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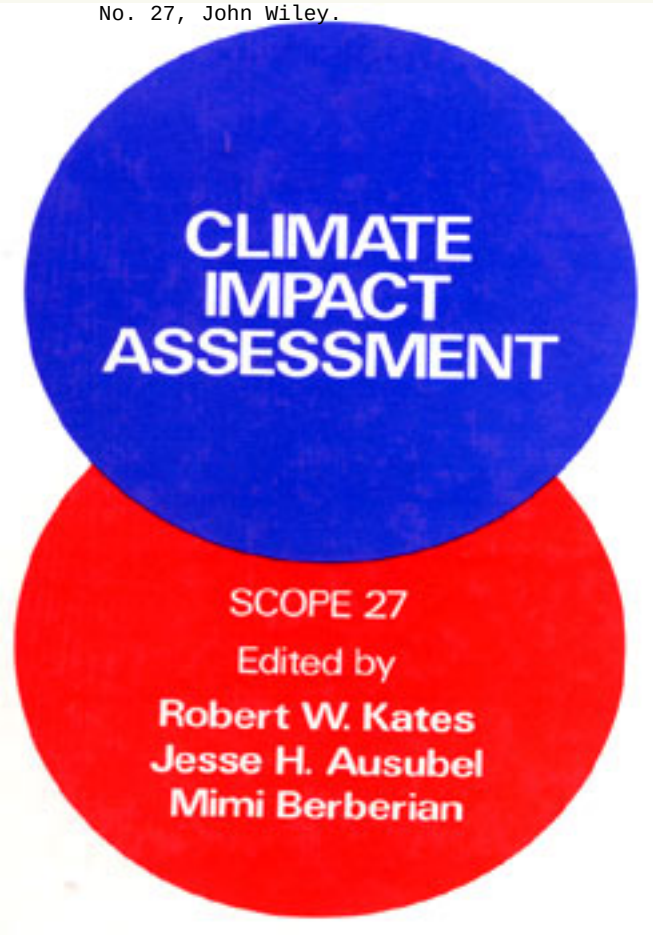

SCOPE 27

Climate Impact Assessment - *Studies of the Interaction of Climate and Society*

Contents

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SCOPE 27 - Climate Impact Assessment

Preface

The decade of the 1970s was marked by a growing climate consciousness, both popular and scientific. The new interest was sparked by a series of extreme climate events and related disruptions, and by scientific speculation as to increased climate variability and possible climate change. Two sets of events during this period attracted both scientific and public interest. The first, in 1972, was the apparent simultaneous occurrence of unfavorable weather in many parts of the globe and its speculative relationship to a wide variety of socioeconomic events, including the quadrupling of various commodity prices around the world, food shortages in the Sahel of West Africa and in South Asia, a drastic fall in the anchovy fishery of the Pacific, and even changes in government in Ethiopia and Niger. The second was an emerging scientific consensus that human-induced alterations in the chemical constituents of the atmosphere could lead to large regional, and even global, changes of the atmosphere in the form of more acidic rain, greater ultraviolet radiation, and altered temperatures.

The early eighties again found persistent drought in northeast Brazil and in many countries of Africa; a warming of sea-surface Pacific temperatures leading to the most remarkable `El Niño' event recorded to date; and the warmest years in a century of northern hemisphere temperatures. A scenario for a new and most serious set of climatic consequences following a major international exchange of nuclear weapons, the `nuclear winter', was postulated. The science of human-induced alterations of the atmosphere became more complex with the slowing of the rate of fossil fuel use and with improved understanding of the way the many `greenhouse' gases contribute to global warming, while at the same time reducing the net destruction of the ozone shield against ultraviolet radiation.

In sum, the diversity of novel climatic experience continues unabated, the recognition of potential sources of human-induced alteration has increased, and the pace and degree of change are questioned and debated. Nonetheless, it is widely agreed that one such change, a long-term global warming derived from the enrichment of the atmospheric content of the `greenhouse' gases, is underway. Within the time period of the projected global average warming, measured in tens of hundreds of years, sustained variation of climate will occur in many places, and lesser periods of favorable or unfavorable climate will occur in most places—a function of normal variability. Where these changes are large—the extremes greater than what is customary-where people and places are vulnerable, or where human activity meshes poorly with natural opportunity, significant climate impacts to people, ecosystems and societies are likely to occur. How to respond to such impacts—adjusting to changing climate, coping with extremes, matching human needs to climate endowment—are issues of considerable import. The scientific study of climate and society will inform societal response. Concepts of climate impact assessment are new, the methods are still under development. This volume is an authoritative review of these methods and concepts, a contribution of the Scientific Committee on Problems of the Environment to the World Climate Program.

The World Climate Program (WCP) was initiated in February of 1979 at a meeting of 350 scientific

experts held under the aegis of the World Meteorological Organization. The Program is directed at four goals:

1. improving our understanding of the physical climate system;
2. improving the accuracy and availability of climate data;
3. expanding the application of current climate knowledge to human betterment; and
4. advancing our understanding of the relation between climate and human activities.

Organized to address the fourth goal was the World Climate Impact Program (WCIP), of which this study is an initial effort. WCIP's purpose was well-stated in its founding document:

> ... the ultimate objective of the Impact Study Programme within the World Climate Programme will be to insert climatic considerations into the formulation of rational policy alternatives. In areas of the world characterized by different natural environmental conditions, social structures or economic systems, and differing levels of development, there can be different interactions and responses to climatic variability. The basic studies should aim at an integration of climatic, ecological and socio-economic factors entering into complex problems of vital importance for society, such as availability of water, food, and energy. Specifically, the Programme should strive for:
>
> a. Improvement of our knowledge of the impact of climatic variability and change in terms of the specific *primary responses* of natural and human systems (such as agriculture, water resources, energy, ocean resources and fisheries, transportation, human health, land use, ecology and environment, etc.);
> b. Development of our knowledge and awareness of the *interactive* relations between climatic variability and change and human socio-economic activities;
> c. Improvement of the *methodology employed* so as to deepen the understanding and improve the simulation of the interactions among climatic, environmental and socio-economic factors;
> d. Determining the characteristics of human societies at different levels of development and in different natural environments which make them especially resilient to climatic variability and change and which also permit them to take advantage of the opportunities posed by such changes;
> e. Application of this new knowledge of techniques to practical problems of concern to developing countries or which are related to a common need for all mankind.
>
> (World Meteorological Organization [1980], *Outline Plan and Basis for the World Climate Programme, 1980-1983*, 32-34)

At the time of the World Climate Conference in 1979, many of the major impacts of climate variation were already well known and others were under study. Participants reported on this sampling of impacts that were then known:

- Natural disasters claim an average of $40 billion in global resources and at least 250,000 deaths a year. Of this dollar amount, $30 billion accrue from three major events with a significant atmospheric component: floods (40 percent), tropical cyclones (20 percent), and drought (15 percent). The distribution of deaths and damages is widely skewed, with 95 percent of deaths occurring in poorer nations and 75 percent of economic damages in wealthy nations. (Kates [1979], in World Meteorological Organization's *Proceedings of the World Climate Conference,* 683)

- The current grain-producing systems of the world are still highly sensitive to the occurrence of large climatic anomalies. The trend toward higher grain yields has slowed down., or even leveled out, since the early 1970s. Some agriculturalists attribute this to worsening weather. Evidence also exists to suggest that grain yields have been subject to more weather-related variability during the 1970s than during the previous two decades, when dramatic increases in yields suggested that technological inputs were overcoming the variability of weather. (McQuigg [1979], in *Proceedings of the World Climate Conference,* 420-421)

- The increasing use of air conditioning and electric heating in homes has increased the sensitivity of energy demand to temperature changes. Results of studies in the United States showed that in one year out of 100 years one should expect the total demand for heating fuel to exceed the long-term average demand (for constant economy) by as much as 10 percent and at least 3.6 percent of an average of one heating system in five. The probable extreme deviations are larger when regions are considered; for example, for the South Atlantic states of the United States, in one year out of 100 years one should expect a total demand for heating fuel to exceed its long-term average demand by 20.4 percent. (Williams, Häfele, and Sassin [1979], in *Proceedings of the World Climate Conference,* 281-282)

- A substantial amount of the production of any economy is directly or indirectly used to offset or negate the economic effects of climatic variation. Considering only the purchases by consumers in the northern hemisphere above 40° latitude, the amount spent may be as high as 10 percent of per capita income. (d'Arge [1979], in *Proceedings of the World Climate Conference,* 656)

Along with impacts, the World Climate Conference was informed about practical actions that are taken to anticipate, prevent, reduce or mitigate undesired impacts or to take advantage of desirable ones. These include:

- For agriculture, crops are planted late or harvested early, and are partially stored for use during exceptionally severe periods of drought or cold. Through genetic selection, hardier or heat resistant varieties of crops are obtained and applied. Farm operators plant a mixture of crops to protect against climate extremes and thereby avoid the possible loss of a single weather-sensitive crop. Energy-intensive machinery is utilized to reduce time for seeding or harvesting. (d'Arge [1979], in *Proceedings of the World Climate Conference,* 656)

- Industries stockpile raw materials to avoid shortages due to reduced deliveries during inclement weather. Employers hire additional workers and adjust working hours to reduce production stoppages due to employee illness or inability to travel to work during periods of extreme climate. Special snow removal equipment is purchased and stored in case of severe storms. (d'Arge [1979], in *Proceedings of the World Climate Conference*, 656)

Additional actions were proposed. For example, it was reported that in the opinion of the authors the:

- Use of the best practice currently available in developing countries could reduce the world death toll from drought, flood, and tropical cyclones by 85 percent and similar use of best practice in industrial countries could reduce property damage by 50 percent. (Burton *et al.*, 1978; quoted in Kates [1979], in *Proceedings of the World Climate Conference*, 687)

Thus the World Climate Impact Program addressed practical necessity: preventing and mitigating the disasters of extreme events; tuning climate-sensitive sectors of the economy (such as energy, food, fiber, water) to accommodate climate variation better; and anticipating, preventing and adapting to natural and human-induced climate change. The work at that date was at best suggestive. Systematic efforts at climate impact assessment were recent; methods, however, are evolving rapidly.

The Scientific Committee on Problems of the Environment (SCOPE) of the International Council of Scientific Unions undertook to prepare the authoritative review of the methodology of climate impact assessment called for in the World Climate Impact Program. The objectives of the review were:

1. to examine existing methodology;

2. to foster the development of new methodological approaches; and

3. to inform a broad range of disciplines as to the available concepts, tools and methods beyond their own specialty.

This volume is a major product of that review. But of equal importance is the network of scientific interest that has been created in the course of the project. Over three hundred individual researchers and administrators from thirty-six countries have participated, exchanged publications, or expressed continuing interest in the review and the general field. Contact with them has been maintained by two SCOPE newsletters devoted to climate impact assessment and will be continued through informational letters coordinated by the US National Climate Program Office.

Included in this network are the thirty-eight authors of papers (from thirteen countries), the one hundred invited reviewers of papers (from twenty-three countries), the eight members of the SCOPE-appointed Scientific Advisory Committee, and the fourteen national correspondents from SCOPE National Committees. The network itself and the production of this volume were coordinated by the Clark University Climate and Society Research Group, using funds from the US National Science Foundation,

the United Nations Environment Program (UNEP), the Scientific Committee on Problems of the Environment (SCOPE), the US National Academy of Sciences, and the Oak Ridge Associated Universities. In addition, through SCOPE, the Andrew W. Mellon Foundation provided funds for William Riebsame to serve as postdoctoral research fellow.

The SCOPE effort began with a Scientific Advisory Committee, chaired by F. K. Hare, whose members were J. de Vries, J. Escudero, H. Flohn, A. Mascarenhas, W. J. Maunder, J. L. Monteith, and R. Slatyer. At the same time, the national correspondents (V. V. Alexandrov, USSR; J. Aragón, Spain; A. P. M. Baede, The Netherlands; C. Capel-Boute, Belgium; P. K. Das, India; M. Glantz, USA; W. Kuhnelt, Austria; S. C. Lu, Taiwan; K. Meyer-Abich, West Germany; J. L. Monteith, United Kingdom; J. Neumann, Israel; Y. Omoto, Japan; A. B. Pittock, Australia; and D. Rosell, The Philippines) appointed by National Committees were solicited for information and suggestions. These were reviewed at a meeting of the Scientific Advisory Committee at St Hilda's College, Oxford University, in September 1980. There the Committee adopted a framework to select topics, authors, and a common set of instructions for contributors. Another meeting, hosted by the Atmospheric Environment Service of Canada a year later, brought together review authors to discuss either preliminary drafts or their plans for papers.

Papers were submitted over the following two years and each received an international, interdisciplinary review from a group consisting of J. L. Anderson, W. Bach, C. L. Bastian, E. Bernus, A. K. Biswas, E. Boulding, R. Bryson, M. I. Budyko, J. J. Burgos, J. C. Caldwell, L. J. Castro, C. Caviedes, R. Chen, L. S. Chia, W. C. Clark, D. Cushing, G. Dahl, K. Devonald, J. Dooge, M. El-Kassas, N. J. Ericksen, H. Flohn, H. D. Foster, W. J. Gibbs, E. S. Gondwe, G. Gunnarsson, J. C. Hock, C. S. Holling, M. A. Islam, W. W. Kellogg, A. Khosla, A. V. Kneese, V. A. Kovda, M. Lechat, T. A. Malone, A. Mani, B. Martin, G. A. McKay, D. H. Meadows, D. Mileti, J. K. Mitchell, S. H. Murdock, T. Murray, W. Nordhaus, J. S. Oguntoyinbo, P. O'Keefe, T. O'Riordan, J. P. Palutikof, C. Pfister, J. D. Post, T. Potter, T. K. Rabb, C. Sakamoto, S. H. Schneider, W. R. D. Sewell, M. M. Shah, M. S. Swaminathan, J. A. Taylor, T. Vasko, R. A. Warrick, G. F. White, G. D. V. Williams, J. S. Winston, B. Wisner and C. P. Wolf. These reviews were followed by several rounds of revision.

At Clark University, Mimi Berberian, Thomas Downing and William Riebsame organized the initial stages of the review, and Maggie Grisdale of Trinity College, Toronto directed the ensuing meeting that brought together review authors. The many drafts of papers were patiently typed by Jane Kjems, Joan McGrath, and Lu Ann Renzoni. I served as volume editor, aided by Jesse Ausubel and Mimi Berberian. Jeanne Kasperson provided invaluable bibliographic assistance.

If one adds to the group of participants the many scientists and publishers that shared material and illustrations with us, literally hundreds of people have generously tendered assistance, motivated by the common bonds of science that transcend discipline and nationality and by shared concerns for climate and society. I hope they can take much satisfaction from our collective activity, as I relieve them of responsibility for any fault or error. I am particularly grateful for the endless patience of the authors, the universal helpfulness of the reviewers, and the generous understanding of funding agency program officers. Relieved also of fault, but tendered special gratitude arising from five years of close

collaboration, I thank Ken Hare for his counsel and support; Bill Riebsame for his energy and insight; Jesse Ausubel for his knowledge and versatility; and for all of us, Mimi Berberian, for her skill and sense.

A project, a network, a volume: this is also a set of papers. The individual papers transcend professional boundaries and examine climate impact assessment in a non-disciplinary fashion as a set of linked analytic components, as techniques of case study and modeling, and as reviews of past experience. Each author has sought to review the state of his or her art, not for peers, but for scientific colleagues who are interested in climate impact assessment but schooled in a different discipline or lacking experience in a particular technique. The achievements, weaknesses, and capabilities of the various methodologies are set forth with candor, tempered by empathy. It is our hope that workers new to climate impact assessment will be realistic in their expectation of the various methods, sympathetic with the common scientific problems faced, and challenged both by their practical necessity and intellectual adventure.

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Worcester, Massachusetts (USA)
June, 1984

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SCOPE 27 - Climate Impact Assessment

Part I Overviews

Running as a thread through the entire volume, linking together the sectoral studies, the analytic methods and the case examples, are conceptual models of the interaction of climate and society, definitions of climate variability and change, and assumptions as to the state of knowledge concerning climate processes. These concepts and definitions, presented by Kates in Chapter 1 and Hare in Chapter 2, provide to all authors a common vocabulary for describing climatic events, consequences and human responses, a common framework for linking climate and societal impacts, and a common interest in both industrialized and developing countries.

Within this framework, climate variability and change provide three types of events of interest: extreme weather events, persistent periods, and little ages. These events impact on exposed social, areal, or activity units of human or ecological organization, leading to ordered biophysical, social, or ecological consequences. In turn these impacts are modified by cultural adaptation and adjustment responses that may amplify or dampen the consequences of climate events. In the simplest of frameworks, the links between events, units and consequences of climate impact models are linear. In the more realistic and complex interaction model framework, causality is jointly determined by climate and society. As with all such frameworks, relationships are linked in ordered flows that belie the reality and simultaneity of the real world.

The degree to which the authors employ these common concepts, concerns and vocabulary differs, as considerable translation of disciplinary or sectoral practice or tradition is often required. Nonetheless, all have tried, and brief editorial introductions to the major sections guide the reader to the connections between a particular chapter and the overarching schema of climate impact assessment.

The overview on research by Riebsame in Chapter 3 serves a different function, providing a common conceptual and historical review of climate-society research organized under four key concepts: climate as setting, as determinant, as hazard, and as resource. Riebsame's view that research, both past and future, flows directly from these different, but not exclusive, concepts of climate-society interaction serves not only to organize the diverse literature of this interdisciplinary field, but to analyze its structure as well.

The final overview, Chapter 4 by Maunder and Ausubel, links directly to the rest of the volume by posing the question of how one begins to undertake specific climate impact studies. They suggest that one major way to begin is by assessing the overall climate sensitivity of activities, places, or groups of interest. Past experience and current methods for determining overall sensitivity are presented. It emerges from many studies that agriculture and water resources are activities and sectors that are clearly sensitive to climate. Methods appropriate to the study of these and other sensitive sectors follow in Part II of this volume.