
REVIEW ESSAY / ÉTUDE CRITIQUE

GLOBAL CHANGE, CLIMATE, AND GEOGRAPHY

Barry Smit

Department of Geography, University of Guelph, Guelph, Ontario,
Canada N1G 2W1

Interest in the interaction of biophysical and human systems is a long-standing tradition in geography. As the issue of global environmental change has become more widely in vogue, many geography departments are modifying curricula to ensure that this latest manifestation of the theme is addressed in their programs. At the same time, many of us are searching for materials to use in courses dealing with global change.

This essay began as a review of the book *Planet under Stress* at a time when I was offering an interdisciplinary, undergraduate course on 'Global Climate Change: Science and Society.' As I grappled with reference material to support the course, the scope of this paper grew. Its purpose is to assess several recent publications which address the issue of global change, and, in particular, global climate change. The review is primarily from the perspective of a geographer considering materials (mostly books) for undergraduate and graduate instruction.

The coverage in the review is neither even nor exhaustive. Several recent volumes are given the most attention, but the paper acknowledges a range of other relevant material throughout. The essay considers first the broad issue of global change. Then one aspect of global change, that of climate, is addressed via both the physical science of global warming and the human dimensions of the issue. The complex interactions of physical, ecological, socio-economic, and political processes involved in the climate change issue, along with its global scope and long time frame, make this topic a fascinating challenge for scholars, policy makers, and humanity generally. It is also

fundamentally geographical; a topic geographers should be embracing.

Global Change

For a broad introduction to the many dimensions of the global change issue, particularly in a Canadian context, *Planet under Stress* is a grand little volume. The Royal Society of Canada attracted some prominent names from the natural sciences, social sciences, humanities, and public and private sectors to contribute to it. The editors, freelance writer Constance Mungall and Royal Society President Digby McLaren, have worked to make the eclectic contributions readable and attractive to a wide, nonscientific audience. Thus, it does a great job in covering the territory and in introducing the issues; but for real scholarly meat you will have to go elsewhere.

The book begins with a series of one-page appetizers, each with colour pictures, covering such topics as food, population, the planet observed, soil, the atmosphere, warming, pollution, and water. Sixteen chapters follow, supplemented by occasional related inserts. The pieces vary greatly in style and organization, but all connect some general facts or principles about the earth's atmosphere, geology, water, population, economics, value systems, and institutions, to current concerns about the globe's eco-health or prospects for sustainable development. There is an attempt to impose a broad structure on the book with Part II 'Setting the Stage,' Part III 'A Closer Look,' Part IV 'Managing Ourselves as Part of One World,' and Stan Rowe's concluding chapter 'Summing it Up.' It doesn't work well, but it doesn't matter either. The strength of book is its breadth, its eclecticism and its variety of perspectives.

The book is a biophysical and social science smorgasbord, offering dishes on natural processes mixed with

garnishes on human systems and suggestions for policy and citizen action. Parts II and III focus on the planet's physical and biological processes. McKay and Hengeveld, for example, outline the nature of the atmosphere, the human 'assault' on it, long-term climate change and warming, the enhanced greenhouse effect, ozone depletion, and toxic deposition, then offer insights on public policy considerations, and personal and community initiatives. Peltier's chapter runs from the formation of planets, through continental drift, glaciation and isostatic rebound, to sea-level rise and the greenhouse effect. Root's piece on the Arctic ranges from the 'architecture of the earth' through an explanation of different Arctic environments, to implications of climate change for Canadian agriculture, oil exploration, biological productivity, population migration, settlements, and military activity.

Maini's chapter on forests is similarly wide-ranging, outlining interactions among biological and economic processes, then offering some estimates of consequences of global warming, before touching on 'North-South dialogues,' temporal and spatial scales, and the need for collective action on atmospheric modification.

Other chapters are less catholic. Mathews' geological travelogue (through sedimentary layers) indicates variations in climate over millions of years. Mysak describes the tempering effect of the oceans and the analytical tools to explore such relationships. The chapter on fresh water, by Schindler and Bayley, draws heavily on the findings from the Experimental Lakes Area in northwestern Ontario. Again, global warming is explored for its impacts on fisheries, power generation, navigation, water diversions, and wetlands. The chapter on 'Grasslands into Deserts' by Stewart and Tiessen, forcefully demonstrates the interdependencies among climate, soil, forests, grasslands, human demands, agricultural practices, land and water management, and adaptive strategies.

Part IV, 'Managing Ourselves as Part of One World,' highlights the human dimensions of global change. Timmerman's provocative paper on environmental ethics draws from debates in philosophy, theology, and political movements (shallow and deep ecology), to show that powerfully entrenched perceptions, beliefs, and values greatly limit prospects for significant changes in the human use of the earth. McDaniel's chapter on 'People Pressure' reinforces the critical role of human behaviour, and not just numbers of people, in understanding and addressing global challenges.

The interdependencies among resources, populations, lifestyles, technologies, and institutions throughout the world are also illustrated by Smyth. Similarly, Hampson

shows how physical disasters are exacerbated by political and social upheaval, itself brought on by economic inequities and population pressures. Goodland and Daly offer a critique of conventional economics and the relationships between economic growth and human welfare. Their argument – recall Meadows' *Limits to Growth* – further illustrates that our comprehension (let alone management) of global change requires recognition of the role of economic and social systems. Holling and Bocking make the same point from an ecosystems perspective. Building on experiences in environmental management, they push for a holistic ecosystem approach, which includes human demands and activities.

Most of these papers argue for action to reduce human modification of the global environment. Quite apart from the specific prescriptions, these papers repeatedly demonstrate that human activities represent a fundamental dimension of the global change issue: as a force of environmental change, as activities impacted, and as agents of response to the issue. Essentially, we cannot expect to understand global changes or do anything about them without an improved knowledge of the human dimensions. Yet, as McDaniel notes explicitly, notwithstanding all the uncertainties about the physical dimensions of global change, we know a lot more about them than we do about the human dimensions.

One of the strengths of *Planet under Stress* is that it discourages the reader from viewing global change as simply, or largely, a biophysical issue. It touches on most of the dimensions (although it is a little thin on the theme of energy and its connections with environment, economy, and behaviour), and it does so in a readable style. To achieve this scope, the trade-off is depth. I found that even a first-year class wanted more substantive material than *Planet under Stress* could provide.

A rich companion piece is the encyclopaedic *State of Canada's Environment*. It provides an impressive compilation of information about Canada's environments and related human activities. Using detailed and well-designed tables, maps and graphs, the volume supplies data and summary assessments in 14 environment-activity areas (atmosphere, fresh water, oceans, ... urbanization, and industries); in 6 regional case studies; and in 6 current issues, including toxic chemicals, climate change, and solid wastes. The volume is published by the federal government as part of Canada's Green Plan, which may explain the heavy reliance throughout on government documents as source materials. Its contribution is not conceptual or analytical, nor is it in the development of scholarship; it is in the provision of a wealth of information.

Sustainable Development of the Biosphere is similar in scope and evolution to *Planet under Stress* (key contributors with commentaries), but is directed at a scholarly audience. Produced by the International Institute for Applied Systems Analysis (IIASA) and edited by Clark and Munn (1986), this international effort has plenty of Canadian content. It also provides ample scientific meat.

The introductory section by Clark alone warrants acquiring the volume. The concepts cover much the same ground as *Planet under Stress* (economic-environmental interdependence, technology and institutions, discontinuities and surprise, climate change, etc.), but it is set in the context of past and contemporary scholarship. We are reminded that these issues are not being addressed for the first time – the intellectual foundations go back to Plato, Malthus, George Perkins Marsh, and Réclus. Furthermore, we are offered a critique of research frameworks for conceptualizing and analyzing these issues. The level of sophistication and rigour is sufficient to stimulate even graduate classes.

The mix of contributors which follows and the calibre of their papers is equally impressive. Thus, we find an historical analysis, demonstrating the utility of this approach in providing insights into processes of societal and environmental change – an approach which has, surprisingly, been little used in the field of climate impacts. Canadians Baskerville and Regier focus on forestry in New Brunswick and fisheries in the Great Lakes. Crosson's chapter on agriculture shows the importance of institutional conditions, and two chapters address the key role of energy in understanding human-environment interactions and in assessing prospects for slowing global environmental change.

Part 3, 'The World Environment,' has four chapters providing rich overviews of the long-term evolution of the earth's environment, atmospheric chemistry, climate and hydrologic cycles, impacts of human activities on climate, and dynamics of terrestrial ecosystems. These are substantive scholarly reviews, outlining facts, theories, principles, conceptual frameworks, and analytical tools. Holling's chapter, for example, covers similar territory to his contribution in *Planet under Stress* (resilience and change in ecosystems), but here there is more depth, more conceptual development, more examples, and more methodological critique.

Part 4, 'Social Response,' is a mixed bag. An engineer (Brooks) addresses environmental surprises and 'behavioral insurance,' a statistician (Majone) looks at international institutions, there is a plea for improved environmental monitoring, and geographer Parry reviews implications of climate change for human development.

The potency of this volume is well illustrated in Parry's chapter. We might expect that the field of climate-impact analysis would have advanced significantly since 1986, yet Parry's piece is still on the conceptual cutting edge. Researchers would do well to consider the ideas presented on contingency conditions for impacts, pathways at various spatial and temporal scales, adaptation and adjustments, payoff concepts, probabilities and properties of extremes, sensitivities, and so on.

Similarly, Ravetz's ideas about the limits of science and its relationships with policy processes are very pertinent to the current debate on global changes and what to do about them. He explodes the myth of scientific certainty in this field, suggests procedures for the construction of 'useable ignorance,' and outlines approaches through which incomplete knowledge can be better integrated into policy debates. This theme is complemented by Timmerman (again in more depth than in *Planet under Stress*), who exposes more myths about the nature of ecosystems and society, and about the systems of knowledge which sustain and promote these perceptions and partial representations of reality.

Particular methodologies for analyzing and synthesizing policy-relevant questions about development and the biosphere are reviewed in the concluding chapter. Brewer shows the serious limitations of common methods for synthesis in resource management (analytic models, simulation, optimizing routines, etc.), and argues for the development of 'free form' games, essentially participatory, process-oriented exercises.

There is an interesting paradox in this volume. The bulk of the book shows ways in which we can improve our knowledge of earth processes and environment-society interactions by systematic analysis, monitoring, conceptualizing, and modelling. Yet the final three chapters leave the message that, no matter how marvellous our research technology, data collection, and analytical expertise, our understanding will still be far from complete, will differ according to our perceptions and paradigms anyway, and furthermore, 'management' of these issues is much less a scientific problem than it is a problem of differing views, beliefs, and interests which must somehow be reconciled.

There are some other books which cover similar territory to *Planet under Stress* and *Sustainable Development of the Biosphere*. *Scientific American* devoted its September 1989 issue to this theme, and has subsequently published the readings in book form as *Managing Planet Earth*. Its purpose is similar to that of *Planet under Stress*, to inform a broad readership of the hazards facing the planet and to offer strategies for sustainable management

of the earth's resources. The contributors are internationally known scholars and communicators, who, for the most part, leave their scientific qualifiers in their laboratories and offices. *Managing Planet Earth* is a very readable volume, international in scope, extremely well illustrated, and not without considerable substance. It has a nice balance, covering atmosphere, climate, water, biodiversity, human populations, agriculture, energy use, manufacturing, and sustainable development. Like *Planet under Stress* and unlike *Sustainable Development of the Biosphere*, it is in paperback and moderately priced.

Global Change and Our Common Future is a set of papers attempting to link the physical science of global change – specifically the International Geosphere-Biosphere Program (IGBP) – with the socio-political debate about sustainable development, particularly the Brundtland report, *Our Common Future*. The outcome typifies much of the available literature in this field, particularly the contrast between the physical and social science components. The papers about geospheric and biospheric change sometimes include comments or recommendations about social or political implications, but these are easily separated from the basic, substantive scientific analyses. In the papers covering the human dimensions it is very difficult to separate analysis of social and policy issues from proposals for policies and social change.

Of course, all analyses are influenced by values to various degrees, but regardless of the research paradigm adopted, it should be possible to distinguish analyses about what, where, how, and why from prescriptions and recommendations about what 'should' be done. This is not to deny the very important role of advocacy pieces, political proposals, and documents such as *Our Common Future* – for university instruction and the public at large – but students should become aware that these do not represent the body of social science dealing with the human dimensions of global change.

Global Change and Challenge is explicitly by and for geographers, but its content is no more or less geography than the other volumes in this review. The contributors were all members of the Geography Department at the London School of Economics. While not as comprehensive in its coverage of environmental issues as some of the other publications (e.g., there is nothing on global climate change), it still covers a wide range of topics and is global in scope. Its audience is high school and university students, so it contains lots of facts to go along with the conceptual material.

Global Change and Challenge includes some solid

review papers on resources and scarcity (Rees), hazards (Jones), and desertification (Scoging), each providing conceptualizations, classifications, critiques, and specific examples. However, the volume's distinctiveness is probably in its coverage of 'non-environmental' global changes: world political economy, economic structures and change, regional economies, development and the Third World, urban planning, and information technology.

Changes in human systems, especially their increasing globalization, are important elements of global change in their own right, and they are also fundamental to understanding global environmental changes. The remainder of this review focuses on climate change. Appreciation of this issue – its causes, consequences, and responses – requires an understanding not only of physical systems but also of the global dynamics of lifestyles, political economies, technologies and institutions.

The Climate Change Issue

The topic of climate change is conventionally addressed via three components:

- the physical science of atmosphere and climate change,
- the impacts on ecosystems and human activities,
- the policy responses.

This structure is common to the research and literature on the topic, and is reflected in national and international governmental initiatives dealing with climate change, including the Intergovernmental Panel on Climate Change (IPCC), sponsored by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO).

A text suitable for a course on 'Climate Change: Science and Society' would cover these three components and address the connections among them. Several books come close to meeting this need, but none are ideal.

Global Warming: Are We Entering the Greenhouse Century? is written by Stephen Schneider, a high-profile scientist-speaker-advocate based at the U.S. National Center for Atmospheric Research. This book covers the basic theory and evidence regarding past, present, and future climates, and outlines some of the impacts of global warming. However, its main contribution is the insight it provides into the political process and the role of science, the media, and personalities in policy developments in the United States. This is very much a personal journey of a scientist accepting that climate change is real, and

accepting a responsibility to better inform the public and hence the political process. Its purpose is 'to make the basic issues and policy implications of global atmospheric change more accessible to the public ...' Thus, the book is readable journalism. Schneider has skill in explaining the scientific issues in lay language. He is also not at all shy in outlining actions which should be taken by individuals, governments, and businesses. Despite its valuable insights, this book is not structured for university instruction. It lacks the conceptual bases and the well-ordered substantive information for a text.

Global Climate Change and Life on Earth is a volume of papers by U.S. contributors which aims to inform the public and college and university students of the consequences of global climate change. It is based on conference presentations, and its style would likely appeal more to a university audience than to the general public. Its strength is its treatment of ecosystems and their sensitivity to environmental changes. Thus, it covers forests as greenhouse gas sources and sinks, tree rings as indicators, ecosystem sensitivity, biological diversity, migrating wildlife, habitat fragmentation, and species extinction. It is rather thin on the physical science of climate change, and notwithstanding papers on sea-levels, agriculture, health, and energy policy, it is also very thin on socio-economic impacts and policy.

Global Warming: The Greenpeace Report comes closer to filling the requirements for an undergraduate text. Its basic rationale, not surprisingly given its sponsor, is that there is a serious problem with anthropogenic climate change, and that action should be taken now to address it. But this volume, consisting of contributions by a range of experts, is much more than just an advocacy piece. It covers the three areas of climate, impacts, and policy responses, and it has substantive contributions in each of these areas. Its sections on the nature of greenhouse processes and the science of climate modelling are comprehensive and well illustrated and referenced. There is plenty of material on policy responses to global warming, particularly on energy alternatives. In fact, almost two-thirds of the book is devoted to policy dimensions of the global warming issue. The predominant message is that greenhouse gas emissions should and can be drastically reduced. The thorny issues of tropical forests, the nuclear option, Third World interests, and global institutions are touched on. The weakest section is the one on impacts. It is almost as if the book takes for granted that there is a problem which warrants major policy responses. Yet Schneider's book, many recent commentaries and national debates, and the experience at the United Nations Conference on Environment and Development

(UNCED) show that impacts, particularly for human well-being, play a pivotal role in the policy process, both nationally and internationally.

Apart from books, other materials provide useful introductions to the climate issue. Canada's State of the Environment Reporting has published Hengeveld's *Understanding Atmospheric Change*, a tidy little overview (bilingual) from a Canadian perspective. *Scientific American*, *Nature*, *Maclean's*, *The Economist*, *Time*, *Fortune*, and other magazines have featured useful articles. For variety, consider videos such as *The Greenhouse Effect* and *Global Warming in Films* for the Humanities and Sciences. If you think these are too much in the Schneider-Greenpeace camp, or if you wish to stimulate debate, then *Greening of Planet Earth* offers a different perspective. Sponsored by the U.S. Department of Energy and drawing heavily on Idso's book *Carbon Dioxide and Global Change: Earth in Transition*, the video argues that the CO₂ environment will offer major benefits to humankind.

None of these materials or books meets the needs of a comprehensive text on the issue of climate change. As a result, we are obliged to draw on materials that focus on particular components of the climate change issue, and achieve the desired balance, integration, and synthesis via other means.

Physical Science of Climate Change

The definitive volume on the physical dimensions of climate change is the report of IPCC Working Group I, *Climate Change: The IPCC Scientific Assessment*. This document – let us call it *IPCC-I* – involved several hundred scientists from 25 countries, producing 'the most authoritative and strongly supported statement on climate change that has ever been made by the scientific community.'

It certainly is a distinctive and impressive document, representing a scientific consensus, fashioned by Houghton and his co-editors. It assembles most of the current theory and evidence about greenhouse processes, the history of the earth's climate, human modifications, global warming, and sea-level changes. It describes and evaluates the methods used to reach the current understanding, including the uncertainties. Given its production by committee, it is of very high quality in comprehensiveness, content, and presentation. There is ample material here, well documented and illustrated, for undergraduate and graduate specialist classes.

IPCC-I can be seen as an update of *The Greenhouse Effect: Climatic Change and Ecosystems*, also supported

by UNEP and WMO, and produced by the Scientific Committee on Problems of the Environment (SCOPE) of the International Council of Scientific Unions (ICSU). This volume – commonly referred to as *Scope 29* – was also a major international collaboration of scientists, and is still an excellent text.

The preparation of *Scope 29* included a conference in Villach, Austria, in 1985, where a position Statement was drafted on climate change and its impacts. This Villach Statement, which is included in *Scope 29*, became a significant stimulus to the movement of the climate change issue from the scientific laboratories and journals to political agendas and public debate. Part of this movement was an increased demand for assessments of potential implications of climate change for ecosystems and human well-being.

Impacts

In the area of impacts there are now numerous studies and commentaries, but still no single volume which provides a comprehensive synthesis of consequences and methods for assessing them. For university instruction, several options exist apart from the scientific journals: books, government reports, and conference proceedings.

The books noted earlier offer some materials. Schneider covers the field, but thinly. The Greenpeace report contains a good piece in the area of human health, but otherwise is even more sparse on impacts than Schneider's book. *Climate Change and Life on Earth* covers ecological impacts well, but it is far from comprehensive and offers no synthesizing framework.

There are several books that deal exclusively with impacts, usually focusing on particular sectors or methodologies. Glantz's *Societal Responses to Regional Climatic Change: Forecasting by Analogy* offers some case studies (North American) of impact assessment by reference to regional and local responses to past climate events. It is really about analogies as a research approach. Parry's *Climate Change and World Agriculture* is an excellent little paperback, drawing heavily on the massive IASA-UNEP volumes on *Impact of Climatic Variations on Agriculture*. This is a well-structured piece, but it deals only with one sector – agriculture.

Climate Change: Evaluating the Socio-Economic Impacts, prepared by the Organisation for Economic Co-operation and Development (OECD), is also very selective. It is not a review of socio-economic impacts, as its title might suggest. Rather, it describes some methodologies to assess implications of climate change, particularly for agriculture.

Although a little dated, the most comprehensive book on impacts is *Climate Impact Assessment – Scope 27*. Edited by Kates and others, and part of the SCOPE series, this volume deals directly and thoroughly with the interaction of climate and society. The 22 chapters, based on submissions and reviews by participants from 30 countries, cover conceptual, analytical, and empirical material dealing with sensitivities, biophysical impacts, social and economic impacts and adjustments, and integrated assessments. It does not serve so much to present 'the facts' – the field does not lend itself to this anyway – but rather it provides frameworks and terminologies for describing climatic events, consequences, and human responses. While it might be a little heavy-going for undergraduate classes, it remains the essential reference document for any serious scholar in the field.

In addition, *Scope 29* includes papers on impacts on terrestrial ecosystems, notably agriculture and forestry, which are of the type and quality of those in *Scope 27*. These papers cover conceptual models, empirical findings, and critiques of research methodologies. For their particular, limited fields, they are outstanding reviews.

More recently, a sister volume to *IPCC-I* has been published, reporting on the findings of IPCC Working Group II, whose task was to assess environmental and socio-economic impacts of climate change. *Climate Change: The IPCC Impacts Assessment* – let us call it *IPCC-II* – summarizes the present global knowledge about potential implications of climate change. The approach taken was to accept some scenarios of future climate – notably a doubling of CO₂ under the 'business as usual' case – then identify sensitive activities and regions, estimate likely impacts, assess possible adjustments, and suggest research and policy needs.

Notwithstanding *Scope 27*, this area of scholarship is not as well developed nor as thoroughly investigated as the physical science of climate change. Furthermore, the interpretations of 'impacts' vary greatly among the several hundred contributors to the volume. As a result, *IPCC-II* does not provide a clear conceptual framework for characterizing or analyzing impacts. Instead, it provides a wide range of synopses and summaries, drawing from a mixed bag of studies and expert opinion, on such areas as terrestrial ecosystems, hydrology and water resources, agriculture and forestry, human settlements, energy, industry and human health, oceans and coastal zones, and ice, snow, and permafrost.

It is instructive that while IPCC Working Group II's task was to assess 'environmental and socio-economic impacts,' the back-cover description of the report refers to 'physical and biological' impacts, which is actually a

more accurate description of the contents. The volume is awkwardly structured and is weak on the socio-economic impact areas. If *IPCC-II* represents the state-of-the-art, then either we have not built on *Scope 27* or analyses of socio-economic implications are not well reflected in the *IPCC-II* report.

Examples of impact studies are also available in government reports and in conference proceedings. Summaries of the more than 20 impact studies completed under the Canadian Climate Program are published by Environment Canada in the series *Climate Change Digest*. These studies together cover a wide range of economic sectors and regions in Canada. The U.S. Environmental Protection Agency covered a similar range of activities and regions in its report *The Potential Effects of Global Climate Change on the United States*.

Another source of material on impacts is conference proceedings, some of which are especially valuable for teaching because of their breadth of coverage and relatively non-technical style. The Toronto Conference on *The Changing Atmosphere: Implications for Global Security* was something of a milestone in the political evolution of the issue and is worth a look. The Washington-based Climate Institute has published several voluminous conference proceedings, and two of them, *Preparing for Climate Change* and *Coping with Climate Change*, provide a wealth of information on a very wide range of impacts, particularly in a North American context. The question of adaptation to changing climate is addressed in a proceedings sponsored by Resources for the Future, *Greenhouse Warming: Abatement and Adaptation*.

There are many other proceedings addressing impacts in Canada, including *Symposium on the Impacts of Climatic Change and Variability on the Great Plains*, *Proceedings of the 4th Meeting on Northern Climate*, *Impacts of Climate Change on the Great Lakes Basin*, *Climate Change: Implications for Water and Ecological Resources*, and *Changing Climate in Relation to Sustainable Agriculture*.

Policy Response

The IPCC trilogy is completed with *Climate Change: The IPCC Response Strategies*—let us call it *IPCC-III*. Whereas *IPCC-I* and *II* were reviews of the state of knowledge, *IPCC-III* set out to formulate response strategies. It aims to provide direction to policy initiatives at the international and national levels and is thus more a part of the policy process than an analysis of it.

Like the other IPCC reports, it involved hundreds of participants from over 50 countries, but it falls short of its

claim to be a comprehensive analysis of policy options. It seems that there is neither the body of scholarship on the policy aspects on which to base a substantive summary or critique nor the political ability to reach a consensus on an evaluation of the policy options. *IPCC-III* is essentially a political document, reflecting rather than describing the political realities, which include the different positions of participating countries.

Nonetheless, *IPCC-III* does provide some solid information on greenhouse gas emissions under various scenarios of population growth, economic development, and energy use. It lists generic types of response strategies to limit emissions from energy, industry, agriculture, forestry, and other activities. It acknowledges strategies to adapt to potential impacts of climate change, particularly in coastal zones and in resource management. It provides a checklist of implementation mechanisms relating to public education and information, technological development and transfer, economic mechanisms, financial measures, and legal and institutional actions.

The inventory of types of response is certainly valuable, but there is not much analysis or critique of policy options, at any scale. What there is deals mainly with technical matters such as ramifications for gas emissions and concentrations. Various criteria are proposed for evaluations of actions (efficiency, equity, economic benefit, environmental protection, implementability, etc.), but these are rarely applied, and principles for resolving incompatibilities among the criteria are not established.

There are many recommendations throughout the volume, most of a form one might expect, given the report's origins. Thus, there are recommendations for more data, for inventory, and for monitoring. There are statements that governments 'should ...' develop policies to reduce deforestation, to promote coastal zone management, to improve energy use efficiency, etc. The words '... there needs to be ...' appear over and over, but these broad principles and recommendations are rarely tied to scholarship or to the political processes of international and national policy evolution. A noteworthy exception is the development in *IPCC-III* of a framework for a Climate Change Convention, which was subsequently developed (or, depending on your point of view, watered down), at UNCED in Rio. Apart from the checklist of potential policy strategies and instruments, *IPCC-III*'s main instructional value is the insight it provides into the way in which the international community handles the question of what to do about climate change.

The caution of *IPCC-III*, its 'wait and see' and 'don't rock the boat' orientation, all of which were widely apparent before the release of the report, prompted

Greenpeace to prepare its *Global Warming: The Greenpeace Report*. Analyses and syntheses of climate-change policy are rare, and the Greenpeace report includes some of the few substantive pieces in this area. Readers may disagree with Greenpeace's premise (that there is a grave and immediate threat), may not support the prescriptions, and may take issue with particular evaluations or calculations in them. But the Greenpeace report is still the most rigorous treatment of policy options around. It does not skirt the technical issues. It lays out the magnitude of the policy challenges, it describes in detail some policy mechanisms, and provides evaluations of their implications. It addresses the questions of costs and benefits, renewable energy, motor vehicles, nuclear power, electricity, the challenge of choices, tropical forests, and so on.

Throughout the policy field there are huge gaps. If the social science of impacts has a way to develop, then the political science of responses is in even poorer shape. Both *IPCC-III* and *Greenpeace* offer very particular and simplistic views of the policy dimension.

Where is the recognition (let alone analysis) of the ideas suggested by Ravetz, Timmerman, or Brewer in *Sustainable Development of the Biosphere*? Where is the analysis of the science-media-policy dynamic described by Schneider? Where is the insight provided by institutional analysts, structuralists, development theorists, social analysts, political economists, or human geographers? Are there some conceptual frameworks in political science which could help us better understand the political dimensions of this issue? The IPCC community seems to think that 'science' is only relevant to the climate part of the issue, and that socio-economic implications and policy responses are things that one (anyone!) does from general knowledge or personal experience. That these fields are amenable to rigorous, systematic analysis is still not widely accepted.

So What for Geography?

Much of the literature noted in this review treats the issues of global change and climate change as if they are relatively new. As a result, we see attempts to develop concepts, to coin definitions, and to design conceptual models to address these recent problems. Yet geography has a rich scholarly heritage to draw from in these areas. Certainly, the global scope of these issues is now more widely recognized than before. And, yes, there is probably a more receptive audience on the applied side to suggestions that we reconsider the ways in which human-

ity uses the earth. But the principles and concepts need not start from scratch.

Rather than focusing exclusively on this year's interesting problem, we should address these issues in light of the relevant existing scholarship. There is considerable merit – even necessity – in exposing students to the intellectual history of society-environment interactions. Perhaps we do not need to go back as far as Plato, Malthus, Réclus, and Marsh. But we should at least consider such works as *Man's Role in Changing the Face of the Earth* and *Limits to Growth*, and we should recognize and build on the integrative traditions in geography.

Of course, as part of our teaching craft, we should play up the topicality, the relevance, even the urgency of these subjects. My experience is that students are easily enthused about these topics – they seem almost primed – and they are reasonably informed about the general nature of the issues. The pressing need is to instill some rigour into their assessments and prognostications. This involves exploring the scholarly fields, within geography and beyond, which can contribute to our comprehension of global changes. In the climate change area there is a desperate need for systematic, critical analysis of human impacts, adaptations, and responses. Surely scholarship in these fields can draw upon the research traditions in human ecology, hazards, impact assessment, cumulative effects, risk evaluation, decision making, behavioural analysis, game theory, institutional analysis, conflict resolution, political economy, structural analysis, and so on. There is more than enough material to enrich the scholarly diets of our students on the topic of global change.

Acknowledgments

I am grateful to the Social Science and Humanities Research Council of Canada and the Canadian Climate Program for facilitating my involvement in this field. I acknowledge the constructive suggestions and other support from Richard Kuhn, John Smithers, Andrew Couturier, Terry Gillispie, and an anonymous reviewer.

References

- BENNETT, R., and ESTALL, R., eds 1991 *Global Change and Challenge: Geography for the 1990s* (London: Routledge)
- BOLIN, B., DOOS, B.R., JAGER, J., and WARRICK, R.A., eds 1986 *The Greenhouse Effect, Climatic Change, and Ecosystems (SCOPE 29)* (Chichester: Wiley)
- CANADA 1991 *The State of Canada's Environment* (Ottawa: Supply and Services Canada)
- CANADA 1987–1992 *Climate Change Digest* (Downsview: Atmospheric Environment Service, Environment Canada)
- CLARK, W.C., and MUNN, R.E., eds 1986 *Sustainable Development of the Biosphere* (Cambridge: Cambridge University Press)

- DEFRIES, R.S., and MALONE, T.F., eds 1989 *Global Change and Our Common Future* (Washington, DC: National Academy Press)
- DZIKOWSKI, P., ed 1991 *Changing Climate in Relation to Sustainable Agriculture: Proceedings of a Symposium/Workshop*, 29–30 July, Fredericton, NB
- GLANTZ, M.H., ed 1988 *Societal Responses to Regional Climatic Change: Forecasting by Analogy* (Boulder, Westview)
- HENGEVELD, H. 1991 *Understanding Atmospheric Change*, SOE report no 91–2 (Ottawa: Environment Canada)
- HOUGHTON, J.T., JENKINS, G.J., and EPHRAUMS, J.J., eds 1990 *Climate Change: The IPCC Scientific Assessment* (Cambridge: Cambridge University Press)
- IDS0, S.B. 1989 *Carbon Dioxide and Global Change: Earth in Transition* (Tempe: IBR Press)
- INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 1991 *Climate Change: The IPCC Response Strategies* (Washington, DC: Island Press)
- KATES, R.W., AUSUBEL, J.H., and BERBERIAN, M. eds 1985 *Climate Impact Assessment: Studies of the Interaction of Climate and Society (SCOPE 27)* (Chichester: Wiley)
- LEGGETT, J., ed 1990 *Global Warming: The Greenpeace Report* (Oxford: Oxford University Press)
- MEADOWS, D.H., and MEADOWS, D.L. 1972 *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe Books)
- MUNGALL, C., and MCLAREN, D.J., eds 1990 *Planet under Stress: The Challenge of Global Change* (Toronto: Oxford University Press)
- NATIONAL CLIMATE PROGRAM OFFICE and the CANADIAN CLIMATE CENTRE 1989 *Impacts of Climate Change on the Great Lakes Basin*, report of the First U.S.-Canada Symposium, 27–29 September 1988, Oak Brook, IL
- ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT 1991 *Climate Change: Evaluating the Socio-Economic Impacts* (Paris: OECD)
- PARRY, M. 1990 *Climate Change and World Agriculture* (London: Earthscan)
- PARRY, M.L., CARTER, T.R., and KONIJN, N.T., eds 1988 *Assessments in Cool Temperature and Cold Regions*, Vol 1 of *The Impact of Climatic Variations on Agriculture* (Dordrecht: Kluwer Academic Publishers)
- 1988 *Assessments in Semi-Arid Regions*, Vol 2 of *The Impact of Climatic Variations on Agriculture* (Dordrecht: Kluwer Academic Publishers)
- ROSENBERG, N.I., EASTERLING, W.F., CROSSON, P.R., and DARMSTADTER, J., eds 1989 *Greenhouse Warming: Abatement and Adaptation* (Washington, DC: Resources for the Future)
- SCHNEIDER, S.H. 1989 *Global Warming: Are We Entering the Greenhouse Century?* (San Francisco: Sierra Club)
- SCIENTIFIC AMERICAN 1990 *Managing Planet Earth: Readings from Scientific American* (New York: W.H. Freeman)
- SMITH, J.B., and TIRPAK, D.A., eds 1989 *Potential Effects of Global Climate Change on the U.S.A.* (Washington, DC: Environmental Protection Agency)
- TEGART, W.J. MCG., SHELDON, G.W., and GRIFFITHS, D.C., eds 1990 *Climate Change: The IPCC Impacts Assessment* (Canberra: Australian Government Publishing Service)
- THOMAS, JR., W.L., ed 1956 *Man's Role in Changing the Face of the Earth* (Chicago: University of Chicago Press)
- TOPPING, JR., J.C., ed 1988 *Preparing for Climate Change, Proceedings of the First North American Conference on Preparing for Climate Change: A Cooperative Approach* (Washington, DC: Climate Institute)
- 1989 *Coping with Climate Change: Proceedings of the Second North American Conference on Preparing for Climate Change – A Cooperative Approach* (Washington, DC: Climate Institute)
- WALL, G., ed 1991 *Symposium on the Impacts of Climatic Change and Variability on the Great Plains* occasional paper no 12, Department of Geography Publication Series (Waterloo: University of Waterloo)
- WALL, G., and SANDERSON, M., eds 1990 *Climate Change: Implications for Water and Ecological Resources: Proceedings of an International Symposium / Workshop* occasional paper no 11, Department of Geography Publication Series (Waterloo: University of Waterloo)
- WALL, G., and WEBER, L., eds 1990 *Canadian Climate Program: Proceedings of the Fourth Meeting on Northern Climate* 17–18 October, Yellowknife, NWT
- WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT 1987 *Our Common Future* (Oxford: Oxford University Press)
- WORLD METEOROLOGICAL ORGANIZATION 1989 *The Changing Atmosphere: Implications for Global Security, World Conference Proceedings*, 27–30 June 1988, Toronto (Geneva: World Meteorological Organization)
- WYMAN, R.L., ed 1991 *Global Climate Change and Life on Earth* (New York: Routledge, Chapman and Hall)