Introduction

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There is rather wide consensus in the scientific community regarding the climatic consequences of doubling CO₂ concentrations, and the potential negative impacts of climate change on natural and human-made systems, as well as human communities. These impacts, aggravated by socio-economic driving forces, such as population growth, deserve careful investigation by social scientists, especially in regions which are already under development and population stresses, such as the Mediterranean, especially along its southern and eastern perimeters. It is expected that climate change will exacerbate many of the area's existing problems, including desertification, water scarcity and limits to food production. Changes in weather patterns and average temperatures are also likely to introduce new threats to human health and natural ecosystems. Such predictions, therefore, should provide a strong motivation for the scientific community to work on developing more accurate and integrated analyses of future scenarios for the area and its sub-regions, to increase our knowledge base and our ability to formulate strategies for adapting to new climatic conditions.

Thus observational records suggest marked changes in the climate of the Mediterranean region over recent years. Models developed by the most advanced institutes coincide in projecting temperature rise and decline in rainfall in the Mediterranean basin. Furthermore, there are some indications that the rainfall pattern could also see an increase in its intra- and inter-annual variability, with greater probability in the basin areas that flow into the Mediterranean. While it is impossible at the moment to be certain whether those changes represent significant trends or depend on short- and medium-term variability, it is also clear that significant proof of changes will be available only after remarkable impacts have started to occur. It is therefore necessary to be prepared for the future evolution of climate, to identify potential impacts and the most vulnerable situations, and to define adequate strategies for the adaptation to and mitigation of those impacts.

More specifically, a number of possible environmental and socio-economic impacts of climate change in the Mediterranean have frequently been mentioned in the literature: coastal flooding, erosion, sea water intrusion in aquifers, which could cause unacceptable hardship for particularly

vulnerable populations (e.g. those living on small island states), or threats to economic activity (e.g. tourism) in coastal zones; an increased probability of large-scale climate instabilities (e.g. a shutdown of the Gulf Stream), with very costly impacts on economies through floods and storms; an increase in the extent and severity of desertification, with possible consequent migration pressures due to changes in land use; increased frequency of water shortages and decline in water quality; food security threatened by a fall in production and world price rises; widespread risks to public health; and losses of valuable ecosystems and biodiversity, with potential threat to certain unique and valuable systems.

The present volume is one such attempt to address, in some greater depth, a number of key issues regarding socio-economic aspects of climate change impacts on various regions around the Mediterranean, their vulnerability to possible impacts, and the potential for adaptation. It brings together selected contributions from two recent international workshops which have focused on these very issues, and thus provides us with a close look at some of the scientific work carried out in these areas in recent years.

The first workshop, 'The Impacts of Climate Change on the Mediterranean Area: Regional Scenarios and Vulnerability Assessment', was held in Venice in December, 1999 and organised by FEEM (with the financial support of the European Commission, DG-Environment) and the Venetian Institute of Arts and Sciences. The objective of that meeting was twofold: (1) To assess the state of knowledge about regional climate scenarios and the potential impacts of climate change on the Mediterranean area, and (2) to identify effective strategies and measures in response to climate change.

The second workshop, 'Socio-economic Assessments of Climate Change in the Mediterranean: Impacts, Adaptation, and Mitigation Co-benefits', held in Milan in February 2001 and hosted by FEEM, was one of the activities of a European Commission Concerted Action project, titled RICAMARE (*Research In global ChAnge in the Mediterranean: A REgional network*), and funded by ENRICH, INCO-DC) and START. The overall objectives of RICAMARE were: (1) to define a medium-term regional research agenda on major global issues in the Mediterranean, in order to allow scientists to define research projects in line with major societal concerns, and policy-makers to set up the appropriate structures to lead such projects; (2) seeking to enlarge the circle of researchers who may lead such works, by encouraging networking efforts, spreading information and results, and organising courses in order to give young scientists the relevant means and knowledge to address these research domains in their professional plans. The Milan workshop aimed to (1) present ongoing or planned research projects on the impacts of global climate change on social and economic systems in the Mediterranean basin, in relation to such areas as water

resources, agriculture and forestry, desertification, biodiversity, extreme weather events, sea-level rise and coastal areas, human health, tourism, and others; and (2) to set a research agenda for and create a network of social scientists from the Mediterranean basin, whose scope was intended to be interdisciplinary, with a primary focus on social science and related research.

Selected papers from the two conferences, revised and updated following a refereeing process, have been included as chapters in this volume and grouped into four sections.

The two chapters in Part II, by Tol *et al.* and Klein, set the general stage by addressing the principal issues of this volume – the social and economic aspects of climate change impacts, vulnerability and adaptation – from a broad, global perspective.

In shaping policies to control climate change, decision-makers invariably focus on the aggregate, in addition to the sectoral, or resource-specific impacts of climate change. Emissions reduction is costly and abatement costs should therefore be balanced against the avoided costs of climate change. Tol and his co-authors particularly address the issue of aggregate costs of climate change, and their distribution over world regions or individual countries. A key challenge for social scientists in this endeavour is the need to reduce the complex pattern of local and individual impacts to a more tractable set of indicators that can effectively summarise and make comparable the impacts in different regions, sectors or systems in a meaningful way. The authors argue that physical metrics suffer from being inadequately linked to human welfare. Instead, if the aim is to integrate the impacts of climate change with standard national accounts, it is necessary to express the costs of climate change in the same metric, that is money. Money is a particularly well suited metric to measure market impacts – that is, impacts that are linked to market transactions and directly affect GDP. It is less successful, however, to assess non-market impacts, such as effects on ecosystems or human health, in money terms. Nonetheless, the chapter presents an overview of various economic studies which have attempted to assess aggregate future damage from current emissions of greenhouse gases.

Klein's chapter underlines the crucial role of adaptation capacity-building in helping societies face future climate change impacts. It asserts that adaptation is intricately linked with non-climatic developments and takes place in a dynamic societal context. The identification of optimal and appropriate adaptation strategies is therefore fraught with difficulties. The chapter explores these caveats and discusses their implications for policy and funding. It concludes that the quantitative assessment of future adaptation costs and benefits should play a less significant part in determining the optimality or appropriateness of adaptation options. Instead, we

should attempt to assess the economic value of an adaptation project to today's society and identify no-regret adaptation options, which would help to reduce vulnerability to both contemporary climate variability and anticipated climate change. Strengthening adaptive capacity and raising awareness should serve to create an enabling environment for adaptation.

Part III presents four chapters which focus on what is probably the most widely studied problem related to climate change in the Mediterranean: water resources. The first contribution by El-Fadel and Bou-Zeid deals in particular with the Middle East area. This chapter looks at the main water resources issues in several Middle Eastern countries and considers regional climate predictions by general circulation models for various scenarios. Adaptation measures are assessed with a focus on no-regret actions in the context of local socio-economic and environmental frameworks. Several potential socio-economic impacts are considered, such as a reduction of GDP, and population redistribution, as a consequence of altered water balances and resource stocks, which in turn may determine negative consequences like increased agricultural water demand, deriving from an expected average temperature rise of between 0.6 and 2.1°C.

Ana Iglesias *et al.* examine the possible adaptation strategies for agriculture under climate change in the Mediterranean. The food security issue is evaluated in face of the social impacts of increasing water scarcity in the Mediterranean. Sources of conflicts for water resources could come from concurrent increasing population and urbanisation, and expanding irrigation needs, in the case of Southern Mediterranean countries, presenting inadequate controls of water use, lack of political will, and cultural impediments. In-depth discussions about agriculture in various Mediterranean countries are presented, starting from the consideration that irrigation is the major consumer of water in the area, using more than two-thirds of the water withdrawn from the rivers, lakes and aquifers. Considerations about the risk management in agricultural production, as related to the ability to understand and respond to climate variability and change are derived in view of more effective decision-making processes for improving resource-use efficiencies that may lead to a reduction of current and future emergency actions.

Khawlie, in Chapter 5, discusses the impacts of climate change on water resources, focusing in particular on Lebanon and the Eastern Mediterranean. Contrary to current notions about water abundance in Lebanon, the author presents the current serious problems of water scarcity and water quality and their relations with social and economic origins; that is, management, low finance, non-integration and a lack of relevant awareness on water use. Once more the chapter presents the risks of further exacerbation of such problems expected as a consequence of climate change.

A relevant issue discussed by Khawlie is the availability of adequate data sets for interpreting correctly the trends of change: precipitation records, in fact, reflect a decreasing pattern over the last century. The need for adequate adaptation measures by both the public and private sectors is evidenced with different opportunities from short- to medium- to long-term phases.

Eva Iglesias *et al.* consider the economic impact of climate change in irrigated farming. Once more agricultural use of water is presented as a crucial aspect of water resource management in the Mediterranean in the future. The chapter focuses in particular on the Spanish situation and presents an approach based on a dynamic stochastic model that integrates climatic, hydrological, institutional and economic components, and evaluates economic losses resulting from plausible scenarios of climate change. The results from two irrigated areas in the Guadalquivir basin reveal that the economic impacts of climate projections may translate into a significant reduction of farmers' profits that could reach 24 per cent. Also, as drought episodes are expected to be more severe and frequent, as a consequence the economic losses will be more persistent and the return to average economic conditions after a drought shock will be significantly slowed down.

Part IV is devoted to Mediterranean lands, with one chapter on desertification and land degradation in general, two focusing in particular on agricultural land use, and one dealing with waste management. Rosato and Giupponi propose a methodology to integrate socio-economics in climate change scenarios, a relevant issue in current research in climate change, which attempts to provide always more integrated approaches in which interrelated cause-effects relationships of environmental and human drivers are simultaneously considered. The chapter presents first the main traits and prospects for Mediterranean agricultural systems, the possible direct and indirect consequences of climate change and the main adaptation options. Some concepts and definitions of the theory of scenario development are then presented to introduce the methodological proposal for building locally consistent agricultural scenarios. Some numerical examples are presented to clarify the procedure and conclusions are drawn about the potential of the proposed approach.

In Chapter 8 Engelen presents the results of European projects in which a decision support system tool was developed – MODULUS-DSS, for integrated environmental policy-making at the regional level. Details of the integration of various dynamic models at different spatial and temporal scales are presented, together with their implementation in a computerised context. Two applications in pilot case studies in Greece and Spain are reported and lessons drawn from those experiences are highlighted, in particular regarding the relationships between science and policy-making on a regional scale. In particular the difficulties in setting up effective relationships between

scientists and local stakeholders during the time frame of a research project are discussed.

Yehoshua and Shechter present an exploratory economic assessment of climate change impacts on Israeli agriculture, in monetary terms. In attempting a preliminary estimate of expected future damage to agriculture in Israel resulting from climate change, the authors investigate the effects of uncertainty about the effects of farmers' adaptation options, the nature of demand for water, and the role of agriculture in the national economy. These sources of uncertainty are added to the inherent uncertainty in forecasting climate change impacts. Also in this case the lack of adequate regional and local data is reported as a main problem for accurate estimations. Contrasting with other less developed countries of the Mediterranean, Israeli agriculture is an example of a highly technological and sophisticated sector, which has provided, during the past 50 years, increased yields of 16-fold, introducing also a variety of new crops. In more recent times, the economic role of agriculture has followed a similar path to the more developed countries, contributing only 2.4 per cent of GDP, with the proportion of labour employed in agriculture at around 3.4 per cent, and agricultural exports amounting to 4 per cent of total exports. Notwithstanding the peculiarity of the Israeli situation, the main issues are seen to be quite similar to the rest of the Mediterranean. The results of this exercise pointed out the importance of adaptation and correct proactive planning in counteracting the adverse effects of climate change. In addition to providing a range of quantitative economic estimates of costs, this is probably the major lesson of the study.

Ayalon *et al.* present an assessment of the ancillary socio-economic benefits of mitigating greenhouse gases from municipal solid waste management. In the sustainable management of the organic fraction of the waste, the ultimate goal is to minimise the amount of methane (CH_4), produced by biological processes of the organic content, by converting it to carbon dioxide (CO_2). The most cost-effective means to treat the degradable organic components is by aerobic composting which provides ancillary socio-economic benefits such as increasing the fertility of arid soils.

The authors propose that such an approach could be implemented, especially in developing countries, in order to reduce significantly the amount of greenhouse gases (GHG) for relatively low costs and in a short time. The chapter points out at this point that the development of a national policy for proper waste treatment could be a significant means to abate GHG emissions in the short term, enabling them to gain time and to develop other means for the long run. In addition, the use of CO_2 quotas will credit the waste sector and will promote a profitable proper waste management.

Part V of this volume deals with the assessment of impacts on coastal zone areas around the Mediterranean, and their vulnerability, a topic which has probably received a relatively large amount of attention, especially in light of development pressures on coastal environments and communities.

Georgas's chapter (Chapter 11) is a comprehensive review of 14 completed first-, second- and third-generation site-specific case studies in the Mediterranean region, carried out in the past 15 years. Today, the Mediterranean coastal zone is home to 70 per cent of the population, and responsible for 80 per cent of industrial activity and 90 per cent of tourism income. Although in the near future the vulnerability from climatic changes is expected to be one of the major consequences of coastal planning, sound central policy options are almost lacking. Consequently, he concludes that early preparation of Mediterranean climate impact studies could be considered as a very cost-effective and successful exercise through which countries and their interdisciplinary experts should be enlisted to study the potential threat that climate change may pose on their environment and socio-economic development.

The chapter by Sterr *et al.* deals in a more generic fashion with the socio-economics of climate change impacts on coastal zones, with a brief review of lessons drawn from German studies. Knowledge of vulnerability enables coastal scientists and policy-makers to anticipate impacts that could emerge as a result of sea-level rise, helping to prioritise management efforts that need to be undertaken to minimise risks or to mitigate possible consequences. One very important lesson – not confined, of course, to this area – is that data collection and information development are essential prerequisites for vulnerability assessment as well as for coastal adaptation. Coastal adaptation requires data and information on coastal characteristics and dynamics, and patterns of human behaviour, as well as an understanding of the potential consequences of climate change. In addition, there must exist awareness among the public and coastal planners and managers of these consequences and of the possible need to act.

The last two chapters in this part focus on tourism. Tourism, being volatile and situation-specific, is responsive to climate change. As Perry points out in Chapter 13, it is a major economic activity as the Mediterranean, especially in coastal zone areas, is currently the world's most popular and successful tourist destination, with 120 million visitors every year. Climate constitutes an important part of the environmental context in which recreation and tourism take place. Since tourism is a voluntary and discretionary activity, participation depends on favourable climatic conditions. The tourist industry is by its very nature fragile and susceptible to political, economic and social changes; the probability of climate change would add a significant element of uncertainty to planning future developments. Not

unexpectedly, he argues that more research is needed to quantify the tourists' well-being, which can in turn be calibrated to include the effects of climate change, because the primary resources of sun, sea and beaches are likely to be re-evaluated in the light of climate change.

Lise and Tol have indeed conducted an empirical investigation from which one could draw some quantitative implications regarding tourist welfare in this context. Their chapter provides a cross-section analysis on destinations of OECD tourists and a factor and regression analysis on holiday activities of Dutch tourists, in an attempt to identify optimal temperatures at travel destination for different tourists and different tourist activities. Globally, OECD tourists prefer a temperature of 21°C (average of the hottest month of the year) at their choice of holiday destination. This indicates that, under a scenario of gradual warming, tourists would spend their holidays in different places than they currently do. The factor and regression analysis suggests that preferences for climates at tourist destinations differ among age and income groups. More work is of course needed in order to explicitly address the question of how predicted changes in climatic conditions would affect Mediterranean tourism. A very tentative conclusion, which should be greatly qualified given the nature of their work, is that the impact would probably be negative overall.

Many open methodological and research issues have been discussed in this book and indications for a future research agenda are also touched on, as they were also in the two events that gave rise to the present book. First of all is the need to launch research initiatives aimed at supporting integrated multidisciplinary work on the Mediterranean as a whole. A crucial starting point, mentioned by various authors, will be data collection and distribution of knowledge, which should be facilitated and targeted to comprehensive studies on both the northern and the southern shores of the sea.

A model or structure should be developed specifically for scenario development and for the analysis of vulnerability, and the potentials for mitigation and adaptation at the local level. These analyses should be conducted while maintaining an overall figure at the regional level and also maintaining consistency with larger-scale scenarios (continental to global). Several different categories of changes should be assessed: that is, population, economy, natural resources, etc.

The common aim of analyses should be the provision of results, which could have a significance for policy orientation, through better understanding of phenomena and more efficient implementation strategies.

Communication will play a fundamental role in future climate change research in the Mediterranean, both in terms of enhanced networks of scientists working in the various fields, but also in terms of the involvement of

policy-makers and stakeholders at the various levels and from the various societal sectors.

It is the hope of the editors that this book could give a contribution in these directions.

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