to 20%.

Unlike high precipitation seasons, the largest increases in the length of dry seasons are projected for the eastern part of the mainland and for northern Crete, where 20 more drought days per year are expected in 2021 and 2050 and up to 40 more drought days 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 by 40 days between 2071 and 2100 across eastern Greece (from Thrace down to the Peloponnese), while smaller increases are expected in western Greece.

The rise in the mean sea level in Greece will range between 0.2 and 2 m

Greece has a very extensive coastline, over 16,000 km, of which around 1,000 km are vulnerable to climate change, due mainly to the risk of a mean sea level rise —by between 0.2 and 2 m— but also to other factors. Long-term changes in sea levels and temporary coastal wave extremes affect many sectors of the economy (tourism, land use, transport, etc.) and their annual total costs are very high.

To sum up, the direct physical impacts of climate change include rising temperatures, reduced precipitation, sea level rise and more frequent extreme weather events. The indirect impacts on economic activity are discussed in more detail below.



3.2.1. Tourism

Greek tourism exhibits strong seasonality and high geographical concentration

Tourism is a major sector of the Greek economy in terms of gross domestic product (GDP) and employment. On the other hand, its shortcomings include strong seasonality, high geographical concentration and slow adjustment to the emerging trends in demand and regional competition.

Greece's tourism product offering relies heavily on climate conditions, which makes it vulnerable to climate change. **Indirect physical impacts** on tourism include damage to coastal tourism infrastructure; physical obstacles to the intended use of certain tourism sites (e.g. lack of snow in skiing areas), sea water intrusion in coastal aquifer; water scarcity due to less precipitation; and decline of ecotourism and relevant infrastructures.

The **economic impacts** of climate change on tourism include:

- declining tourist arrivals and average length of stay;
- higher average cost of services provided to tourists;
- damage to cultural, historical and archaeological sites and monuments;
- less income available to be spent on tourism worldwide, due to falling GDP levels as a result of climate change;

- cost of forced suspension of certain tourism services due to extreme natural events (loss of revenue);
- cost of adaptation to the physical impacts of climate change and extreme events (e.g. anti-flood dams, water recycling systems, etc.);
- cost of substitution of natural capital with man-made capital in order to preserve the attractiveness of a destination (e.g. a theme park in lieu of a forest, a climbing track in snowless ski resorts, etc.); and
- cost of repositioning the tourism product in the international market.

Against this background, the private and the public sectors need to take action to reduce the high seasonality and geographical concentration of the Greek tourism product. This calls for long-term strategic planning. Among other things, there is a need to advertise the rich natural beauties of other, less known, destinations across the country; promote mild and alternative forms of tourism; focus on new target groups; extend the tourism season; and take measures to reduce the environmental footprint of tourism facilities.

3.2.2. Agriculture

Agricultural production is inextricably linked to climate, which largely determines the type, quantity and quality of crops. The effects of climate change will vary across individual crop types and across climate zones. Thermophilic crops (e.g. cotton, maize, citrus, olives) could benefit from rising temperatures, while cryophilic crops (e.g. winter cereals and pulse vegetables) will be affected only slightly or negatively. The loss of agricultural land, which is likely to reach 19% between 2040 and 2050 and 38% of Greece's total agricultural land in 2090-2100 (CCISC 2011), will also play an important role in crop yields.

To address climate impacts, measures have been proposed, including more efficient water management, relocation of crops and various changes in cultivation methods (sowing times, irrigation planning, selection of varieties, preservation of soil fertility, etc.). In particular, in order to reduce GHG emissions, incentives should be provided to expand organic farming and livestock breeding, establish modern animal waste management systems, make sustainable use of fertilisers and pesticides, promote integrated agricultural management practices in order to reduce pollution and the degradation of aquatic ecosystems, promote the use of RES, save marginal agricultural land and restore production capacity.

Agricultural production is inextricably linked to climate: the loss of agricultural land is likely to reach 19% in the period 2040-2050 and 38% of Greece's total agricultural land in 2090-2100

Meanwhile, the digitalisation of agriculture (**Agriculture 4.0**), i.e. the development and introduction of new tools and methodologies in production (interconnected farms, interconnected tractors or other agricultural machinery, etc.), helps raise productivity and improve quality, as well as protect the environment. Agriculture 4.0 is changing agricultural business ecosystems and value chains, while creating new opportunities for profits. The application of ICT in agriculture helps farmers to more efficiently manage their business (by increasing output, saving inputs, or both).

3.2.3. Built environment and energy consumption

Today, for the first time in the history of mankind, more than half of global population live in urban areas. Over the last 40 years, built-up areas on the planet have grown faster than global population (according to UN Urban Global Observatory data and European Commission, Joint Research Centre, *2016 Annual Activity Report*). As a result of growing population and higher demand for urban land, more and more people and properties will be located in densely populated urban centres, and this trend is disproportionately stronger in low-income countries.

In Greece, energy consumption for domestic use has increased by 65% since 1990, while in the EU as a whole at least one-third of final energy consumption is accounted for by buildings, making the buildings sector one of the largest energy consumers, but also the largest GHG emitter (Eurostat 2018). Cement is the world's leading construction material, and its production is responsible for a significant proportion of global anthropogenic CO_2 emissions (MIT 2019).[44]

Energy consumption for domestic use in Greece has increased by 65% compared to 1990

The world's built-up areas have spread faster than global population growth in recent decades

In the face of an ageing building stock, the EU and national legislation lay down a number of mandatory provisions on green infrastructure in new buildings and retrofitting of old ones, with particular focus on public buildings, which can lead by example with efficient energy design. Such provisions concern, among other things, the energy profiling of buildings, the introduction of smart systems for managing and tracking energy consumption and a 3% annual renovation requirement for all public buildings, to make them zero-energy from 2019 onwards. Moreover, all new buildings from 2021 on have to be "nearly zero-energy buildings" (NZEB). A drastic reduction in energy needs is therefore required, along with a gradual shift away from energy-consuming systems towards cleaner energy.

The microclimate prevailing in a metropolitan area is called urban climate. The energy released by human activities in cities contributes to a rise in air temperature; this is known as the

All new buildings have to be nearly zero-energy buildings (NZEB)

The energy released by human activities in cities contributes to a rise in air temperature; this is known as the "urban heat island" effect

"urban heat island" effect. Athens is a typical metropolis, with densely built-up areas in the city centre and less so in the suburbs and a scarcity of green spaces, which is a key driver of the urban heat island effect. The centre of Athens is about 7-8°C warmer than the suburbs, as much as 12-13°C in high road traffic areas.

Higher city temperature causes discomfort and leads to intensive use of cooling appliances (e.g. air conditioners) in buildings, which ironically contributes to a further rise in air temperatures. According to estimates, air conditioners alone added 1.3°C to the average air temperature in Athens between 1976 and 2008 (CCISC 2011), which points to a need for a comprehensive revision of energy consumption methods. It should be noted that climate projections for the Greek capital are quite dismal, with average air temperature expected to rise dramatically in the next few decades.

The impact of climate change on the Greek economy is expected to be adverse

3.3. Economic costs for Greece

The impact of climate change on the Greek economy is expected to be adverse, far outweighing the possible positive effects.

Lower productivity (e.g. in agriculture) as a consequence of the changing climate is expected to lead to a decline in household disposable income, hence in consumption. Other sectors, e.g. tourism, will likely face similar effects. Moreover, the environment of constant change and uncertainty will probably affect consumption and investment patterns.

Greece's trade will also be strongly affected. Higher production costs (due to lower productivity and rising raw material prices) will weigh on exports, while damages to road networks and distribution channels will hamper the movement of goods. More imports will become necessary to make up for lower domestic production (in sectors such as agriculture). On the supply side, the decline in investment and in physical capital, as well as lower labour productivity, will adversely affect the productive capacity of the economy (potential output) and dampen long-term growth. In this context, technology has an important role to play in the process of restructuring production.[45]

In order to assess the economic impacts of climate change on the Greek economy and its individual sectors, CCISC (2011) used four climate change scenarios based on different assumptions regarding social and economic developments at a global level, which in turn determine GHG, in particular carbon dioxide (CO_2), emissions and, ultimately, four different paths of climate change. Specifically, the CCISC used:

- A "**mitigation scenario**", which foresees a moderate increase in CO_2 concentration in the atmosphere, as there is a global shift towards low-carbon energy sources and activities. Climate change is not prevented, but it is mitigated. Therefore, even under this scenario, there are economic costs, albeit limited.
- A "**baseline scenario"**, which anticipates moderate economic growth, hence weak energy consumption growth. Technological changes are not as drastic as in the mitigation scenario, implying that there is still some increase in GHG concentrations. Overall, there are economic costs due to climate change.
- A "**business-as-usual scenario**", which assumes a continuation of current trends in socioeconomic conditions, where technological advances lead to the use of more energy-efficient production processes, although conventional technologies remain in use. This scenario anticipates rapid economic growth and increased consumption, resulting in strong increase in emissions, and entails significant costs due to climate change.

- Finally, a "**worst-case scenario**" in terms of GHG emissions and concentrations, which predicts slow technological advances coupled with strong population and energy consumption growth and is a more severe version of the "business-as-usual scenario".

Under the worst-case scenario, the cumulative cost to the Greek economy would come to EUR 701 billion up to 2100.

Accordingly, Greece's output losses would be between 0.9 and 2 percentage points of GDP growth by 2050 and between 2.7 and 6 percentage points by 2100. The negative "household welfare equivalent variation"[46] would range annually from EUR 3 to EUR 5.7 billion by 2050 and from EUR 8.4 billion to EUR 24.4 billion by 2100. Definitely, the more severe the underlying scenario, the stronger the annual effects on GDP and household welfare.

Output losses in Greece are projected to range from 0.9 to 2 percentage points by 2050 and from 2.7 to 6 percentage points by 2100

Under the worst-case (inaction) scenario, total cumulative costs would be EUR 701 billion by 2100, whereas under the mitigation scenario they would be EUR 407 billion lower for the same period (given that the total costs of climate change escalate for the most part after 2050).

In its 2014 report[47] on Greece's National Climate Change Adaptation Strategy (NCCAS), the CCISC included a vulnerability analysis,[48] quantifying and ranking the expected climate risks for the Greek territory. Agriculture is identified as the sector to be the most affected by climate change in Greece, while the impacts on tourism and coastal systems would have major consequences on household incomes and the economy as a whole. Of particular significance is also the water reserves sector, given its importance for agriculture and water supply.

As part of newer CCISC research and the Life-IP AdaptInGR project, impacts and costs of climate change continue to be investigated on the basis of new scenarios.

In the absence of action to tackle climate change, the total cumulative cost to the Greek economy would come to EUR 701 billion by 2100

3.3.1. National Climate Change Adaptation Strategy

As early as 2015, Greece adopted the **National Climate Change Adaptation Strategy (NCCAS)**, drafted by the CCISC. This strategy established an initial framework for the development and prioritisation of adaptation actions to strengthen the country's resilience to climate change. It sets out the general objectives, guiding principles and tools for implementing effective growth-oriented adaptation policies, in line with European directives and international experience. Moreover, it is the first step in a continuous and flexible process for planning and implementing the necessary adaptation measures at national, regional and local levels and aspires to leverage the capabilities of Greece's public authorities, economy and society at large, in an aim to address the impacts of climate change in coming years.

Meanwhile, the integrated project "**AdaptInGR – Boosting the implementation of adaptation policy across Greece**"[49] is part of the EU's LIFE funding programme and monitors the implementation of adaptation measures and policies throughout Greece. The Bank of Greece participates in this eight-year project (2019-2026) through the CCISC, along with 19 other national partners (Academy of Athens, National Technical University of Athens, Regions and Municipalities of Greece, etc.), under the coordination of the Ministry of Environment and Energy.

This national project aims to catalyse the implementation of the NCCAS and focuses on establishing a mechanism for monitoring adaptation actions and policies, as well as collaboration with private stakeholders and social partners to raise awareness of adaptation measures. Selected pilot actions under the project are being promoted according to schedule and in view of the exceptional circumstances caused by the COVID-19 pandemic.

In the current phase of the project, the Bank of Greece is involved in the development of the methodological framework for monitoring the social and economic impact of the project; updates the 2011 CCISC study on the economic, environmental and social impacts of climate change in Greece; undertakes preparatory work for a new **NCCAS**; contributes to the dissemination of research results and information and awareness-raising activities; monitors and evaluates the outcomes of the project's actions; and participates in the project's Complementary Funding Committee aiming to mobilise additional financing for adaptation actions in the country.

The NECP sets ambitious national goals to be achieved by 2030 and prepares the transition to climate neutrality by 2050

3.3.2. National Energy and Climate Plan

The Bank of Greece also participated in the Committee for the National Energy and Climate Plan (NECP).[50] The new NECP, submitted to the European Commission in 2019, is a strategic plan setting out a detailed roadmap regarding the attainment of ambitious national energy and climate targets by 2030 and preparing the transition to a climate-neutral economy by 2050. It envisages a lignite phase-out and a radical transformation of the energy sector and supports the design of policy measures that will efficiently (from a social, environmental and economic point of view) help attain the country's medium- and long-term energy and climate objectives.

Available research results show that climate change, if not mitigated, is set to cause huge costs for Greece, pointing to an urgent need to drastically reduce GHG emissions, save energy, improve energy efficiency and shift to renewable energy. At the same time, the transformation of production models in a broad range of economic sectors, notably including the energy sector, can and must drive the Greek economy's path to sustainability, in line with national and EU policies, as well as the UN Sustainable Development Goals.

Transition to climate neutrality is now technically feasible and economically viable. It will also open up opportunities associated with new renewable energy and innovative products, investment in energy efficiency and saving, new infrastructures and jobs. The NECP is a key tool for the necessary energy transition and emission reduction, and Greece is one of the EU Member States that have adopted ambitious climate targets through a comprehensive and coherent set of measures and policies, both for 2030 and in the longer term, for 2050. Guided by a holistic sustainability concept, this transition is combined with action to strengthen the competitiveness of Greek businesses and consumer protection, making best use of national and European funding instruments and appropriate market mechanisms in line with EU legislation.

Transition to climate neutrality is now technically feasible and economically viable

4. FINANCIAL SYSTEM, CENTRAL BANKS AND CLIMATE CHANGE

Handle with care

Climate change is a major concern for central banks and financial supervisors

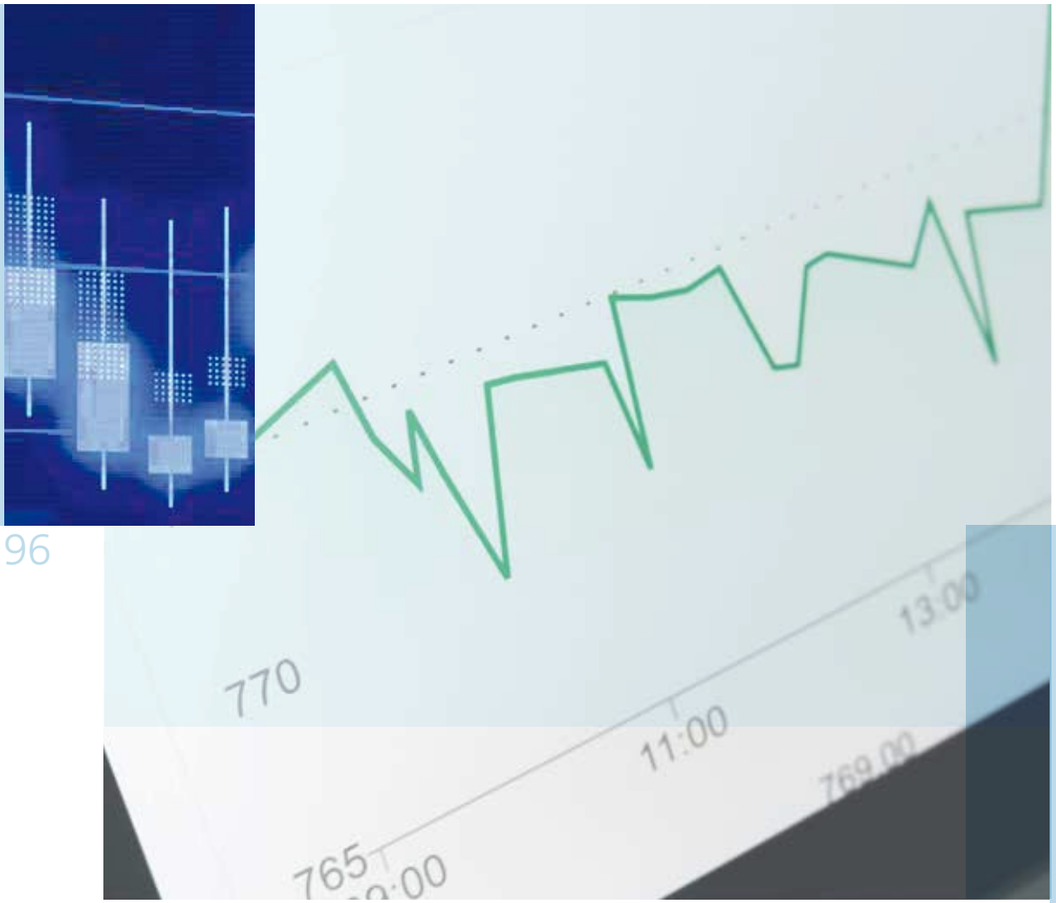
4.1. Central banks and climate change

Climate change, as a source of risks to the economy and the financial system, is a major concern for central banks and financial supervisors (NGFS 2019).[51]

There are two main channels through which climate change poses challenges to the economy and the financial system: (i) physical risks, e.g. as a result of the increasing frequency and severity of extreme weather events; and (ii) transition risks relating to the process of adjustment towards a low-carbon economy, involving changes in policies, technologies and consumer preferences. Thus, both climate change itself and policies to address it can affect economic growth and price developments not only in the short term, but also over longer horizons. In particular, natural disasters such as floods and droughts could affect food production and prices. Mitigation policies, on the other hand, could affect inflation by leading to higher prices and production costs. These issues fall squarely within the Eurosystem's price stability mandate and will be discussed in detail in the following sections. Physical impacts, by causing e.g. direct damage to infrastructures, impairment of productive capacity or decline in productivity, expose the financial system to the risk of loss due to counterparty default. On the other hand, a delayed or abrupt introduction of mitigation policies could have a negative impact on certain carbon-intensive industries, affecting their debt repayment capacity.[52] The adverse consequences on commercial banks' balance sheets could lead to reduced credit to the real economy and affect monetary policy transmission and the stability of the banking system.

Finally, central banks are exposed to climate risks in respect of the assets they hold on their balance sheet; the value and risk profile of such assets can be negatively affected, potentially leading to an undesirable accumulation of climate-related financial risks.

In view of all the above factors, climate change has consequences for central banks pursuing their primary mandate of price stability, but also in other areas of their competence, including financial stability and banking supervision (see President Lagarde's speech, 11.6.2021).[53]



Although it is the governments that have the primary responsibility and the most effective tools to address the risks arising from climate change, the need for urgent action by central banks is also increasingly recognised. This is reflected in the significant expansion of NGFS membership, from just eight members at its inception in 2017, to more than 100 members and observers from all over the world today. More and more central banks recognise the importance of incorporating climate change considerations into their operational frameworks. In March 2021, the Bank of England revised its mandate to explicitly include environmental sustainability and net-zero compatibility.

For its part, the Eurosystem, which is the monetary authority of the euro area and comprises the European Central Bank (ECB) and the national central banks of the 19 euro area Member States (including the Bank of Greece), has committed to further integrate climate change considerations in its policy and operations. In its recent monetary policy strategy review, the Eurosystem further identified the role it can —and should— play in addressing climate change risks within its price stability mandate (see Section 4.3).

Signalling the high importance it attaches to the issue of climate change, the ECB set up a climate change centre in early 2021. This new ECB unit will shape and steer the ECB's climate agenda internally and externally (in close cooperation with the other Eurosystem central banks), focusing on five work streams:

(a) financial stability and prudential policy;

(b) macroeconomic analysis and monetary policy;

(c) financial market operations and risk;

(d) EU policy and financial regulation; and

(e) corporate sustainability.

As ECB President Christine Lagarde pointed out: "We are now launching a new climate change centre to bring together more efficiently the different expertise and strands of work on climate across the Bank [...]. The climate change centre provides the structure we need to tackle the issue with the urgency and determination that it deserves" (25.1.2021).[54]

The Bank of Greece is one of the first central banks in the world to respond to the issues of climate change and sustainability. As early as 2009, it established the Climate Change Impacts Study Committee (CCISC), which makes a key contribution to research to highlight the risks and opportunities arising from climate change (see Section 4.1.1). The Bank is also very active within the NGFS (see Section 4.1.2). As a member of the Eurosystem, it works closely with the ECB and the other euro area NCBs to continuously strengthen the effort to address climate change risks (see Section 4.1.3). At national level, the Bank contributes to the design of national climate change adaptation (NCCAS and Life-IP AdaptInGR) and mitigation policies (NECPs).

Finally, it is worth noting the important initiative of the Bank of Greece to set up in June 2021 the Climate Change and Sustainability Centre. Its main tasks are: to design, coordinate, support and implement the climate and sustainability activities of the Bank and of the CCISC; to conduct research on climate and sustainability in collaboration with external parties; to design and promote relevant themed activities in the financial system and beyond; and to represent the Bank at relevant national, Eurosystem-wide and international fora.

4.1.1. The Climate Change Impacts Study Committee (CISC)

"The Bank of Greece systematically studies the impacts effects of climate change in Greece, having set up the Climate Change Impacts Study Committee (CCISC) in 2009, and is one of the first central banks to actively deal with this issue. At the same time, it continues to actively support initiatives such as Life-IP AdaptInGR 'Boosting the implementation of adaptation policy across Greece', an ambitious eight-year project for adapting Greece to climate change" (Stournaras 2020).[55]

Over the past twelve years, the CCISC has brought together experts in environmental and energy economics, climate science, physics, biology, agriculture, forestry, engineering, social sciences and other fields of knowledge, conducting research on the economic, social and environmental impacts of climate change in Greece and recommending ways of adaptation and transition to a sustainable economy

Over the past twelve years, the CCISC has brought together experts in environmental and energy economics, climate science, physics, biology, agriculture, forestry, engineering, social sciences and other fields of knowledge, conducting research on the economic, social and environmental impacts of climate change in Greece and recommending ways of adaptation and transition to a sustainable economy.

CCISC research has shown that the cost of climate change for the Greek economy is particularly high. In addition to mitigation actions taken in the context of EU policies, Greece could achieve gains and cost saving (by almost 30%) through adaptation actions that will help the Greek economy become climate-resilient.

The National Climate Change Adaptation Strategy (NCCAS), drafted by the CCISC in collaboration with the Ministry of Environment and Energy and the Academy of Athens, identifies these adaptation actions, giving priority to policies that have positive effects on employment and growth, so that adaptation can deliver a dual benefit by protecting against climate change and boosting the country's economy.

However, there is also a need for new growth strategies across the sectors of the Greek economy. A CCISC report on Greek tourism points out that the industry is likely to face heavy losses if it continues with the same growth model.[56] Instead, a growth strategy geared towards reducing the geographical and, more importantly, seasonal concentration would bring about significant benefits, as climate conditions in spring and autumn are expected to become more favourable for tourism in the future.

The CCISC publication *The economics of climate change*[57] provides a comprehensive, state-of-the-art review of the economics of climate change, focusing on a design of economic policy aimed at controlling the climate externality (referring to the welfare costs of an environmentally unsustainable, e.g. carbon-intensive, economic growth). It suggests that mitigation policies (e.g. carbon tax, emission trading systems) can correct market failures, helping the transition to a low-carbon economy. Finally, it addresses the issue of monetary policy under conditions of global warming, as well as the role of central banks and supervisors.

The aim is to enhance the younger generation's awareness of and preparedness for the impacts of climate change and to draw attention to the need for action

With a view to climate action synergies with domestic institutions and bodies, the Bank of Greece and the CCISC have cooperated with the Hellenic Banking Association and the Hellenic Association of Insurance Companies. They have also co-organised or participated in relevant workshops, seminars and conferences of the Hellenic Parliament, the British Embassy, the Sustainable Development Solutions Network Greece, the EIT Climate-KIC Hub Greece, the Business Seeds project of the National Bank of Greece, the Hellenic Association for Energy Economics, etc.

Committed to promote climate awareness and education, the Bank has signed a Memorandum of Understanding with the Goulandris Museum of Natural History on the design and implementation of a three-year educational programme (2019-2021), based on CCISC research. The aim is to enhance the younger generations' awareness of and preparedness for climate change and its impacts and to draw attention to the need for action.

Moreover, as a follow-up to the international scientific conference "Climate Change Impacts on Cultural Heritage: Facing the Challenge", held in Athens in 2019, the CCISC participates in the joint initiative of the Greek government, the World Meteorological Organisation (WMO) and UNESCO entitled "Addressing climate change impacts on cultural and natural heritage".

Despite the unprecedented circumstances that have emerged worldwide since 2020 as a result of the pandemic and the associated containment measures, the CCISC has seamlessly continued its work, focusing on research to develop tools for designing and evaluating actions and decisions and networking with domestic and international organisations for joint climate and sustainability action.

4.1.2. Network for Greening the Financial System (NGFS)

At the One Planet Summit in Paris in December 2017, eight central banks and supervisors set up a **Network for Greening the Financial System** (NGFS), which now brings together more than 100 members and observers from all over the world.

The NGFS aspires to help strengthen the global response required to meet the goals of the 2016 Paris Agreement and enhance the role of the financial system in managing risks and mobilising funding for green and low-carbon investments in the broader context of environmentally sustainable development.

In order to achieve its goals, the NGFS has structured its work into five dedicated Workstreams involving representatives of the Bank of Greece:[58]

1. (Micro)prudential and supervision
2. Macrofinancial
3. Scaling up green finance
4. Bridging the data gaps
5. Research

In the past few years, in response to banks' growing interest in and understanding of environmental challenges, the NGFS has published dozens of important reports, recommendations and guidance to central banks, legislators and financial institutions.[59]

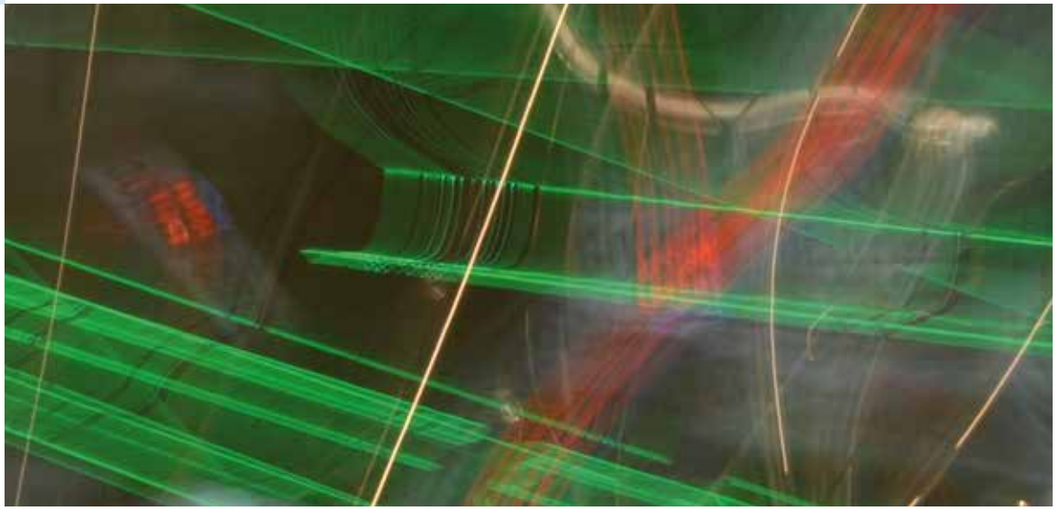
These publications include:

The NGFS report entitled *A Call for Action: Climate change as a source of financial risk* in April 2019.[60] It provided six initial recommendations for central banks, supervisors, policymakers and financial institutions to enhance their role in the greening of the financial system and the managing of environment and climate-related risks: (a) integrating climate-related risks into financial stability monitoring and micro-supervision; (b) integrating sustainability factors into own-portfolio management; (c) bridging the data gaps; (d) building awareness and intellectual capacity and encouraging technical assistance and knowledge sharing; (e) achieving robust and internationally consistent climate and environment-related disclosure; and (f) supporting the development of a taxonomy of economic activities.

A NGFS technical document entitled *A sustainable and responsible investment guide for central banks' portfolio management,* published in October 2019. This called for the adoption of **Sustainable and Responsible Investment (SRI)** practices by central banks in respect of their own portfolios, as long as they do not interfere with their primary objective. "As public institutions, central banks are subject to public scrutiny if they fail to address stakeholders' concerns related to climate change".[61]

In 2020, the NGFS published an *Overview of Environmental Risk Analysis by Financial Institutions*,[62] as well as a *Guide to climate scenario analysis for central banks and supervisors*, together with a set of NGFS reference scenarios that were updated in 2021.[63] Other publications in 2020 concerned issues of particular relevance to central banks, such as addressing climate risk in monetary policy portfolios, or the progress made and further steps needed in the area of SRI practices, etc.

Particularly noteworthy was the publication entitled **Survey on monetary policy operations and climate change: key lessons for further analyses.**[64] This reviewed the institutional frameworks and balance sheets of 107 central banks around the world, as well as the responses of 26 of them (representing 51 countries) to a questionnaire on whether they are contemplating adjusting their operational frameworks to take account of climate-related risks in the implementation of monetary policy (NGFS 2020, December).



All central banks consider climate change to be a challenge, both on account of its potential threat to the economy and its impact on central banks' operational frameworks, though only few of them indicate that they have already experienced some of these transmission channel effects (mainly following the occurrence of natural disasters)

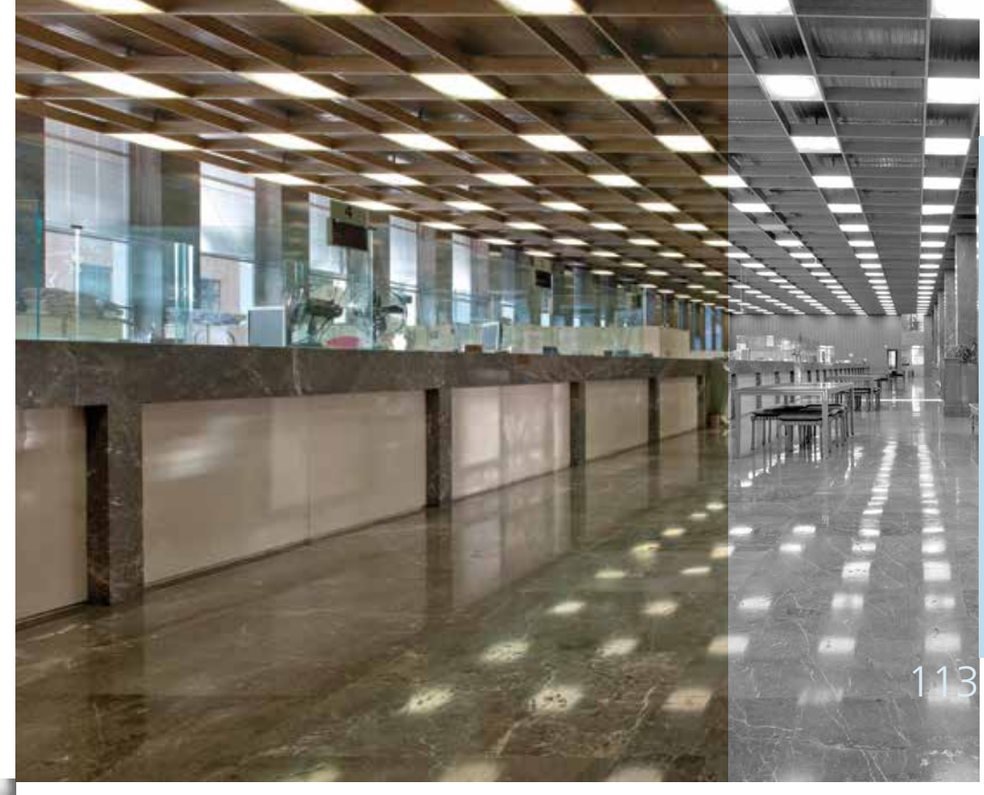
The key findings of this comprehensive and geographically diverse overview were the following:

- All central banks consider climate change to be a challenge, both on account of its potential threat to the economy and its impact on central banks' operational frameworks, though only few of them indicate that they have already experienced some of these transmission channel effects (mainly following the occurrence of natural disasters).
- Most central banks see scope in their respective mandates for adjusting their operational frameworks to reflect climate-related risks and several of them are already considering adopting protective and/or proactive measures in this direction in the near future.
- The main incentive for central banks to adopt protective measures is stated as being the mitigation of financial risks stemming from exposures to climate-related risks on their balance sheets. The lack of consistent climate-related disclosure requirements is reported as an obstacle.
- The main argument put forward in favour of adopting proactive measures reflects the primary objective of most central banks, i.e. supporting an orderly transition towards a low-carbon economy to ensure a smooth monetary transmission over the long term.

Overall, this survey confirms an increasing shared understanding of climate-related risks among central banks. International coordination is seen as key to facilitating the integration of climate risks into central banks' operational frameworks.

4.2. Banking and insurance supervision

In any economy, banking and/or insurance supervisors (in Greece, the Bank of Greece) need to take into account the potential impact of climate change on the entities they supervise, i.e. banks and insurance undertakings.



4.2.1. Banking supervision

"If we are to meet the Sustainable Development Goals of the United Nations and the objectives of the Paris Climate Agreement, the banking sector needs to maximise its contribution and align itself with these goals" (Stournaras 2019).

The banking sector fulfils a very important function: by providing credit (loans) to the economy, it promotes investment and output growth. Banks convert the short-term deposits they accept from economic units (households and firms) into long-term loans to other such units, which are used to finance investment, thereby supporting growth.

In order to properly fulfil this intermediation role, the banking sector needs to be stable and healthy. While it is itself exposed to the impacts of climate change in multiple ways, at the same time it is called upon to help the transition to a more sustainable economy by providing more and greener financing. As an indication of the size of the financing needed, an EU-wide green investment gap of EUR 260 billion per year must be bridged

The banking sector needs to be stable. To meet the EU 2030 climate goals, an investment gap of EUR 260 billion per year must be bridged

to meet the EU 2030 climate goals.[65] The EU will finance the transition to climate neutrality by implementing the European Green Deal, a EUR 1.8 trillion package of measures and actions, while also aiming to ensure recovery from the pandemic. Meanwhile, the financial sector has a key role to play in financing sustainable development, with banks taking the lead, followed by other funding providers (investors, capital markets, venture capital, etc.). For banks, this will be a demanding task, but it is also an opportunity.

Climate change risks for banks include the risk of assets becoming stranded due to climate-related policies or technological shift to clean energy, as well as the risk of potentially large and systemic losses on their investments as a result of weather extremes and/or the changing climate.

Against this background, among other central banks and supervisors, the ECB has formally identified climate-related risk as one of the key risks facing the banking sector, particularly in the long term, given the potential impact on the value investments, hence on banks' capital positions and, ultimately, the supply of funds to the economy.

The Single Supervisory Mechanism (SSM) —the European banking supervision system, which comprises the ECB and the National Supervisory Authorities (such as the Bank of Greece) of the participating countries— actively contributes to the efforts to assess and address climate financial risks, with the main objective of maintaining stability and the smooth functioning of the banking and financial system. Supervisory actions include:

- adding climate risks to the list of risks requiring closer supervisory attention;
- developing supervisory expectations from banks in terms of integrating climate change risk into their business models, governance, risk management and disclosures;
- assessing banks' exposure to climate risks under different scenarios of climate action (or inaction); and
- organising information and educational events for supervisors, banks and other stakeholders.

The availability of transparent and granular climate risk data together with a proper pricing, can support the effective channelling of the necessary funds by credit institutions to investments that help mitigate such risks.[66]

Central banks and supervisors monitor potential climate risks not only for individual banks under their supervision, but also for the financial system as a whole. Thus, the ECB has developed an analytical framework (De Guindos 2019)[67] for carrying out a climate risk stress test for the major euro area systemic banks in 2022. The exercise will consider both physical and transition risks and explore how they interact and affect banks' solvency and lending capacity. It will be based on the banks' own assessment of their exposure to, and preparedness for, the risk of climate change.

Central banks and supervisors monitor potential climate risks not only for individual banks under their supervision, but also for the financial system as a whole

In addition, the ECB conducted a centralised (top-down) economy-wide climate stress test and published its results in September 2021.[68] This exercise —the first of its kind— encompassed approximately four million companies worldwide and 1,600 banks —almost all financial institutions in the euro area— and covered a period of 30 years into the future. Its objective was to assess the exposure of euro area banks to future climate risks by analysing the resilience of their counterparties under various climate scenarios.

The stress test results showed that the climate change represents a major source of systemic risk, particularly for banks with portfolios concentrated in certain economic sectors (e.g. mining, energy and agriculture) and/or geographical areas (as physical risks vary across regions). In the absence of further climate policies, the costs to companies arising from extreme weather events rise substantially, and greatly increase their probability of default. In particular, the most vulnerable 10% of banks could see a 30% increase in the average probability of default in their credit portfolios over the next 30 years, unless further policies

are implemented to tackle climate change. The analysis also showed that the short-term costs of shifting to a net-zero economy are lower than the long-term costs of the lack of climate change policies. An important takeaway is also that companies and banks would benefit from the early adoption of green policies to drive the transition to a net-zero economy.

The European Banking Authority (EBA), the prudential regulator for all banks in the EU, supports efforts to address climate-related risks by publishing reports and recommendations on how to incorporate climate risks in the prudential framework (EBA 2020), which answers questions such as the following:

- How should climate risks be reflected in banks' risk management methodology and in the supervisory review and evaluation process?
- Should there be a more favourable prudential treatment of exposures that finance sustainable investments (e.g. green loans and other assets)?
- Conversely, should there be an increase in the minimum prudential requirements for banks that finance activities with an adverse impact on climate?
- What kind of data and information should banks and investment firms be required to disclose regarding their exposure to climate-related risks?

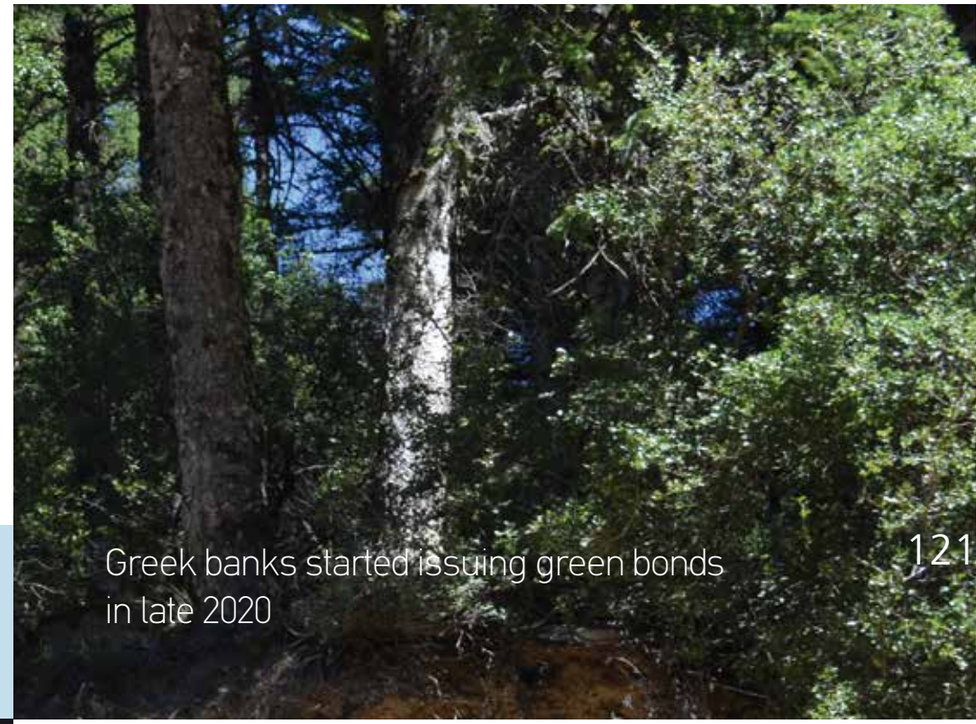
The Bank of Greece has been the first central bank to endorse the UNEP FI Principles for Responsible Banking (PRB)

The Bank of Greece is actively involved in consultations on all these and other issues discussed in international fora. At the same time, it focuses on monitoring and analysing the exposure of Greek banks to climate risks, as well as their climate-related risk management practices.

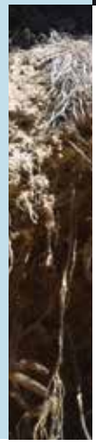
In 2020, the Bank of Greece launched a mapping exercise aimed to assess Greek banks' exposure to environmental risks. In this context, it held meetings with Greek systemic and non-systemic banks, in order to inform them of upcoming developments in the regulatory framework, engage them to address environmental risks and gauge their preparedness for the upcoming regulatory and supervisory requirements. The results of this exercise will feed into the ongoing supervisory dialogue. In line with further progress made in 2021 at the European and international levels in integrating sustainability into banking regulation and supervision, the Bank of Greece is planning more actions.

The Bank of Greece has been the first central bank to endorse the Principles for Responsible Banking (PRB) of the UN Environment Programme Finance Initiative (UNEP FI).[69] It remains committed to the PRB and, in its capacity as the national central bank, strongly urges banks to do the same and set ambitious climate goals. "The Principles for Responsible Banking, as part of a roadmap towards sustainability, support and accelerate the fundamental changes needed to achieve shared prosperity for current and future generations" (Stournaras 2019).

In particular, as the banking sector can channel funds towards actions that deliver positive effects on the environment, the PRB seek to define banks' role and responsibilities in shaping a sustainable future. Signatory banks commit to align their strategy and practice with the vision that the global community has set out in the UN 17 Sustainable Development Goals[70] and the Paris Agreement.



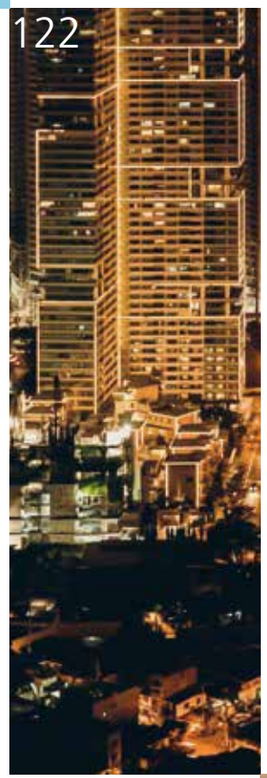
Greek banks started issuing green bonds in late 2020



The Principles aim to create value for banks and society by defining criteria for responsible and sustainable banking, through a holistic evaluation of risks and opportunities stemming from banks' activities. Furthermore, they encourage banks to measure and disclose the (positive or negative) impact of their products and services on society and the environment.

Greek banks are stepping up their efforts to meet the challenges of climate change by participating in international fora and organisations and adopting global principles and standards (such as the PRB and the Global Reporting Initiative (GRI) standards. Moreover, they increasingly integrate climate-related risks and opportunities into their business and risk management strategies.

Finally, in line with the trend seen in the rest of Europe, Greek banks started issuing green bonds in late 2020.



4.2.2. Insurance undertakings

Insurance undertakings are financial companies which, in return for a monetary consideration (premium), offer insurance coverage against one or more risks (e.g. earthquake, fire, accident, sickness, death, etc.), promising to compensate policyholders (natural or legal persons) in the event that any of such risks should occur. In order to be able to fulfil this promise, they need to have funds available at all times, derived from the premiums they earn. These funds, until they are used to pay compensation, are invested and contribute to the economy.

Climate change is of direct concern to insurance undertakings, as it is expected to increase the frequency and severity of natural hazards and worsen weather extremes (e.g. droughts). Insurers are affected directly, through increased compensation claims for damage to property, injury, etc., as well as through potential losses on their investments. There are also indirect effects, associated with the mitigation actions taken in the context of the transition to an environmentally sustainable economy; although these actions will certainly have a beneficial impact on the economy in the long term, they will entail considerable costs in the short term.

There are also effects working the other way round: through their investment decisions, insurance undertakings can have a positive impact on the environment, insofar as they are aligned with the coordinated efforts to tackle climate change. And they have the power to do so, given the large size of their total assets, which e.g. in Greece amounted to almost EUR 20 billion in 2020 (Bank of Greece, *Annual Report 2020*, April 2021). In general, insurance undertakings decide on how to invest on the basis of their customers' preferences, which can also include environmental considerations apart from purely investment-related ones. Thus, by asking their policyholders also about their environmental preferences, insurance undertakings can invest in a manner that responds to customer choices but, at the same time, supports mitigation and/or adaptation as well. Furthermore, when selecting and assessing their investments, they could guide and advise the investee companies on the potential impact of their activities on climate change.

The European Insurance and Occupational Pensions Authority (EIOPA), as part of its broader sustainability agenda to integrate environmental, social and governance (ESG) risk assessment in

Climate change is of direct concern to insurance undertakings

the regulatory and supervisory framework, conducted a sensitivity analysis of climate-change related transition risks in the investment portfolio of European insurers in 2020. The UNEP FI, in line with its mission to promote sustainable finance, has developed the Principles for Sustainable Insurance, which have already been endorsed by numerous organisations worldwide, as well as insurance undertakings in Greece.

The Bank of Greece, as the supervisor of insurance undertakings, supports the initiatives of international organisations and seeks to raise the awareness of citizens on the urgent need to insure their property against losses as a result of extreme weather events.

4.3. Monetary policy strategy, conduct and implementation

The term "monetary policy" refers to the decisions made by central banks to influence the cost and availability of money in an economy. These decisions primarily concern the interest rates and the other terms and conditions on which commercial banks borrow money from central banks. The interest rates at which citizens and businesses borrow from commercial banks are affected accordingly.

Monetary policy refers to central banks' decisions, primarily on interest rates and other terms on which they provide credit to commercial banks

Monetary policy in the euro area is implemented in a decentralised manner. The Governing Council of the ECB —of which the Bank of Greece Governor is a member— formulates the single monetary policy of the Eurosystem, and the national central banks are responsible for implementing it in their respective jurisdictions. The Bank of Greece implements monetary policy in Greece, provides credit (liquidity) to and accepts deposits from domestic commercial banks, while it also provides information to the Greek public by regular publications and reports. The primary objective of the Eurosystem's monetary policy is to maintain price stability (i.e. neither high inflation nor deflation) in the euro area in the medium term.

The Governing Council of the ECB —of which the Bank of Greece Governor is a member— formulates the single monetary policy of the Eurosystem, and the national central banks are responsible for implementing it in the respective jurisdictions

It is now commonly accepted that climate change requires urgent action also by central banks. While governments have the primary responsibility and the most effective tools to tackle climate change, the Eurosystem must also integrate the impact of climate change into its monetary policy.

As a first step, the impacts of climate change on price developments and economic activity are considered. It is important that these impacts be taken into account by the Eurosystem in order to ensure that potential risks to price stability are identified in a timely manner, given that:

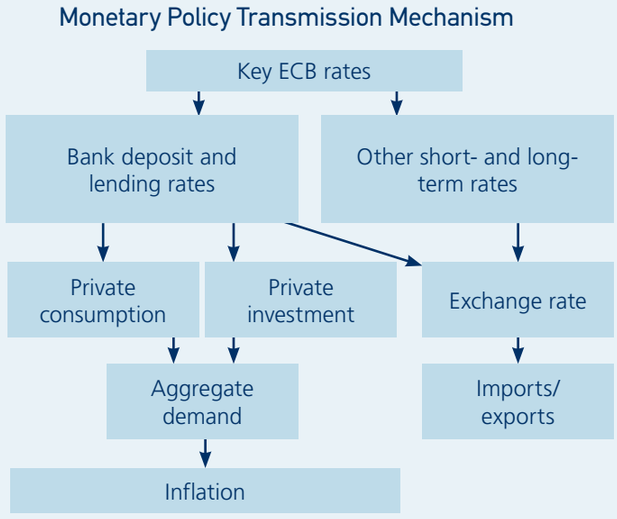
- Climate change risks and mitigation policies are increasingly affecting the structure and dynamics of the economy and of the financial system, thereby the Eurosystem's primary mandate to maintain price stability.
- Climate change increases market risk for certain assets held on the Eurosystem's balance sheet, potentially leading to financial losses.

- Furthermore, action against climate change is a key EU priority, and the Treaty on the Functioning of the European Union requires the Eurosystem to "support the general economic policies of the Union", without prejudice to its primary objective. Therefore, the Eurosystem can —and must— assist the EU in its action to tackle climate change, provided that its primary objective of maintaining price stability is not compromised.

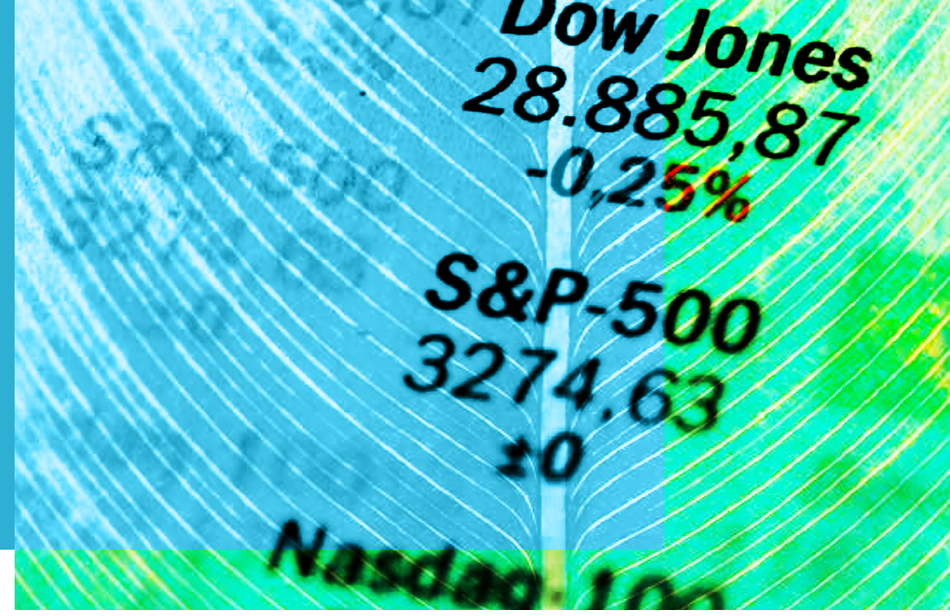
4.3.1. Impact on monetary policy-making

Although the most significant impact of climate change is expected to occur in the medium to long term, most central banks worldwide, including the Eurosystem, are already devoting more and more time and resources to enhancing their understanding of the challenges and risks arising from climate change, as well as the implications on their price stability mandate.

This is because —apart from the fact that continued global warming would lead to significant output losses (Rezai et al. 2018)[71]— climate change is expected to affect long-term growth, the natural rate of interest, the monetary policy transmission mechanism, financial stability and inflation expectations, hence also the assumptions underlying the empirical models that are used to forecast economic activity and price developments.



Climate change is highly relevant to monetary policy, as it can affect the ability of central banks to fulfil their price stability mandate



In simpler terms, climate change affects economic activity, interest rates, inflation, inflation expectations, the channels through which monetary policy influences inflation, uncertainty about other economic aggregates and future developments, as well as public perceptions. Climate change is therefore highly relevant to monetary policy, as it can affect the ability of central banks to fulfil their mandate to maintain price stability.

As far as inflation is concerned, the effects of climate change are ambiguous. High temperature volatility and extreme weather conditions often exert upward pressure on food prices, in addition to that caused by the potential damage to production capacity. Moreover, the impact of climate change on energy prices would affect the general price index. On the other hand, a steadily lower output growth likely to be caused by climate change would reduce inflation.

The results of a CCISC study (Economides & Xepapadeas 2018)[72] examined whether a monetary policy following a Taylor rule for the nominal interest rate is influenced by climate risks and suggest that climate change and the use of instruments to mitigate its detrimental effects have a significant impact on monetary policy design. Based on this study, research as part of the Bank of Greece's contribution to the Eurosystem's Workstream on climate change and monetary policy shows that standard shocks to the economy tend to be amplified under climate change and that economic activity and price developments tend to be much more volatile, unless the central bank takes action on climate change.

Should disruptions to the economy resulting from climate change become more frequent, downward pressure would be exerted on the natural rate of interest, further complicating the implementation of monetary policy.

Finally, higher global temperatures and weather fluctuations could slow down or accelerate growth in individual sectors of the economy, affecting credit spreads, precautionary savings, business profits and, ultimately, overall financial stability. Meanwhile, climate risks are increasingly priced in, with implications for financial markets, and several measures are being taken to meet the climate-related disclosure requirements.

4.3.2. Impact on monetary policy implementation

The measures taken (or considered) by central banks to address climate change risks have implications for several aspects of monetary policy implementation, such as asset purchase programmes, the collateral framework for central bank refinancing operations, counterparty eligibility criteria for monetary policy operations, as well as the risk management framework (e.g. collateral valuation, haircuts).

In a first move to support sustainable finance innovation within its mandate, the ECB decided that, as from 1 January 2021, sustainability-linked bonds with coupon structures linked to certain sustainability performance targets will become eligible as collateral for Eurosystem credit operations and for Eurosystem outright purchases for monetary policy purposes, provided they comply with all other eligibility criteria (see ECB press release, 22 September 2020).

An important aspect of the monetary policy implementation framework which can have a substantial impact on the Eurosystem's contribution to the transition to a low-carbon economy is the increasing importance of green bonds in asset purchase programmes, i.e. both the Asset Purchase Programme (APP)[73] in place since 2014 and the Pandemic Emergency Purchase Programme (PEPP). The former aims to help bring inflation to levels consistent with the ECB's target, while the latter was launched in March 2020 to address the effects of the pandemic. Under these programmes, the Eurosystem purchases securities issued by governments, supranational institutions and non-financial corporations.

Although these programmes do not explicitly include any climate or environmental goal, the Eurosystem has already purchased green bonds issued by several eligible issuers (ECB, *Annual Reports 2019*[74] and *2020*) in proportion to their share in total eligible securities, i.e. in line with the principle of market neutrality.

Green bonds are debt instruments issued to finance investment projects that are meant to have positive environmental or climate effects. Green bond issuance has grown rapidly in recent years. The financing of investment through the proceeds of green bonds has increased rapidly in recent years

Green bonds are debt instruments issued to finance investment projects that are meant to have positive environmental or climate effects. Building on the Green Bond Principles of the International Capital Market Association (ICMA), the financing of investment through the proceeds of green bonds has increased rapidly in recent years, and the global market for green bonds and green loans in 2020 has reached nearly USD 300 billion (Climate Bonds Initiative data).[75] The euro has become the leading currency of denomination globally for green bond issuance, and its role in strengthening the euro area capital markets can be enhanced by the development of an appropriate regulatory framework. However, green bonds still have a very small share in the global bond market, and the market for green bonds and green loans is not liquid enough. Moreover, climate-related risks are uncertain factors that are typically not included in asset pricing models. Better pricing of climate risks is therefore essential for improving the attractiveness of green bonds, which, according to a CCISC study (Sartzetakis 2019),[76] can play an important role in financing the transition to a low-carbon economy.

In addition to a possible increase in the share of "green bonds" in central banks' portfolios, the introduction of criteria for bond issuers, relating to the climate change impact of their activity (e.g. CO_2 emissions), in the selection of the bonds to be purchased could also reduce the attractiveness of bonds whose issuers are more detrimental to the climate. This is particularly relevant for corporate bonds purchased under the CSPP and PEPP programmes (see endnote 75). At present, the lack of sufficient information and of a commonly accepted definition of a green firm complicates such a shift towards green bonds.

In order to unlock its potential and stimulate investment, the green bond market needs to deepen, overcoming a number of significant challenges.

One such challenge relates to expanding the supply of green bonds that are used to finance investment mainly by small- and medium-sized enterprises that lack direct access to financial markets. Improving the attractiveness of green bonds also remains a key concern. To match supply and demand, there is a need to further develop international guidelines and standards, address the lack of historical data and reduce the costs of green bond standardisation, reporting and reviewing.

In this regard, the European Commission, together with the relevant authorities of other countries across the world, launched in October 2019 the International Platform on Sustainable Finance (IPSF), aimed to scale up the mobilisation of private capital towards environmentally sustainable investments. By deepening international cooperation and, where appropriate, coordination on approaches and initiatives for the capital markets (such as taxonomies, disclosures, standards and labels) that are fundamental for private investors to identify and seize environmentally sustainable investment opportunities globally, the main objective of the IPSF on the demand side is to make green bonds even more attractive to private investors, so that the market can expand.

4.3.3 The Eurosystem's action plan to further integrate climate change considerations into its monetary policy strategy

Recognising the major challenges to price stability stemming from climate change, the ECB took a landmark decision, as part of its monetary policy strategy review, to further incorporate climate change considerations into its monetary policy framework. With an ambitious climate-related action plan announced on 8 July 2021, the Eurosystem committed to fully take into account, within its mandate, the implications of climate change and the low-carbon transition for monetary policy and central banking.

The plan envisages a strengthening of macroeconomic analysis tools with regard to climate change and the development of statistical indicators for climate change risk analyses. The implementation of the plan will focus on the following main areas:

(a) Disclosures: the effective assessment and management of climate and environmental risks crucially depends on the availability of relevant metrics and data, which would improve risk management and transparency. In fact, the Eurosystem plans to

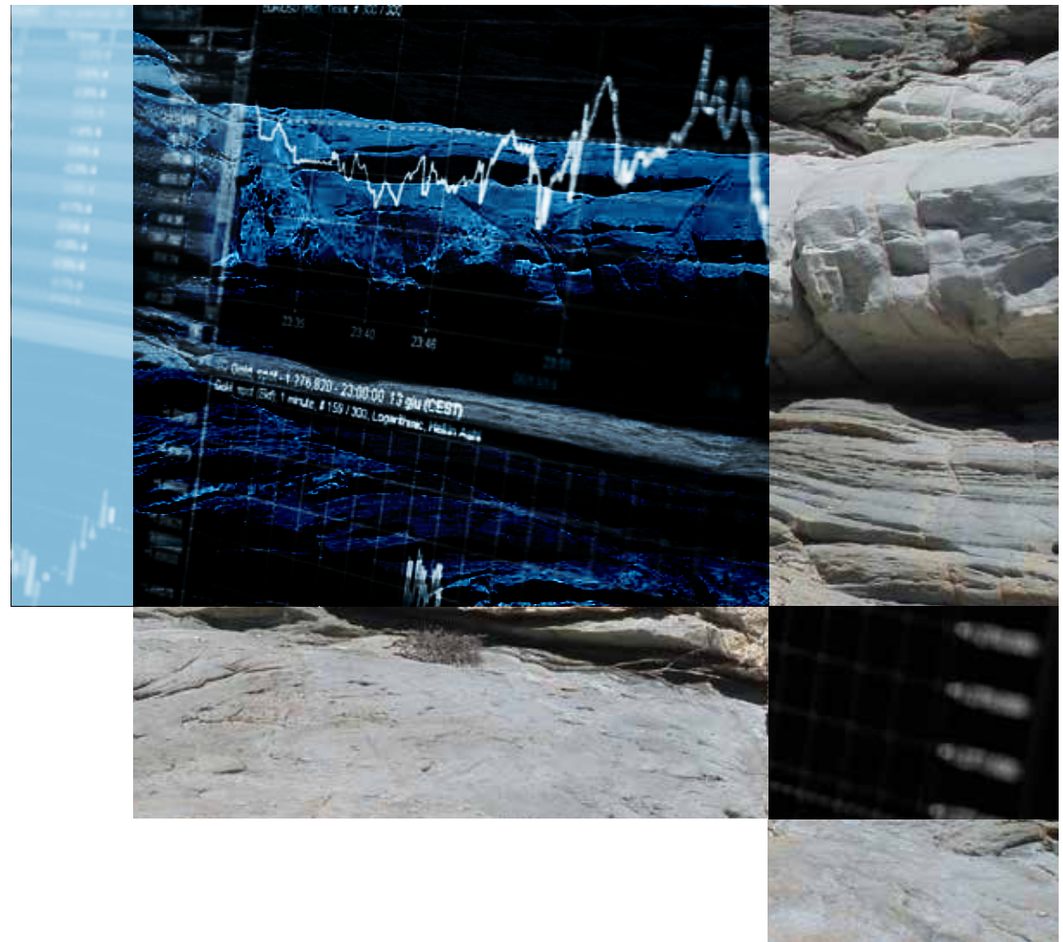
introduce disclosure requirements for private sector assets as a new eligibility criterion for collateral in credit operations and for asset purchases. The ECB will announce a detailed plan in 2022.

(b) Risk assessment: the ECB will launch climate stress tests of the Eurosystem balance sheet in 2022 to assess the Eurosystem's risk exposure to climate change. Furthermore, recognising the role of credit ratings in the operational framework of its monetary policy, the Eurosystem will assess whether the credit rating agencies adequately and transparently disclose how they incorporate climate change risks into their credit ratings for securities and issuers.

(c) Corporate sector asset purchases: the framework guiding the allocation of corporate bond purchases will be adjusted to incorporate climate change criteria. In addition, the Eurosystem will start disclosing climate-related information on the corporate sector purchase programme (CSPP) by the first quarter of 2023 (complementing the disclosures on the non-monetary policy portfolios; see Section 4.4 below).[77]

(d) Collateral framework for Eurosystem credit operations: climate change risks will be considered when reviewing the valuation and risk control frameworks for assets used as collateral in Eurosystem credit operations.

With this action plan, the Eurosystem clearly expresses its decision to address the impacts of climate change and the transition to a low-carbon economy in its new strategy. It has also been recognised that climate change is of strategic importance for the ECB's mandate (Lagarde, 11.7.2021).[78]



4.4. Central banks' own investment portfolios

In addition to their monetary policy portfolios, central banks also hold own investment portfolios, in the management of which they can also integrate climate change strategies. By doing so, central banks would make an important contribution to mitigating the impacts of climate change and would lead by example for other asset managers, while also reducing reputational risks associated with failure to integrate environmental considerations into own-portfolio management (see also NGFS 2019, April).

Although each national central bank of the Eurosystem manages its own portfolio according to its respective framework and rules, the Eurosystem announced in February 2021 that all its members agreed on a common stance for climate change-related sustainable and responsible investment (SRI) applicable for their euro-denominated non-monetary policy portfolios.[79] The aim is to ensure that climate risks are duly disclosed in central bank balance sheets, but also to specify common goals and strategies for stepping up the contribution of such portfolios to the low-carbon transition.

In managing its balance sheet, the Bank of Greece is committed to promote sustainability. Having endorsed the UNEP FI PRB and the relevant NGFS recommendations, it actively invests in green bonds and is expected to further green its own investment portfolio in coming years

This common stance prepares the ground for the measurement of GHG emissions and other SRI-related metrics and increases the awareness and understanding of climate risks. Over the next two years, the Eurosystem aims to start making annual climate-related disclosures for these types of portfolios, using the recommendations of the Task Force on Climate-related Financial Disclosures (TFCD) as the initial framework.

In managing its balance sheet, the Bank of Greece is committed to promote sustainability. Having endorsed the UNEP FI PRB and the relevant NGFS recommendations, it actively invests in green bonds and is expected to further green its own investment portfolio in coming years.

In 2021, the Bank of Greece invested in the euro-denominated green bond investment fund for central banks (EUR BISIP G2) introduced by the Bank for International Settlements (BIS). Also, in line with the Eurosystem common stance announced in February, it intends, within the next two years, to design and implement a comprehensive investment strategy for its non-monetary policy portfolios, with a view, among other things, to making them greener.

Furthermore, the Bank systematically monitors international developments and practices in this area. It actively contributes to the work of the NGFS, which has issued recommendations for the management of central banks' portfolios, and participates in BIS working groups dealing with the development of green investment products and methods to improve the assessment and measurement of the environmental footprint of investments.

The European Commission has developed a uniform taxonomy to help market participants identify sustainable activities, businesses and assets, based on a common classification system

4.5. EU Taxonomy of Sustainable Activities ("green list")

In order to effectively respond to the challenges of climate change, central banks, supervisors and the financial system need to speak a common "language" and communicate in common terms. This implies a growing need for agreed definitions and classification of activities, for data on banks' exposure to climate risks, as well as for common tools and methods.

Therefore, the European Commission has developed a uniform EU-wide taxonomy to help market participants identify sustainable activities, businesses and assets, based on a common classification system. On 18 December 2019, the European Parliament and the Council reached political agreement on the creation of the world's first ever green list, to be implemented in the next few years.[80]

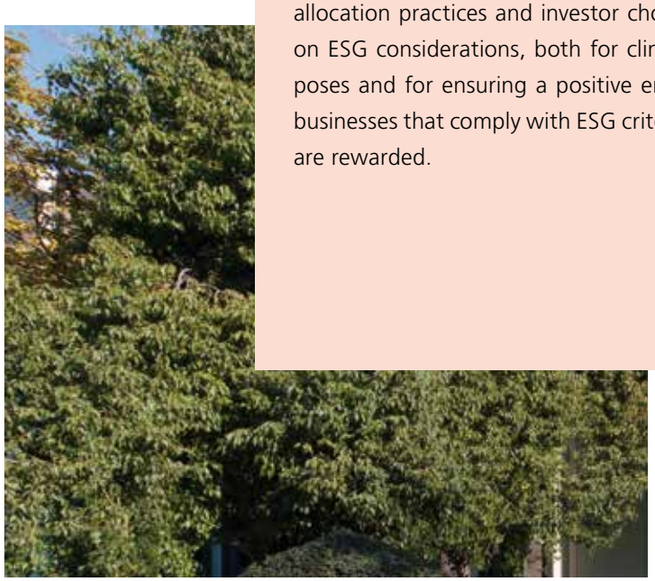
The relevant Taxonomy Regulation, which was published in the Official Journal of the EU on 22 June 2020 and entered into force on 12 July, sets out the criteria that an economic activity has to meet in order to qualify as environmentally sustainable. It establishes six environmental objectives: climate change mitigation; climate change adaptation; sustainable use and protection of water and marine resources; transition to a circular economy; pollution prevention and control; and protection and restoration of biodiversity and ecosystems.[81]

4.6. Other climate change-related actions of the Bank of Greece

4.6.1. Contribution to sustainable development

As an institution serving the public interest, the Bank of Greece applies ESG (environmental, social and governance) criteria in its operations and processes, deeming them essential in the context of its commitment to create value for society. Given their function as an important climate risk mitigation tool, such criteria are widely used to assess the contribution of an organisation or firm to addressing the common challenge of climate change.

ESG criteria are also important for investment decisions. Asset allocation practices and investor choices are increasingly based on ESG considerations, both for climate risk management purposes and for ensuring a positive environmental impact. Thus, businesses that comply with ESG criteria and follow SRI practices are rewarded.



4.6.2. Education and information

In addition to its role in the economic life of the country, the Bank of Greece is also committed to provide information to citizens about economic, cultural, technological and environmental issues by organising conferences, workshops, exhibitions, educational programmes and other events, as well as through its publications – prepared under the responsibility of the Centre for Culture, Research and Documentation or the Economic Analysis and Research Department.

As far as climate change is concerned, the Bank of Greece, is in close cooperation with European and international organisations, works to raise public awareness and understanding of the impacts of climate change on the economy and the financial system, as well as of policies to address it (climate literacy).

To promote climate literacy, benefiting from CCISC research and expertise, the Bank has held numerous conferences and other educational events and collaborates with other institutions in designing and implementing educational programmes (particularly targeting young audiences and students).

This is precisely the concept of the new temporary exhibition at the Bank's Museum entitled "Economy and climate: Handle with care". Its aim is to raise awareness and engage the public —especially the young generation— in the global collective effort to tackle the climate emergency.

4.6.3. Environmental protection: facilities and operational framework

As environmental protection is a key pillar of its social responsibility, the Bank has integrated environmental criteria into its daily operations with a view to reducing its environmental footprint. In particular, it complies with the relevant European and national legislation and takes action in the areas of resource efficiency, waste management, environmentally friendly procurement, energy saving in its buildings and overall environmental management across its operations.

As part of its constant effort to more effectively address the environmental impact of its activities, with measurable results and taking into account climate change developments and data, the Bank revised the composition and scope of the **Environmental Policy Committee** in January 2021 and mandated it to review and report on the various relevant issues and recommended further actions to reduce the Bank's carbon footprint.

Under its **new Environmental Policy** adopted in May 2021, the Bank aligns all its practices and functions with the principle of environmental protection and, through the development of a consistent **Environmental Management System,** takes action to constantly evaluate and optimise its environmental performance, ensure full compliance with the form and substance of applicable EU and Greek legislation, maximise its contribution to addressing environmental issues at the national level and provide information and raise awareness among its staff and partners and the society at large. In May 2021, the Bank's environmental action programme was named **BoGReen**.

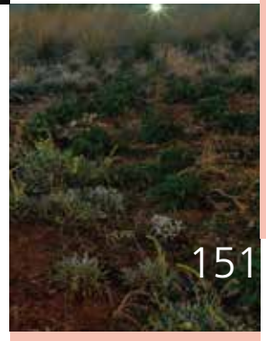
The Bank also takes measures to ensure efficient energy management across all its premises and facilities. Being well aware of the long-term individual and collective benefits of investing in climate change mitigation, it works towards greening its buildings, thereby reducing its overall environmental footprint.

The Bank aligns all its practices and functions with the principle of environmental protection and has developed a consistent Environmental Management System

Thus, the new buildings acquired by the Bank since 2000 combine high architectural and quality standards with bioclimatic design. In particular, the design of the Thessaloniki Cash Processing and Distribution Centre, constructed in 2009, exploits local climatic features and ensures seamless integration into the natural environment. In line with the concept of blending natural and built elements, an expansive garden of Greek flora was developed in the grounds, along with a green roof.

For most of the Bank's older buildings, energy upgrading is more challenging, given the constraints implied by the need to preserve their landmark character and distinct architecture and often also by their designation as historic monuments. The most prominent of the latter is the Head Office in the centre of Athens, an 80-year-old building covering an entire block.

At that building, the Bank designs and implements retrofitting projects, including passive and active energy efficiency measures and using modern building materials with the least possible impact on the environment.



Building envelopes are heat- and cold-proofed by replacing old windows with new, energy-efficient ones, as well as by adding thermal insulation, mainly to roofs, in order to reduce heating and cooling requirements.

At the building of the Information Systems Department in Halandri (Attica), the façades have been redesigned to conform with high energy efficiency, bioclimatic and aesthetic standards and to optimise the energy performance of the entire complex. The replacement of exterior glazing with new glass panels and adjustable shading systems will significantly improve thermal comfort in interior spaces and save energy for cooling/heating.

Since as early as 2008, the Bank has taken a large number of measures to reduce the environmental footprint of the Banknote Printing Works Department (IETA/the National Mint), which, as an accredited Eurosystem manufacturer, implements an integrated Environmental Management System that complies with ISO 14001:2015, certified by the national authority. It fully adheres to the relevant legislative requirements and to the industry's best practices in terms of energy and resource saving, environmentally friendly procurement, minimisation of noise and gas emissions, and waste reduction and efficient management.

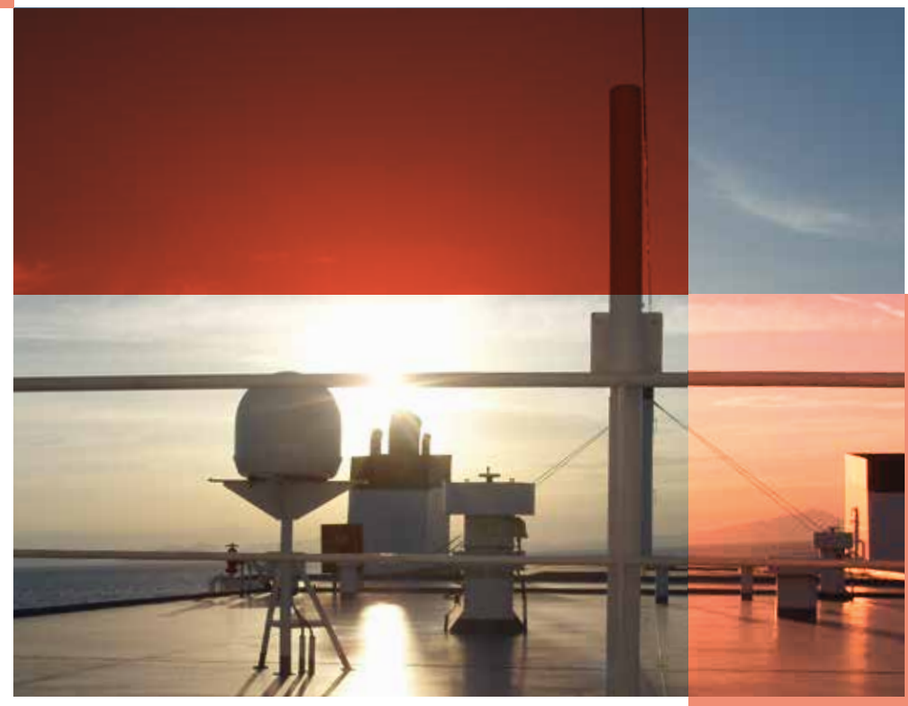
As part of its Environmental Management System, the Banknote Printing Works Department applies waste separation, recycling and reuse. The waste materials are forwarded to national collection and recycling systems or licensed commercial recyclers

or, in the case of industrial waste requiring special treatment, to authorised waste disposal facilities. Damaged and worn banknotes are forwarded to energy recovery facilities. The ultimate objective is to fully eliminate the trash dumped in landfills.

The Banknote Printing Works Department also participates in committees, workshops and research programmes of the ECB and the Eurosystem (Life Cycle Assessment, Product Environmental Footprint, etc.) that study the environmental impact of the production and circulation of the euro throughout its life cycle, from the production of raw material to the final destruction of the worn product. Moreover, according to Eurosystem practice, banknotes are printed on sustainably sourced (from organic or transitional crops) cotton-fibre paper; fair-trade cotton is also used in a very high proportion, expected to reach 100% by 2023.

As required by Law 4342/2015 and Ministerial Decision 175275/30.5.2018, in 2019 the Bank submitted an energy audit report to the Ministry of the Environment and Energy for all its facilities, also outlining follow-up action (a feasibility study on the installation of photovoltaic systems and the phasing-in of other RES). The measures recommended are in line with technological possibilities and regulatory requirements, including those under the national Regulation on Energy Efficiency in Buildings. They reflect a comprehensive approach towards improving energy performance and reduce operating costs across all facilities.

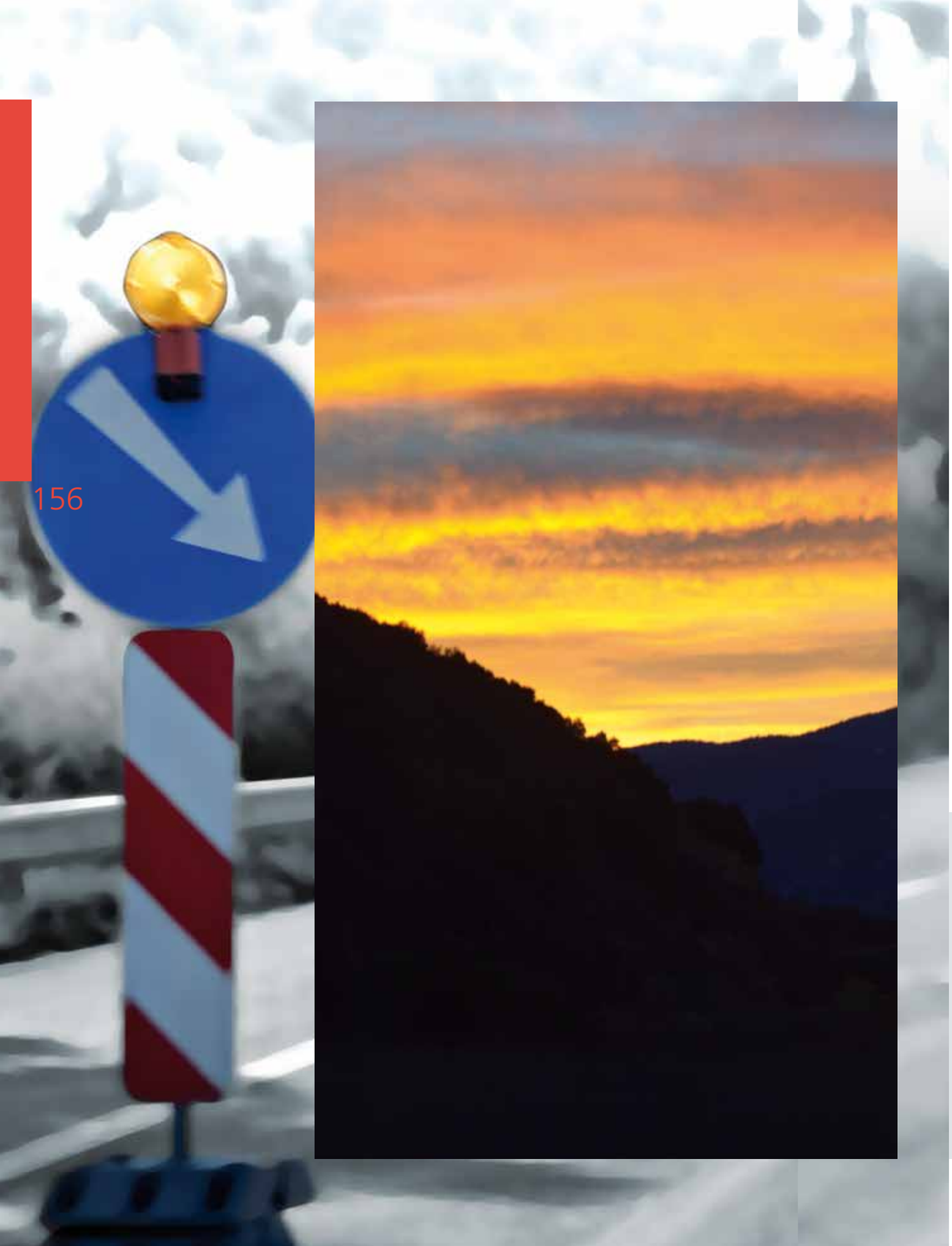
More generally, in the context of its broader institutional role, the Bank strives to promote compliance with applicable legislation and to develop a strong environmental culture and awareness among its staff. The aim is to maximize everyone's contribution to the national effort for a sustainable future and to keep pace with European and global developments in this area.



With specific regard to the Banks' effort to reduce its own environmental footprint and ensure optimal management of its resources, the actions taken include:

- limiting the use of materials and equipment to the extent strictly necessary and minimising waste by adopting efficient management systems (recycling, scrapping, etc.);
- gradually replacing all energy-inefficient windows and glazing;
- retrofitting various offices and premises with state-of-the-art systems and infrastructure (e.g. sensor-based automated shading);
- using environment-friendly materials and alternative energy sources;
- gradually shifting heating systems away from oil boilers towards natural gas;
- modernising electrical and mechanical equipment and systems to make them less energy-consuming and less polluting;
- rationalising water consumption and using water from wells (at the Head Office) or from drilling;

- exploiting natural lighting and substituting energy-saving electric bulbs for incandescent bulbs;
- installing automation (e.g. photocells, detectors, etc.) in the various systems used;
- gradually switching to hybrid cars for its corporate fleet, as well as reducing the carbon footprint of business travel;
- gradually reducing the number of hard copies of its regular publications and avoiding unnecessary use of paper, printing inks, etc.; and
- increasingly shifting to sustainable procurement supplies.



5. Afterword
Financing the future

The impacts of climate change are so far-reaching that no sector of the economy and society remains unaffected. The threatened costs to the global economy and financial system are heavy (under any scenario of global warming and policy response), cutting across all areas of responsibility of central banks, which are faced with the following crucial question:

The threatened costs to the global economy and financial system are heavy (under any scenario of global warming and policy response), cutting across all areas of responsibility of central banks

The fight against climate change will not likely be won quickly, easily or without cost, implying that central banks will need to adapt their monetary policy, reserve management and overall operation accordingly.

To what extent and how could central banks contribute to mitigating climate change risks?

According to one view, central banks should mainly focus on studying climate change and on ensuring the resilience of their balance sheets and of the banking system to climate risks; this approach is of vital importance for the fulfilment of their price stability mandate. According to a more proactive view, they could also facilitate, strengthen or even accelerate the transition to a low-carbon economy by properly formulating their monetary policy and by supporting the relevant fiscal and other policies (such as the climate policies of the EU and national governments) within their mandate.

Some central bankers have argued that climate change is a negative externality and that central banks can help to raise awareness and a better understanding of the risks related to sustainability factors and the channels through which they are transmitted to the financial system (Visco 2019).[82]

For others, climate change is the most defining structural development of our time and should therefore be taken into account in the formulation and implementation of monetary policy, with the aim to facilitate or accelerate transition to a greener economy, without prejudice to the primary objective of price stability.

In this context, some advocate an even more active policy on the part of central banks, always within the remit of their mandate: "The ECB, acting within its mandate, can —and should— actively support the transition to a low-carbon economy in two main ways: first, by helping to define the rules of the game and, second, by acting accordingly, without prejudice to price stability" (Coeuré 2018).[83]

Finally, some argue that climate risks have such high impact and such high probability that a longer-term monetary policy focus is needed. Central bankers must break this "curse of horizons" and take decisive steps to address fossil-fuel-related risks. Combatting climate change while maintaining global financial stability requires nothing less (Arezki, World Economic Forum 2020).[84]

The debate on these issues continues, as the answer is not at all easy. However, one thing is certain: the fight against climate change will not likely be won quickly, easily or without cost, implying that central banks will need to adapt their monetary policy, reserve management and overall operation accordingly.

The Eurosystem stresses on every occasion (and in particular in the context of the review of its monetary policy strategy) that it considers climate change a crucial issue for every central bank.

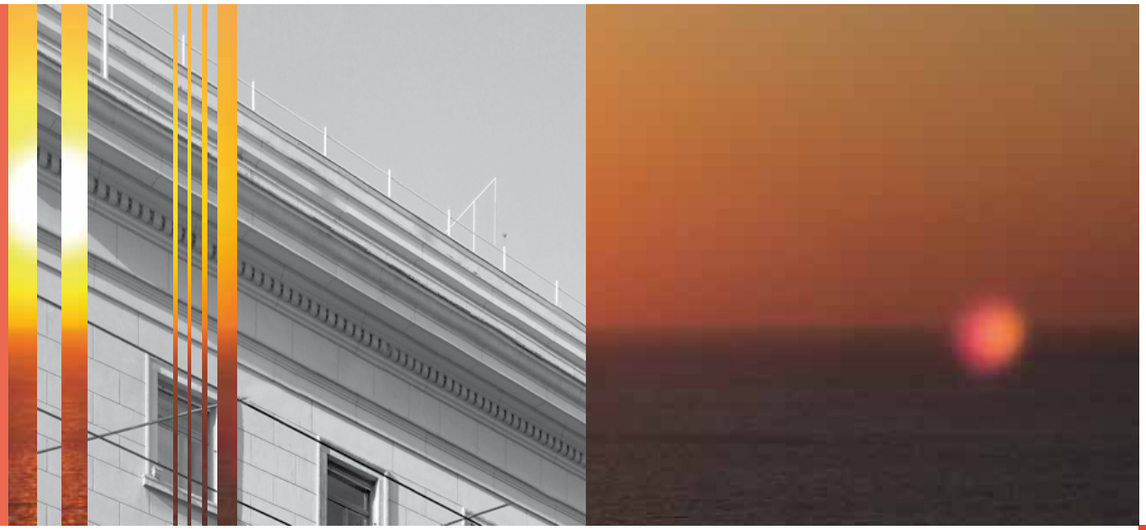
The Eurosystem considers that climate change is a crucial issue for every central bank and should be addressed as such.

"...there are now signs that policy action to fight climate change is accelerating, especially in Europe. We are seeing a new political willingness among regulators and fiscal authorities to speed up the transition to a carbon neutral economy, on the back of substantial technological advances in the private sector. [...] Climate change is one of the greatest challenges faced by mankind this century, and there is now broad agreement that we should act. But that agreement needs to be translated more urgently into concrete measures. The ECB will contribute to this effort within its mandate, in tandem with those responsible for climate policy" (Lagarde 25.1.2021).

For this reason, the Eurosystem decided, in the context of its revised monetary policy strategy, on an action plan on climate change, with a detailed roadmap describing climate change-related actions in nine key areas (see press release "ECB presents an action plan to include climate change considerations in its monetary policy strategy").[85]

In exactly the same vein, Bank of Greece Governor Yannis Stournaras stated in his article in *Handelsblatt* (29.9.2021):

"At the Governing Council of the European Central Bank (ECB), we agreed this summer on a comprehensive action plan, with an ambitious roadmap to further incorporate climate change considerations into our policy framework and to more systematically reflect environmental sustainability considerations in our monetary policy. The roadmap foresees, among others, expanding analytical capacity in macroeconomic modelling, statistics and monetary policy with regard to climate change and assessing the impact, not only to banks and companies across the euro area, but also to our own balance sheet from exposure to climate risks [...] Another milestone in this roadmap includes the further incorporation of climate change considerations in our monetary policy operations, with a view to promoting better climate disclosures and making our asset purchases, and therefore our balance sheet, greener. [...] Within the remit of its mandate, the Eurosystem, alongside central banks around the world, explore their range of instruments, adjust their monetary policy framework and act as a catalyst in the financial system, to accelerate the transition to an environment-friendly, carbon-neutral economy and enhance society's resilience to climate change risks".



As noted by President Christine Lagarde, "The strategy review has provided us with a framework to evaluate how our policy implementation could evolve […] The challenges the world already faces due to the climate change will only increase over time. Therefore, within our mandate, we will continue to analyse climate-related risks, to provide advice to stakeholders, and, importantly, to act" (11.7.2021).[86]

Notes

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3. United Nations Economic Commission for Europe (UNECE), International Conference on Raising Awareness on Adaptation on Transport Infrastructure to Climate Change Impacts, Athens 18-19 November 2019.
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5. https://www.who.int/news-room/fact-sheets/detail/children-new-threats-to-health
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14. von der Leyen, U. (2019). Political guidelines for the new Commission, see https://ec.europa.eu/unitedkingdom/news/ursula-von-der-leyen-team-will-focus-climate-change_en
15. Namely, the Just Transition Fund (JTF). See: https://www.europarl.europa.eu/ factsheets/en/sheet/214/just-transition-fund-jtf- and section 2.9 below.
16. https://www.consilium.europa.eu/en/meetings/european-council/2020/12/10-11/
17. General term implying taxation of all fossil fuels.
18. Global Commission on Adaptation, *Adapt Now: A Global Call for Leadership on Climate Resilience*, Flagship Report, September 2019. https://gca.org/about-us/the-global-commission-on-adaptation/
19. See Batten, S. (2018), "Climate change and the macro-economy: a critical review", Staff Working Paper No. 706, Bank of England.
20. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0021&from=EL
21. Since 2015, the 10 key policy priorities of the European Commission included the creation of a digital single market with the aim to remove all regulatory barriers and ensure a level playing field, reshape the industry, create new goods, services and processes, boost employment and enhance cybersecurity.
22. https://gesi.org/posts/ambitious-movement-unites-the-giants-of-tech-toaccelerate-sustainable-change-for-planet-and-society
23. Knickrehm, M., B. Berthon and P. Daugherty (2016), "Digital disruption: The growth multiplier", Oxford Economics and Accenture Strategy.
24. https://www.bankofgreece.gr/ekdoseis-ereyna/ekdoseis/ekthesh-dioikhth (in Greek).
25. https://gesi.org/posts/ambitious-movement-unites-the-giants-of-tech-to-accelerate-sustainable-change-for-planet-and-society
26. A smart grid uses two-way flow of electricity and data to create an automated, distributed and advanced grid/power distribution circuit. Using instant information technologies, it provides energy in more efficient ways and at the same time responds to a broad range of conditions and events.
27. https://www.bankofgreece.gr/enimerosi/grafeio-typoy/anazhthsh-enhmerwsewn/enhmerwseis?announcement= 7887a851-D864-4D80-87e3-48fdb0d52d4b (in Greek).
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36. See Katerina Sakellaropoulou, "Speech at *The Economist's* 4th Sustainability Summit for South-East Europe and the Mediterranean", 1.10.2020, http://www.presidency.gr/omilia-sto-4o-synedrio-toy-the-economist-gia-ti-viosimi-anaptyxi-stin-notioanatoliki-eyropi-kai-tin-mesogeio/ (in Greek).
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38. See M. Carney, P. Honohan, C. Atkinson & O. Jeanne, "Rebuilding the Global Economy: Role of international finance and central banks", 16.12.2020, https://www.piie.com/events/rebuilding-global-economy-role-international-finance-and-central-banks
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41. https://www.climateambitionsummit2020.org/
42. See CAS Press Release 25.1.2021: https://www.cas2021.com/binaries/cassummit-en/documents/media-articles/2021/01/25/world-leaders-embrace-climate-adaptation-action-at-climate-adaptation-summit-2021/PR_WorldLeadersCAS2021.pdf
43. Data from the NCCAS and the CCISC study (2011).
44. See http://news.mit.edu/2019/carbon-dioxide-emissions-free-cement-0916
45. See CCISC (2011) and Batten (2018, note 19).
46. The income to be deducted or given to consumers (households) based on the level of commodity prices under the baseline scenario. A negative equivalent change signals a decrease in household income if the commodity prices of the baseline scenario are applied.
47. https://www.bankofgreece.gr/en/the-bank/social-responsibility/sustainability-and-climate-change/ccisc/research
48. Exposure and vulnerability to a specific risk.
49. https:/www.adaptivegreece.gr/en-us/
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51. NGFS (2019, April), https://www.ngfs.net/sites/default/files/medias/documents/synthese_ngfs-2019_-_17042019_ 0.pdf
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65. See *Overview of sustainable finance*, https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/overview-sustainable-finance_en

66. According to the Financial Stability Board (FSB) Task Force on Climate-Related Financial Disclosures (TCFD) that reports to the G20, as well as the Bank of England (see *Financial Times*, 18.12.2019).

67. de Guindos, L. (2019). Speech "Implications of the transition to a low-carbon economy for the euro area financial system", Brussels, https://www.ecb.europa.eu/press/key/date/2019/html/ecb.sp191121_1~af63c4de7d.en.html

68. https://www.ecb.europa.eu/press/pr/date/2021/html/ecb.pr210922~59ade4710b.en.html

69. https://www.unepfi.org/banking/bankingprinciples/

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72. Economides, G., & Xepapadeas, A. (2018). "Monetary policy under climate change", Bank of Greece *Working Paper* No. 247. https://www.bankofgreece.gr/Publications/Paper2018247.pdf

73. The asset purchase programme (APP) comprises four active securities purchase programmes: the third covered bond purchase programme (CBPP3), the asset-backed securities purchase programme (ABSPP), the public sector purchase programme (PSPP) and the corporate sector purchase programme (CSPP).

74. https://www.ecb.europa.eu/pub/annual/html/ar2019~c199d3633e.en.html

75. https://www.climatebonds.net/

76. Sartzetakis, E.S. (2019), "Green Bonds as an instrument to finance low carbon transition", Bank of Greece *Working Paper* No. 258. https://www.bankofgreece.gr/ Publications/Paper2019258.pdf

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79. The equity portfolio is invested in assets with the aim to achieve returns, subject to risk limits. This ensures the financial independence of national central banks, as it includes a reserve to cover potential losses. To a large extent, it consists of investment in sovereign debt and covered bonds. The assets held in the equity portfolio are for purposes other than monetary policy.

80. See European Commission, press release, 18.12.2019, and International Capital Market Union, 19.12.2019.

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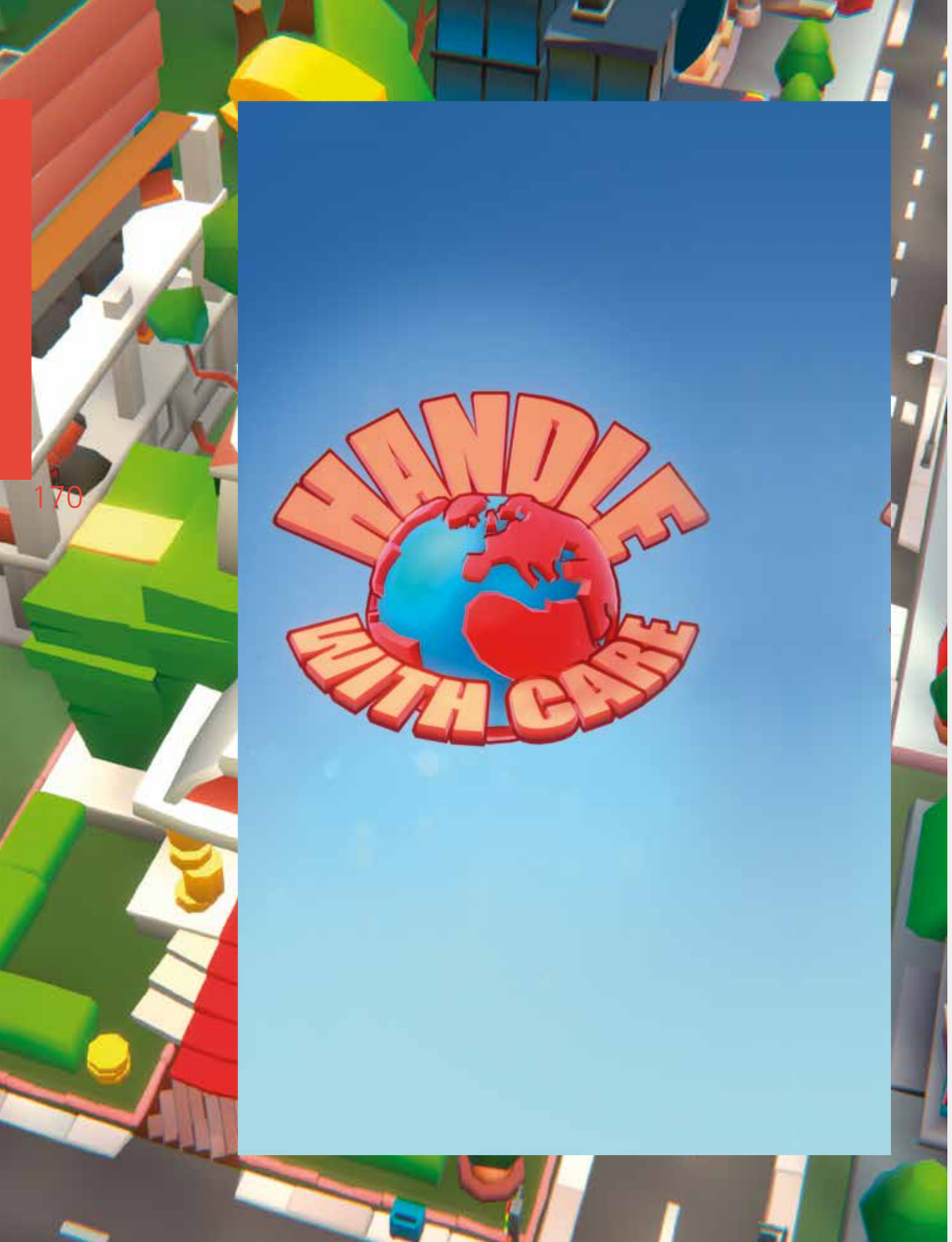
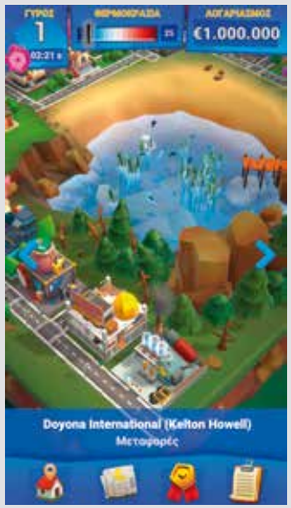


The “Handle with care” game

In a dedicated area of the exhibition, visitors have the opportunity to play a 3D investment simulation game on their mobile devices to learn how the investment market works and understand its importance for the economy and its impact on the climate.

It is a business strategy game that can be played individually or in groups, by people of any age. Players can choose from a list of 25 different roles as investors or producers. Investors each choose a business to invest in and then have six rounds to earn money through their investment decisions, which also have implications for average global temperature. If their choice is exclusively based on profit criteria, they may earn more money, but this may imply additional global warming and damage to the environment in which all players interact. Thus, they realise that the choices and actions of one player affect all of them. Every time a round is completed, the overall impact on global temperature and the climate is reflected in a score. The team to earn the most money without adversely affecting the temperature is the winner.



The game features enjoyable 3D graphics and statistics, enabling each team to see its score in every round and its final score once it has completed all six rounds. The experience can differ each time one plays the game, as there are three alternative settings that represent different scenarios: a river, a lake and a frozen seaside area. Also, a player can choose a different role each time, e.g. that of a bank, a pension fund, a car manufacturer, etc.

The game "Handle with care" was developed by Tamasenco and can be downloaded free of charge from AppStore or Google Play to be played outside the Museum.

As part of the exhibition, the Greek version of the comic book
Die grosse Transformation: Klima – Kriegen wir die Kurve?
is available free of charge from the Museum of the Bank of Greece; it is also available in digital form on the Bank's website.
An English version of the comic book is also available free of charge at
https://www.wbgu.de/en/publications/publication/the-great-transformation

Ο ΜΕΓΑΛΟΣ ΜΕΤΑΣΧΗΜΑΤΙΣΜΟΣ

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