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Introduction

Climate change in the Mediterranean

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The Intergovernmental Panel on Climate Change (IPCC), whose work played a major role in the 'historic' agreement reached at the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21) in Paris in December 2015, has shown that the Mediterranean Basin is one of the most vulnerable areas of the planet to climate change. COP 22 will take place in Marrakesh from 7 to 18 November but ahead of this event, Morocco hosted MedCOP Climate, the Mediterranean climate forum for all governmental and non-State bodies on 18 and 19 July in Tangier in order to build on the work begun during MedCOP 21 in Marseille the previous year. In his introductory speech at MedCOP 22, His Majesty Mohammed VI, King of Morocco, stressed the Mediterranean's duty to set an example by creating new consumption and production patterns and developing innovative approaches to combating climate change.

In response to a request from the Moroccan authorities, particularly Environment Minister Mrs Hakima El Haité, the 28 ALLENVI members have published a remarkable summary work for COP 22. This work aims to provide an overview of high-level scientific research on climate change, the consequences of this climate imbalance and mitigation and adaptation solutions specific to the

Mediterranean. It demonstrates the remarkable work carried out by scientists, researchers and academics on both shores of the Mediterranean to understand the mechanisms of climate change both today and in the long term, and the impact of climate imbalance on the environment, the economy, health and society. It also suggests and recommends responses based on ‘scientific evidence’, including adaptation, resilience, conservation of resources and risk prevention. This book is the work of a broad scientific community which has been working together for a number of years to capture the complexity of the Mediterranean situation and create the conditions for better mutual knowledge of the interlinking scientific issues that will be defined step-by-step with a view to breaking down the barriers between disciplines.

This work does not claim to be exhaustive, despite the diversity and quality of the contributions it contains. Certain key themes, such as the role of reducing greenhouse gas emissions and energy innovations in mitigation processes, are mentioned only briefly. Furthermore, certain chapters highlight the limitations of the results that have been obtained (for example the limited observations and climate simulations in the study on extreme hydrological events and the lack of long-term data on the impact of climate change on human health), revealing subjects for up-and-coming or future research.

Readers will be able to form their own idea of the significance of the various contributions, but we believe that the scientific community is issuing a clear three-part message to public decision-makers, European and international institutions, economic and civil society organisations and, more broadly speaking, public opinion and all citizens.

The first message is that science has established beyond all doubt that climate change is a fact and that Mediterranean societies and ecosystems are some of the most susceptible to these developments.

The Mediterranean is a ‘miniature’ laboratory due to its geological past, its semi-arid environment with a climate intrinsically different from that of temperate zones as a result of its significant inter-seasonal variations and its role in the turbulent history of human societies. Although it represents only 1.5% of the earth’s surface, the Mediterranean is a ‘test area’ that is home to, and indeed tends to exacerbate, almost all the potentially catastrophic issues facing the entire planet; these include natural risks, global warming, changes in the water cycle, changes to soil and vegetation functions, modifications to biological diversity and biodiversity damage, the unequal distribution of resources and the scaling back of political, economic and social relations between north and south, leading to conflict, large-scale migration, land occupation and rapid urbanisation and coastal development. In addition, it is important to remember the central or peripheral effect the Mediterranean area has on its neighbours, for example the role of Mediterranean climate extremes on the various components of the Earth system and the role of hydrological exchanges with the Black Sea and the Atlantic, as water from the Mediterranean flows through the Strait of Gibraltar and affects the European climate.

The Mediterranean is now a major area of investigation for researchers in every scientific field. The modalities and importance of human activity and its ability to reveal completely new perspectives are some of the key themes currently being studied by the scientific community. New approaches to research, which are reviewed in this work, are essential if we are to understand the way in which they operate and develop, whether in terms of systematic approaches to modelling, integration or investigations.

In the current context where, in the absence of radical countermeasures, a global temperature increase of 1.4 to 5.8°C is expected (3 to 7°C for the Mediterranean region by the end of the 21st century), it was the deep waters of the Mediterranean that first registered the greenhouse gas effect and where changes to thermohaline circulation were observed. Scenarios predict that these changes will continue and that there will be a significant reduction in the convection phenomena that lead to the oxygenation of the Basin; this will inevitably affect biogeochemical cycles as well as the ecosystem and its resources. In this region in particular, global changes seem to affect the frequency of extreme events such as cyclogenesis, hydrometeorological or wind phenomena, droughts and soil degradation.

Research must lead to advances in knowledge, so that we can i) improve our understanding of climate change and its features and mechanisms. This will involve studying past climate cycles and the ways in which societies have responded to them, the latest results reported in this book relating to the water cycle, the origin and frequency of extreme events, groundwater (continental, coastal and deepwater) dynamics and seasonal and long-term variability; ii) quantify flows between compartments and their impact on the system, so we can study air quality and active pollutants and understand their impact on human health; iii) characterise the dispersal and intensity of the main practices affecting marine and continental ecosystems. This involves assessing impacts and vulnerabilities in relation to marine resources and ecosystems, with particular focus on the coastal area. The effects on continental ecosystems are more specifically related to terrestrial biodiversity, particularly forests; iv) study the assessment of the Basin, including the direct impact of global warming on health; v) finally, evaluate and manage risks through adaptation, resilience, conservation of resources and prevention.

Although observations and models based on physical, chemical and biological approaches allow researchers to understand and quantify the processes mentioned above, one of the key areas for reflection must focus on the way in which these processes are affected by human activity and the resultant consequences for the evolution of the changing ecosystems. By changing the climate and river systems, changing the chemistry of the atmosphere, lands and water and tapping into natural resources, we are in fact changing the functioning and value of the ecosystem itself.

Only with a systematic approach can we document the current 'crisis' caused by human activity and particularly noticeable in the Mediterranean, and answer

questions on the risks related to usages, practices and social views. These risks are linked to i) the geodynamic (seismic, volcanic and gravitational) context; ii) climate (droughts, fires, coastal erosion, changes to marine dynamics and biogeochemical cycles); iii) industrialisation, urbanisation and transport (pollution of air, water, soil and living resources); iv) usages and practices relating to the quantity and quality of mineral and living resources, biodiversity (land, aquatic and marine), its functions and its services.

This approach to the functioning and functions of the coupled system requires infrastructures and methods for observing and analysing environments and peoples and local strategies adapted to the long term and the short term as well as to the significant seasonal variations found in the Mediterranean. Models and scenarios exist, but need to be improved and regionalised, and other integrated digital tools must be developed. This book is a contribution, albeit a modest one, to the work bravely launched by our Moroccan colleagues so that COP 22 could be an opportunity to support research and the strengthening of the technological and scientific capacities at the heart of climate negotiations. The scientific community is hoping that one of the consequences of this work could be the creation of an inter-country, inter-ministerial and inter-regional authority operational working group to begin the important, in terms of both knowledge and action, work of creating a coordinated observation and surveillance system for Mediterranean anthropo-ecosystems.

The contributions included in this book directly and candidly stress the many remaining uncertainties regarding the real dynamics of the impact of climate change, both in general and across the different spatial scales of the Mediterranean basin.

The **second message** of this work, however, is that these uncertainties must not be used as an excuse for inaction. On the contrary, they must encourage us to better understand the complex causal chains that link climate and the other environmental and anthropic parameters, and to take immediate action to minimise those effects of global change that are threatening the environment and human health and well-being. Some of the contributions show that research provides direct scientific bases for improved management of environments, resources and heritage, for the preservation and strengthening of biodiversity and ecosystem services and for spreading concepts and relevant knowledge throughout society so they reach both decision-makers and the parties involved. In so doing, science is not content to merely report on the risks; it also proposes innovative solutions that could allow us to overcome the barriers currently restricting climate change mitigation and make them easier to adapt, by considering the specific environmental and societal context of a region such as the Mediterranean.

The **third message** is that science is best placed to link the fight against climate change, sustainable development goals and development funding, in accordance with the desire expressed by Christiana Figueres, the previous Executive Secretary of the United Nations Framework *Convention on Climate Change*

(UNFCCC), who stated that *'the solutions to climate change offer a portfolio of no-regret policies and actions that are essential for achieving sustainable development'*.

The redefinition of the international agenda in 2015 imposed on us a duty to do so. Prior to COP 21 in December 2015, the 3rd international conference on financing development took place in Addis Ababa in July, followed by the United Nations Summit in New York in September which saw the adoption of the 17 new Sustainable Development Goals (SDG); these are universal goals that, according to the summary report by Secretary General Ban Ki Moon, will create a road to *'dignity for all by 2030'*, by *'ending poverty, transforming all lives and protecting the planet'*. As is the case with all international agreements, both the SDGs and the content of the Paris Agreement on climate change, whose initial operational measures are due to be consolidated at COP 22, represented progress we can be proud of, despite the fact that they were inevitably the result of a compromise between different and even contradictory interests and between governments with a large number of downright divergent geostrategic visions and constraints.

The wording of the SDGs reveals inconsistencies that could, if care is not taken, be exacerbated by their implementation; a short-term vision of the requirements for combating poverty or achieving food safety (SDG1 and 2) may, for example, result in technological and economic choices that in the medium term jeopardise the achievement of SDGs 15, 14 and 13 on the preservation of life on land, life below water and combating the effects of global warming respectively. Likewise, meeting the energy needs of developing countries on the southern shore of the Mediterranean and on the African continent in the short term may come into conflict with the need to reduce the carbon intensity of economies in order to combat global warming. And there are many similar examples. Scientific progress can reasonably be expected to produce solutions for reconciling sustainable development goals, creating innovative multi-party coalitions that will be able to impose these solutions in practice and providing enough of the global public goods that the planet needs and of which climate security is one of the best examples.

It has been shown that mankind is finding it very difficult to obtain these public resources to meet the global challenges that, by their very essence, transcend national borders, because it comes up against what political science researchers call the *'Westphalian paradigm'*, from the name of the 1648 European treaty that for the first time created an international order based on the strict respecting of State sovereignty. Thousands of years of history and the current situation in the Mediterranean have provided many examples of this paradigm. Let's hope that work to combat global warming, in which Morocco and France consider themselves to play a leading role, will help to make the Mediterranean an example of how to move beyond this paradigm and demonstrate solidarity between stakeholders, governments and populations facing joint threats and helping to promote development for the good of all mankind.