Human choice and climate change: an international assessment

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EDITED BY
Steve Rayner & Elizabeth L. Malone

VOLUME ONE
The societal framework

VOLUME TWO
Resources and technology

VOLUME THREE
The tools for policy analysis

VOLUME FOUR
"What have we learned?"

The *Human choice and climate change* sample file

This file comprises enough sample material from the four-volume work, *Human choice and climate change*, for the reader to be able to judge whether the books are likely to be useful for teaching purposes. The following items are included:

- The complete Introduction, which is common to all four volumes
- The table of contents for each volume
- The first two pages of each chapter.

At the end of the file is an inspection copy request form for use by anyone needing a detailed look at any of the volumes in anticipation of recommending the books strongly for purchase by students taking an examinable course.

NOTE: These pages are printed at 80% of their true final size.

Why study human choice and climate change?

Steve Rayner & Elizabeth Malone

Why the concern with climate change?

Time and again over the course of the past decade, climate change has been described by scientists, environmentalists, and politicians as a threat unprecedented in human experience. Tolba's (1991: 3) statement is representative of such concerns: "We all know that the world faces a threat potentially more catastrophic than any other threat in human history: climate change and global warming." Many reasons and combinations of reasons are advanced for this claim, especially the potential rapidity of temperature rise, the irreversibility of change once the forces are set in motion, the geographical scale of the threat, the complexity and nonlinearity of the natural systems involved, the ubiquity and strength of human commitment to combustion technologies, and the political challenges of global cooperation that climate change seems to demand. The real danger, say many, lies in the potential for catastrophic surprise.

Similarly, several candidate causes have been identified. Emissions of greenhouse-related gases from human activities constitute the proximate cause, of course. In the background lurk possible underlying causes: population growth, overconsumption, humans' inability to control the technologies they have created, their inability to implement environmentally benign technologies, their unwillingness to spend current wealth to benefit future generations, their powerlessness to forge effective international agreements and abide by them. Whatever the cause, climate change is framed as a problem, which admits the possibility of solution.

Solutions come in many forms and approach the problem from different angles. Solutions to scientific problems take the form of improved knowledge, understanding, and predictability of natural systems. Solutions to technological problems require innovation and commitment of resources. Solutions to problems of societal cooperation and coordination are offered in the form of international treaties and policy instruments such as taxes or emissions

controls. However, all solutions imply choices that must be made, consciously or unconsciously, enthusiastically or reluctantly, and with levels of information that may be satisfactory or unsatisfactory to the choosers.

Why the concern with human choice?

The possibility of human choice, albeit constrained, underlies all of these discussions; that is, humans can choose to respond to the prospect of climate change and can decide, with undetermined and perhaps undeterminable degrees of freedom, what steps to take. However, choice does not merely underlie any possible solution to climate change; it also underlies the problem itself. Increasing global greenhouse gas concentrations are the result of myriad choices that compose the history and contemporary operation of industrial society. Any attempt to change the course upon which human society appears to be embarked requires not only new choices about future actions, but also understanding of past choices—the existing social commitments that have set the world on its present course. The possibility, indeed the inevitability, of choice lies at the core of the climate change issue.

Everyone makes choices about accepting participation in any sort of society (even rebelling against it). Much of human life is devoted to negotiating within families, laboratories, firms, communities, nations, and other institutions the particular balance of independence and interdependence that each person is willing to accept. This tension, characteristic of all forms of social existence, is thrown into stark relief by the controversies that rage and the choices that must be made about the potential for climate change. Questions of choice, therefore, lie at the heart of not only the climate change issue but also the social sciences.

Possible choices with reference to climate change can be grouped into three broad categories, which can be combined in various ways:

- Do nothing. Some say that concern about climate change is unwarranted; the science is unproven, based on speculation bolstered by models so inaccurate they cannot reproduce historical shifts in climate. Others believe that impacts will be gradual, easily accommodated through technology, or insignificant on a global scale. If climate change does occur, then piecemeal adaptation will suffice. Even some who do believe that climate change is likely and may be disruptive suggest that the aggregate benefits of allowing climate change to run its course would outweigh the costs.
- Mitigate, that is, lessen emissions to reduce the magnitude of climate change. If one is convinced that anthropogenic emissions are giving rise to climate change, the obvious direct solution to the problem is to reduce

net emissions. Motivations for preferring this option include not only its directness but also, perhaps more importantly, that it can be conjoined with favored solutions to other perceived problems, such as population growth or the income disparities between industrialized and less industrialized nations.

- Anticipate and adapt; that is, change crops and growing regions, retreat from or defend coastal areas, prepare for population shifts and health impacts. Advocates of anticipatory adaptation also regard it as an opportunity to develop policies and technologies that would be beneficial in any event, such as infrastructure that is more resilient to extreme weather events.

For all three strategies, or any combination of them, it makes sense to invest in new knowledge. Improving the accuracy of climate forecasting may confirm that humans need not take any concerted action. Mitigation may require developing new technologies that will allow economic development while reducing the anthropogenic contributions to climate change. Society could invest in geoengineering techniques or large-scale removal of carbon dioxide from the atmosphere. Anticipatory adaptation will require foresight about impacts and new technological and social developments to respond to them.

But who should choose among the possible responses and combinations of responses to climate change? Since it is a global issue, the obvious decision-makers are the governments of nation states who have enjoyed legitimacy as the arbiters of high policy throughout the modern era. People habitually turn to their governments to choose goals (such as emissions reductions) and policy instruments (e.g., a carbon tax). Often climate change research among the social sciences focuses on the macro level of national and international political choice. Certainly the knowledge of how choice processes and mechanisms operate at these levels is valuable in framing issues and conducting negotiations.

However, research at the macro level may reduce important dimensions of social choice to simple instrumental issues. For example, the fundamental concept of fairness, as the glue holding societies together, may be reduced to an instrumental factor affecting the efficient implementation of the goal of emissions reduction. Furthermore, who chooses when the nation state or the market fails to produce a solution? The slogan, "Think globally—act locally" expresses the widespread recognition that choices are made at the micro level, by individuals and groups in particular places. Even in the context of national or international regulations, firms, families, communities, and citizens choose how to respond to incentives and sanctions. Moreover, other institutions, such as environmental organizations, can choose to respond in more robust ways and to try persuasive strategies so others will act voluntarily to comply with or even exceed statutory requirements.

Behind all such questions about choices associated with climate change lurk general questions about how societies and institutions choose the choosers and confer legitimacy upon their decisions. These are problems of collective choice. Choices are embedded and intertwined in social institutions of all kinds, including interest groups, pressure groups, lobbies, elected officials, citizens, and so on. Choices are often so deeply entrenched in societal norms that people will resist persuasion and coercion aimed at changing their behavior.

In part, the role of the social sciences is to probe these background choices by providing the capability to continually examine and re-examine our assumptions, that is, to provide what social scientists call "reflexivity" about societal choice. In the case of climate change, the social sciences remind us to question assumptions and propositions that those who are already committed to a course of action may take for granted. For instance, the conscious choice of responses arises only after we have chosen which issues to take seriously. How do people choose from among a large set of possible problems to work on as scientists, activists, entrepreneurs, homemakers, or politicians? How do individual choices influence what happens at a societal level? What roles do cultural and institutional processes play? How did the choice set of possible or potential issues come to be framed? How did other issues get to be excluded or incorporated into others? With regard specifically to climate change, various questions about choice are intertwined, for example:

- How do scientists choose to study climate change? How do they form a scientific consensus?
- How do people decide that climate change is worthy of attention?
- How do people attribute blame for climate change and choose solutions?
- How do people choose whom to believe about climate change and at what level of risk do they or should they choose to act?
- How do people and institutions mobilize support for (or against) policy action on climate change?
- What is the relationship between resource management choices and climate change?
- How do governments establish where climate change stands in relation to other political priorities?
- How are climate change policy instruments chosen?
- Why and how did the international community choose to address climate change?
- How do societies select technologies that cause, mitigate, or assist adaptation to climate change?
- How can research on social or collective action be useful to the global climate change debate?

Understandably, those who are unshakably convinced, either that climate

change is an urgent and impending catastrophe or that talk of climate change is merely, to quote one US Congressman, "liberal claptrap," are likely to be impatient with such questions. For almost everyone else concerned about the issue, such questions may be the starting point from which society can work to make wise decisions about its future.

Different disciplines approach the kinds of questions that we pose from different perspectives, frequently simply modifying or fine-tuning the tools already in hand to account for choice. Issues of human needs and wants, the social bases for cultural or institutional choices, uncertainty, imperfect knowledge, and irrationality are often elided because they are too difficult to represent in equations and computer models.

As we venture among the social sciences, we run into rival prescriptions about how such choices ought to be made (e.g., by experts, by majority vote, by consensus, by preferences revealed in the marketplace) as well as the criteria to be used (e.g., the greatest happiness of the greatest number, or safeguarding individual or majority rights). In this sense, the social sciences reflect the diversity and the unity of human societies, institutions, and individuals on the issues of human choice facing the prospect of climate change.

The problem of collective choice has usually been framed as one of aggregation or of coercion:

- how to aggregate individual preferences into a collective preference, or
- how to persuade individuals to conform with normative requirements of corporations and governments, as implemented by the decisionmakers who are their officials.

Arrow (1951) has famously demonstrated the impossibility of aggregating individual preferences into a collective one in a way that satisfies certain minimal conditions of rationality and transitivity. For Arrow, the dictatorial social welfare function is the only one possible. However, dictatorship is incompatible with democracy. We seem to be caught in a bind. But Arrow's analysis assumes that preferences are inherently individual. If we use another set of assumptions—for example, that preferences are inherently relational (that is, expressions of social solidarity)—we change the nature of the problem from being one of aggregating individuals to discerning the structure and dynamics of social solidarity, which in turn may open up a new solution space for the problem of collective action.

Social science has long been confronted with the central issues of choice and constraint, and, thus, climate change is far from being a unique problem for the social sciences. Moreover, the individual–society tension within the social sciences often reflects a theoretical and methodological gap between the mindsets and methods of various social science disciplines. Even within disciplines, social science paradigms differ in their views of collective action. The problem

of understanding and choosing a course of action with respect to climate change is that of articulating choices and consequences across the local and global levels.

For some analysts, social choice is an issue of aggregating individual preferences (from citizens to nations), whereas for others it is rather a problem of decomposing national or communal preferences into appropriate units of social solidarity, such as the household, the village, or the firm. It is pointless to ask which approach is right and which is wrong. Like wave and particle explanations of light, each offers insights that the other cannot reproduce. The characteristics of light's wave and particle properties cannot be simultaneously measured, yet both sets of properties are essential to understanding the behavior of light. Similarly, it is important to understand the sources and consequences of the divergent social science approaches to explaining human behavior so that climate change researchers and practitioners can capitalize on the strengths of that diversity.

The conceptual architecture of this assessment

Human choice and climate change is a climate-oriented assessment firmly rooted in the social sciences. That is, it takes as its starting point human social conditions around the world. Instead of examining the physical and chemical processes of climate change, this assessment looks at climate change in the broader context of global social change. Analysis of climate change needs to be conducted in the context of mainstream social science concerns with human choice and global (not just environmental) change. A global developmental and environmental perspective can be helpful to policymakers and scholars for at least two reasons:

- Social systems intersect and interact with several natural systems simultaneously and interdependently. Human activity therefore represents a crosscutting system constituting major linkages among natural cycles and systems. Hence, changes in human activity stimulated by interaction with one such system tend to influence others in potentially significant ways.
- The scale and rate of change in social systems may well outpace the scale and rate of climate change for the foreseeable future. For example, even vulnerable populations and vulnerable natural resources may plausibly be more directly affected by general economic conditions than by climate change over the course of the next hundred years.

The entry point of a global social science perspective allows us to set our bounds very widely. For instance, in the social sciences, the topic of "climate change" encompasses people's perceptions and behavior based on the threat

(or, in a few cases, the promise) of such change, as well as the causes, processes, and prospective impacts of the change itself. In *Human choice and climate change*, we broaden our scope beyond that of the Intergovernmental Panel on Climate Change (IPCC) Working Group on the Economic and Social Dimensions of Climate Change (Bruce et al. 1996) to include research that, although relevant, is not focused specifically on climate change itself. At the same time, we have retained the orientation of climate change as an important policy issue that can act as a touchstone or reference point for theories and research.

Just as the same physical object confronted from different angles may present very different appearances to an observer, so can the same problem be very differently defined when viewed from different paradigms. One strategy for our assessment would have been to accept the conventional framing of the human dimensions of climate change in terms of proximate causes and impacts. Most extant texts concerned with the human dimensions of climate change or, more broadly, of global environmental change begin with a summary of the way that the natural sciences describe the changes that are occurring on the land and in the atmosphere and oceans (e.g., Jacobsen & Price 1991, Stern et al. 1992). These assessments draw directly on the natural sciences to frame the issues for social science inquiry. However, the authors and contributors to this project opted for a riskier approach of attempting to define climate change and, by extension, global environmental change from a thoroughgoing social science perspective.

We seek to learn from approaching the natural sciences from a social science viewpoint rather than through what has been the more orthodox approach of wading into the social science waters from the conventional terra firma of the natural sciences. In so doing, we do not seek to subvert the findings of the natural sciences or discover some social pretext to dismiss societal concern about climate. Rather, we seek to provide an additional footing from which the intellectual landscape of the climate change issue can be viewed. We have tried to complement the natural science perspective, not to replace it with another single vantage point.

Human choice and climate change is presented in four volumes. In the first three volumes, our goal is twofold: to create a text that could serve as an overview of social science relevant to global climate change for researchers with backgrounds in the natural sciences or in the social sciences but not as those backgrounds relate to global climate change; and to provide a reference work for both scholars and practitioners as they perform research, conduct negotiations, or plan and implement policies. To accomplish this goal, the assessment seeks to:

- Represent the range of social science research applicable to global climate change
- Provide insights into the world as viewed through the lens of social science topics, tools, and data
- Review what is currently known, uncertain, and unknown within the social sciences in relation to global climate change
- Assemble and summarize findings from the international research communities of industrialized, less industrialized, and newly democratic nations
- Report these findings within diverse interdisciplinary frameworks
- Relate research results to policy issues and problems.

The fourth volume provides an editorial overview of the first three, reflexively focusing on the challenges that climate change issues present to the intellectual organization of social science, the lessons that the social sciences can bring to understanding climate change issues, and the implications of all of this for policymakers.

In each volume, we have sought to present the subject at a level of detail and theoretical sophistication to make the assessment useful as a reference work for scholars. We have also attempted to tie the material to practical issues useful to decisionmakers and their advisors. We are acutely aware that in aiming the assessment at two audiences we run the risk of pleasing neither. To the first audience we may seem simplistic, even instrumental in our approach. We may strike the second audience as excessively abstract and academic. However, it is our hope that the dual focus of this assessment can be fruitful in pointing to convergence between scholarship and action.

Human choice and climate change, volume 1: the societal framework

Volume 1 of *Human choice and climate change* begins our inquiry into social science perspectives and climate change with an assessment of the state of the Earth's social, cultural, political, and economic systems, which provide the context that supports and consists of the activities that contribute to the emissions of greenhouse gases and within which:

- climate change is perceived and debated
- the impacts of change will be experienced
- human beings will make the critical choices about their future, including choices about how to confront the prospect of changing climate in a changing world.

Climate change is occurring in a complex and rapidly changing framework of human choices that shapes people's perception of it and the opportunities for human response. The social context of climate change and knowledge about it

are usually taken for granted. Subjecting it to social science analysis reveals the extent to which our understanding of the science, diagnoses of underlying causes, and views of appropriate action are not merely technical judgments, but embody deep-seated social commitments that provide the context for response options.

"Science and decisionmaking," the first chapter, examines the social processes by which technical knowledge about climate change (and other science-based issues) is created by scientists and communicated to policymakers. The authors begin with four interlocking questions that remained unasked, even unacknowledged, in earlier assessments of social science and climate change:

- How do scientists and their societies identify and delimit distinct problems related to climate change that are considered amenable to scientific resolution?
- How do scientists come to know particular facts and causal relationships regarding climate change and to persuade others that their knowledge is credible?
- How do conflicts over risk arise, and how are responses to them handled in a world of conflicting and plural political interests?
- How do human societies and their designated policy actors draw upon scientific knowledge to justify collective action on a worldwide scale?

The authors describe the role that the production and dissemination of scientific knowledge have played in the elevation of climate change to a topic of worldwide interest and political concern. Their analysis reveals how the normal model of the relationship between science and policy, which has been termed "speaking truth to power," assumes that the two domains are and should be largely distinct. However, social science analysis indicates a level of interdependence between science and politics so strong as to constitute a process of co-production of relevant knowledge, which most often occurs unrecognized by either scientists or policymakers.

Science and technology studies demonstrate how scientists build on local experiments and knowledges in laboratories and field studies to formulate generally accepted methods, facts, and theories. Through a process of standardization and network building, scientific knowledge can attain a universal validity, as climate change science has through the deliberations of the IPCC. Applying insights from studies of the social processes of scientific inquiry, the chapter examines the implicit assumptions embedded in theories and models used to study interactions between the biogeophysical and social systems. Making these assumptions explicit provides an opportunity to question them and to examine their validity in the specific situations to which the theories and models are being applied. This reflexivity is important because scientific research that fails to engage in such self-examination risks becoming irrelevant

to the world beyond the laboratory or academy walls. Perhaps worse, it leaves science susceptible to political backlash against scientific consensus on climate change—just as has happened in the US Congress. Policymakers who rely on data from unreflexive research risk errors in their decisionmaking that may cost them (and the societies in whose name they act) dearly, whether financially, politically, or socially.

The interdependence between scientists and policymakers constitutes a process of co-production of knowledge seldom recognized by either.

"Population and health" and "Human needs and wants," the next two chapters, demonstrate that neither of the standard diagnoses of the underlying causes of climate change—overpopulation and overconsumption—can be justified by social science research. Chapter 2, "Population and health," lays out the world's changing sociodemographic profile, the social science controversies about the role of population in climate and other environmental change, and the micro-scale factors that shape peoples' preferences about family size and spacing of children. Although the authors find that rapid population growth has a negative effect on the development of many, albeit not all, less industrialized countries, the extent of this effect is difficult to quantify, or even to demonstrate on a global scale because of the complexity and multiplicity of relationships involved and the variability of local circumstances. The authors conclude that population policy has too often been based on the easy, specious logic "You would be happier if you had fewer children," which cannot be justified by rigorous social science evidence. The real underlying logic is often "I would be happier if you had fewer children."

The real logic underlying population policy is often "I would be happier if you had fewer children."

Population, as such, is not the issue shaping climate change or other environmental degradation. The appropriate question is how are population factors mediated through institutional and social structures to affect natural resources and the environment? In some areas population makes a big difference to environmental impacts; in others it does not. Where it does make a difference, the costs and benefits of intervening directly to affect population must be weighed against the costs and benefits of policies designed to loosen institutional rigidities that prevent families from responding flexibly to the pressures of population growth. The people most vulnerable to impacts of climate change tend

to be members of impoverished populations living in environmentally fragile zones of less industrialized countries. These populations already adapt very flexibly to the impacts of extreme climatic fluctuations, such as storms and droughts, albeit at considerable cost of human life and suffering. But climate change may overstretch their coping capacity. Although it is quite unlikely to change the big picture of world population size, rate of growth, and age structure, climate change will have an impact on mortality, fertility, and migration at regional and local levels.

If the impact of population is less than straightforward, what can be said about consumption? What justification is there for distinguishing consumption for survival from luxury consumption? Chapter 3, "Human needs and wants," evaluates the attempts of various disciplines to establish human needs as the basis for climate policies compatible with individual fulfillment and societal development. The authors show that the concept of basic human needs has universal rhetorical appeal, but it cannot made operational coherently in a way that helps policymakers to define climate policy goals. Everyone may agree that clean air, access to potable water, a minimum ration of calories and protein—even entitlements to atmospheric carbon sinks—are all somehow basic human needs, but in practice it is impossible to devise universally standardized measures for their operationalization. How clean is clean? How pure is potable? What constitutes access? What is the age and level of activity of the individual to be fed?

Only by understanding the essentially social character of needs, wants, and their satisfaction through consumption can analysts and policymakers lay the basis for behavioral change.

Furthermore, needs and wants cannot be usefully distinguished. Needs turn out to be wants that someone is unwilling to give up. So long as social scientists and policymakers continue to treat wants as private appetites, they cannot understand how wants come to be standardized in society and how those standards change. The issue of how societal preferences change is a critical one for long-term modeling and for policy interventions that seek to alter either the scale of consumer demands (including demands for small or large families) or the technologies by which demands are satisfied. If consumption choices are recast—not as private preferences but as public statements establishing or confirming community identity, group membership, or social solidarity—then fundamental changes in consumption patterns are likely to require very basic changes in the kinds of society people live in. Only by understanding the essentially social character of needs, wants, and their satisfaction through consumption can analysts and policymakers lay the basis for behavioral change.

The authors of Chapter 3 focus attention on the emergence of new models of wealth, based on the notion of social capital, that includes the levels of social support that people can expect from the communities and institutions to which they belong (rather than focusing on dollars per individual). Criteria for measuring social capital are being explored; however, they have not yet reached the level of development or received the recognition already being given to the valuation of natural capital and so-called green accounting.

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The broader "Cultural discourses" about climate are the subject of the fourth chapter, which probes deeper into societal controversy over diagnoses and prescriptions and exposes the social commitments that underlie the range of opinions and political positions. In the course of debating climate change at home, at work, in the media, or in the halls of power, experts and lay people alike diagnose the underlying human causes of climate change as lying in population growth, profligate consumption, or incorrect pricing and property rights allocations. In response to these diagnoses, participants in these cultural discourses seek prescriptions to remedy climate change while protecting competing principles for procedural fairness as well as distributional and intergenerational equity. Disagreements about the underlying human causes of climate change and proposed solutions to it are deeply rooted in competing institutional narratives about nature as well as rival principles of fairness. The chapter illustrates that debate about climate change is often a surrogate for a broader, so-far intractable political discourse about population, lifestyles, and international development.

In elucidating the various voices of experts and lay people in the climate change debate, the chapter demonstrates that the basis for such discourses is essentially institutional. The authors make a strong claim that social relationships, rather than individual preferences, stabilize the public expression of values about what is natural and what is right. How people bind themselves to each other simultaneously shapes the way they bind themselves to nature. Social and cultural variables of network density, interconnectedness, and rule sharing account more effectively for variations in environmental perceptions and behavior than do standard demographic variables such as age and sex. To guide the reader through this novel landscape, the authors present a conceptual map of human values to help social scientists identify and track the strength of support for alternative positions and to help policymakers identify opportunities for effective intervention in the debates.

Public information campaigns that assume that discrepancies between lay and experts accounts of climate change are simply attributable to knowledge deficiencies are bound to fail.

The social science perspective represented in this chapter suggests that public information and education campaigns to change people's energy use or other environmentally relevant behavior fail because changing behavior is not simply a problem of removing exogenous barriers to the natural flow of knowledge. The social science perspective redirects efforts at communication from simply overcoming ignorance to creating shared frames of reference and opportunities for shared action. Public information campaigns that assume that discrepancies between lay and experts accounts of climate change are attributable simply to knowledge deficiencies are bound to fail.

Climate discourses are complex and turbulent. Many voices join in, and they are often inconsistent, even self-contradictory, but not randomly so, nor in a way that can simply be ascribed to naked self-interest. By labeling the present state of affairs as disorderly, each voice seeks to legitimate the reordering of society along its own preferred institutional principles. How these institutional arrangements are structured and operate in the climate change arena is the topic of Chapter 5, "Institutions for political action," which ties the value commitments of climate discourses to the institutional arrangements that human beings use for making collective choices about society and the environment.

The growing prominence of global environmental issues as matters of high politics is itself a sign that the nation state retains an important and powerful position. However, the character and the role of the state are changing rapidly in fundamental aspects of its international and domestic roles. Political influence and real power is diffusing to international and domestic policy networks in which governments and their agencies interact directly with social movements, firms, and communities. The notion of unitary national interest is increasingly difficult to sustain. The rising importance of nonstate actors and the emergence of aspects of a global civil society, in the light of global climate change, are now garnering much attention from sociologists and international relations scholars alike.

The real business of responding to climate concerns may well be through smaller, often less formal, agreements among states; states and firms; and firms, nongovernmental organizations, and communities.

The new landscape of world politics—and global environmental politics in particular—has given voice to those formerly marginalized or excluded from political dialogue. The authors conclude that, although the Framework

Convention on Climate Change represents an important expression of worldwide concern about climate and the persistent issues of global development that are inextricably bound up with it, the real business of responding to climate concerns may well be through smaller, often less formal, agreements among states; states and firms; and firms, nongovernmental organizations, and communities.

However, this response process is likely to be messy and contested—not that messiness or contestation are to be disparaged. Patterns of interest-group mobilization and representation help to sustain a bias in favor of activities that lead to increasing greenhouse gas emissions. The status quo is insulated from fundamental change by the influence of routines, established procedures, and traditional and close ties among economic and political elites. Climate policies as such are bound to be hard to implement. Simply incorporating climate change into existing political agendas is unlikely to produce the desired outcomes. Similarly, presenting climate change measures as ways of achieving higher taxation or welfare expenditure is also likely to meet significant opposition. True win–win solutions prove to be elusive. Effective actions designed to mitigate or respond opportunistically or adaptively to climate change are likely to be those most integrated into general policy strategies for economic and social development.

Volume 1 places climate change in the dynamic context of a changing societal landscape that shapes changes in the atmosphere. Here the responses of political and social institutions are crucial, and human choice must be taken into account. Sometimes the separation of the biogeophysical systems from the social systems has led global climate change researchers to focus on climate change as if it were the most important issue facing the sustainable development of human society. Yet sustained consideration of one issue can be maintained only at the cost of excluding others. Decisionmakers need to consider the opportunity costs as well as the benefits of directing their present attention to climate change. Furthermore, for most of humankind, climate change is not life's most pressing issue, certainly not on a day-to-day basis. A social science framing of the problem introduces a more complex view by asking what else is going on in the development of human society and how climate change will affect and be affected by these societal changes. Volume 2 looks at climate change in relation to human resource use, and opportunities to reduce human impacts on the climate and climate impacts on humans, particularly through a broadly defined conception of technological change.

Human choice and climate change, volume 2: resources and technology

Volume 2 of *Human choice and climate change* anchors both the climate change issue and social science approaches to it in the context of the Earth's resources: climate, land, water, energy sources, and materials used in technologies. Climate change is the result of fundamental human choices about the conversion of energy and human occupation of the Earth's surface. These activities have been identified as both the proximate causes of greenhouse-related emissions and the sites of primary impacts on human activity.

Chapter 1, "The natural science of climate change" summarizes the present state of the international scientific consensus about climate change, drawing on the findings of the Second Assessment Report of the IPCC, as well as on other research. The social processes that go into producing and standardizing this kind of scientific consensus are described in the first chapter of Volume 1. Current scientific claims about climate change and its impacts introduce Volume 2 because it focuses on the major resource systems, or human support systems, that enable people to live as they do on the Earth: that is, land use, occupation of coastal zones, energy production and use, and the processes of technological change. As human systems, these are no less institutional systems than the ones examined in Volume 1. However, each is perhaps more directly dependent on constraints and opportunities presented by natural systems than (with the possible exception of population) the frameworks presented in Volume 1. Thus, it is appropriate at this point to introduce material from the natural sciences that social scientists should be aware of in analyzing and understanding the human dimensions of climate change.

This chapter explains the greenhouse effect, the results of greenhouse gas emissions on radiative forcing, and the mechanisms by which forcing translates into climate change. The complexities of these processes are further compounded by emissions of aerosols, the role of clouds, and interactions of gases in the atmosphere. Furthermore, the natural variability of climate is an undisputed fact, so the possible human contributions must be analyzed in the context of natural changes.

The current scientific consensus is that the global mean surface temperature has increased by 0.3–0.6° Kelvin (K) over the past century. The global temperatures in recent years have been among the warmest in historical records and probably one of the warmest periods in the past six hundred years. However, the warming is not uniform over the globe, with some areas even experiencing a cooling. The understanding of this climatic change is a high priority in the natural science community. Although the signal is still emerging from the noise of natural variability, recent studies suggest that the current changes in climate

are indeed related to human activities, including the emissions of carbon dioxide and other radiatively important gases and aerosols.

The chapter goes on to outline the potential effects of changes in various climatic factors, specifically sea level rise, human health, agriculture and food supplies, water resources, and nonagricultural ecosystems. Although knowledge is improving in these areas, many aspects of climate change remain highly uncertain. In particular, the regional changes in climate expected from global climate change are poorly understood, as are the impacts on humanity and the biosphere.

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The next four chapters trace the origins of climate change in human behavior at aggregated and disaggregated levels and focus on the potential impacts of climate change on fundamental human systems of productivity.

Chapter 2, "Land and water use," examines human activities that increase greenhouse gas emissions from the use of land and water resources. It also assesses the potential impacts of climate change and climate change policies on land and water use for the production of food, energy, fiber, and construction material, as well as for recreation, aesthetic and spiritual satisfaction, and creation of a sense of identity.

The intensification of land and water use has been a global trend during the five centuries of the colonial, industrial, and postindustrial periods. Today, every accessible hectare and waterway are managed (or deliberately not managed) for human ends. The most remote tundra in the Arctic North and the most forbidding reaches of the Sahara Desert are subject to human management decisions of one sort or another.

Land use and and water use are important to global climate change in at least three ways. First, land use affects the exchange of carbon dioxide, methane, and other greenhouse-related gases between the Earth and its atmosphere. Second, agriculture, forestry, and other land-based productive activities depend crucially on surface energy and water balance, which are closely linked to climate. Hence, they are more likely than other human activities to be affected by climate change. Third, projected growth in both population and resource-demands presents important challenges to land and water use in coming decades, whether climate changes or not. Discussions of global environmental change have tended to subjugate the issues of sustainable development of land and water resources to the globally systemic changes of ozone depletion and climate change. Analysts seek to identify no-regrets strategies that would enhance

sustainability and at the same time help to prevent or adapt to climate change. Many opportunities exist for sequestering carbon or limiting emissions, although they require a searching analysis of their full social and environmental repercussions.

The chapter concludes that climate change is by no means necessarily the most important challenge to the sustainability of land and water resources. The connections between land use and climate change are important, but should not be allowed to set the land-use research agenda. There is room for serious concern about the adequacy of land and water resources to meet current and likely future demands locally and globally, whether climate changes or not. Around the world, increasing misuse of land and water resources already threatens human welfare in the near to medium term. The apparent failure in these regions of management to forestall such threats underlines the need to study land-use and water-use adaptation strategies, regardless of any efforts toward reducing greenhouse-related emissions. Responses that can address these issues while addressing the challenges of climate change should be a priority for research.

Climate change is by no means necessarily the most important challenge to the sustainability of land and water resources.

Measures encouraging adaptation to climate change may likewise offer collateral gains in other areas, improved agricultural research being an important case in point, and institutional strengthening to facilitate adaptive shifts in land and water use another. The key lesson of social science analysis is that the constraints on and opportunities for successful response are not only technical, and that influencing land and water use in desired ways requires a sound understanding of how and why these resources are used.

Similar themes emerge from Chapter 3, "Coastal zones and oceans." Coastal regions are particularly important because of high concentrations of human population living close to the sea and their particular vulnerability to potential climate impacts.

Coastal zones have historically generated economic activities that allowed societies to flourish. Many coastal problems now being encountered worldwide result from many people's use of the terrestrial and aquatic resources over a long period of mostly unrestricted development of coastal areas. These problems include the accumulation of contaminants in coastal areas, shoreline erosion, and the rapidly accelerating decline of habitats and natural resources. Population growth and migration associated with economic development places additional demands on coastal areas and resources, posing another

threat to the sustainability of these areas. The impacts of unsustainable and often uncoordinated coastal development are likely ultimately to result in the degradation of natural systems that provide protection against the sea, habitat for many species, and food for many people. These impacts could pose significant risks to public health and welfare.

With or without climate change, coastal zones will see further growth in urban areas and increased tourism. The growing population density along the coasts will put further pressure on the resource base, including ocean fishing, wetlands-dependent products, and unique ecosystems and species. This pressure will probably result in deteriorating living conditions for many inhabitants, especially in less industrialized countries. Hence, there are strong imperatives to adopt integrated coastal zone management strategies that will combine responses to growing demands on coastal and ocean resources and the threat of climate change. Local knowledge will be essential to the success of these strategies. The adaptive coping abilities of coastal, often rural, and often nonliterate people have enabled their survival under stress. They have detailed knowledge of local conditions and past responses, as well as the complex and varied patterns of ownership and use of marine and coastal resources. In the policy hierarchy they seldom get their due recognition. Consultative and participatory approaches that include local stakeholders offer challenges and opportunities for both analysis and decisionmaking.

The adaptive coping abilities of coastal, often rural, and often nonliterate people have enabled their survival under stress. In the policy hierarchy they seldom get their due recognition.

The fourth chapter in Volume 2, "Energy and industry," examines global and regional patterns of greenhouse-related emissions arising from the production of goods and services. Over the twentieth century, energy use has become the most important human-generated source of greenhouse gases, especially carbon dioxide produced by fossil-fueled energy generation. Most analyses predict steady increases in worldwide energy consumption over the next several decades. Thus, any attempt to limit greenhouse gas concentrations in the atmosphere must focus on energy supply and demand and the costs associated with reducing greenhouse-related emissions from fossil fuel combustion. There is considerable uncertainty about what the levels of energy use and associated carbon dioxide emissions will be over the next century. Worldwide emissions of carbon from fossil fuel combustion are currently about 6 billion tonnes per year. In the absence of new policy initiatives, emissions projections range from a modest decrease to an increase by a factor of 15 over the next century.

Three complementary methods have been used to forecast the evolution of these changes:

- a top-down economic approach, relating aggregate energy use to fuel prices, labor and capital prices, and various measures of economic activity
- a bottom-up approach, employing engineering calculations on a technology-by-technology basis
- a social-psychological approach, focusing on how and why decisions regarding energy use are made at a more micro level than the top-down approach and embodying a more human-behavioral approach than the bottom-up approach.

In the absence of new policy initiatives, emissions projections range from a modest decrease to an increase by a factor of 15 over the next century.

A decade ago top-down and bottom-up approaches produced dramatically different projections. Since then it has become evident that each approach has its strengths and weaknesses, and various hybrid approaches have been proposed. Assumptions regarding the characteristics and likely rate of penetration of new technologies have been developed, and researchers have started sorting through the various explanations for slower than expected adoption of new technologies. There is still some debate about whether some of these explanations describe market failures or simply reflect indirect costs not typically included in the engineering estimates of using a new technology, but that debate has shifted from one about the analytic method to one about the fundamental assumptions employed.

All analyses point towards a much greater rate of growth in greenhouse gas emissions in the less industrialized countries than in the highly industrialized countries for at least three reasons:

- much higher rates of population growth
- higher rates of economic growth driven by technology transfer from the industrialized countries
- a propensity to pursue development through very rapid increases in the output of the heavy industries required to construct the facilities and infrastructure required to modernize economies.

Despite the greater importance of the presently less industrialized countries in shaping the greenhouse-related gas emissions and concentrations of the next century, analysis of these countries has been seriously undertaken only recently.

Two major research directions would greatly improve the usefulness of the analysis to policymakers:

- more intensive study of the less industrialized countries, where most of the growth in emissions is expected to occur
- improved integration between the economic, engineering, and social-psychological approaches.

The second of these is the topic of Chapter 5.

Whereas Chapter 4 concentrates on modeling energy production and use at the macro level, Chapter 5, "Energy and social systems," scrutinizes energy-related institutional decisionmaking about production and consumption at the level of the firm and household behavior. The chapter highlights the meaning and evolution of energy-consuming practice in everyday life. The authors advocate moving beyond conventional policy-oriented research, focused on the beliefs and behaviors of individual end users, to a focus on people as social actors operating within households, offices, government departments, or other institutions. Such a shift entails viewing energy-related decisions as processes of social negotiation rather than as the result of personal attitudes or enthusiasms. Rather than focusing on energy in isolation, or on the services that energy provides, energy-related practices are instead addressed as forms of consumption, much like any other.

What would the social world have to be like before specific energy-related innovations made sense?

Instead of taking the social goals and purposes of energy consumption for granted, the approaches explored in this chapter call those ends into question. The rationalistic notion that technologies are neutral problem-solving devices gives way to the view that problem and solution are, as it were, joined at the hip. The authors challenge researchers and policymakers to rethink the relationship between policy and energy demand and the way in which energy analysts and policymakers conceptualize the future. Instead of trying to predict the future, the authors advocate efforts to specify the sociotechnical preconditions for a range of possible futures. Rather than seeking to model people's impact on future energy demand, the question would be, what would the social world have to be like before specific energy-related innovations made sense?

Much of the research reviewed in this chapter emphasizes the extent to which the future is already inscribed in existing practices, infrastructures, and cultural arrangements that limit the scope for doing things differently. Together these suggest that, even in the most favorable of circumstances, policy levers that focus on end-users are unlikely to modify the web of interests and histories that surround their choices and habits. But conventional tools and forms of policy analysis configure the conceptual landscape and the perception of possible

courses of action, just as the tools and technologies of energy consumption configure their users. Discussion of the human dimensions of energy and global environmental change is currently embedded in a policy paradigm that contains within it a somewhat limited and restricting theory of social and technological change.

The dynamics of technological change have important implications for the expectation of many researchers and policymakers that such change will be important to resolving the issues of climate change. The final chapter in Volume 2, "Technological change," brings these issues into the foreground, illustrating how individuals, institutions, and societies select and reject technological opportunities. The chapter focuses on the important issues surrounding the dynamics of technical change and their outcomes, particularly in relation to attempts to orient technological developments.

"Technological change" begins with the fundamental question, "What is technology?" The answer is that the social sciences conceptualize technology in different ways, ranging from concrete artifacts and skills to more abstract, less nuts-and-bolts notions of technology as material culture or as sociotechnical landscapes.

Artifacts are black boxes that work; they are black boxes because users cannot see beyond their functions to their inner workings or their energy sources. Technological regimes, such as the hydrocarbon-based energy regime, consist of many commitments, sunk investments, and institutionalized practices that evolve in their own terms and are hard to change. Sociotechnical landscapes are the patterns of physical infrastructures, artifacts, institutions, values, and consumption patterns—the material culture of our societies—and the backdrop against which specific technological changes are played out. It is important to include all three levels of understanding technology, because its implication in climate change is as much through sociotechnical landscapes and technological regimes as through particular artifacts such as steam generators or internal combustion engines.

Thus, the conventional technology policy model of technology describes artifacts emerging from research and development establishments and subsequently transferred to the marketplace. However, this model tells only part of the story of technology in society. Other aspects include the processes and conditions of novelty creation, the messiness of implementation and introduction, and the aggregation of myriads of little decisions that underlie the development and embedding of technology in society. All of these elements are part of successful technological transformations that involve growing irreversibility and interdependence among social, economic, and material components of the sociotechnical landscape and that make it very difficult (but not impossible) to consciously direct technological change to meet climate policy ends.

There is no simple technical fix.

In exposing the societal embeddedness of technical systems and highlighting the opportunities and constraints for changing the ways in which humans use energy and the Earth's surface, the final chapter of this volume drives home the fact that there is no simple technical fix. What tools do we have? This question is the topic of the chapters assembled in Volume 3.

Human choice and climate change, volume 3: the tools for policy analysis

Public policy and private decisionmakers often look to the simplifying frameworks of formal tools of analysis to guide their decisions. The third volume of *Human choice and climate change* evaluates the adequacy of the conventional tools of policy analysis for supporting or making prudent human choices in the face of climate change.

Chapter 1, "Economic analysis," describes the strengths and limitations of the most widely applied toolkit of contemporary industrialized society and a substantial contributor to the current state of understanding climate change. "Economic analysis" seeks to explain how the wants of a population interact with the technical means for their satisfaction to produce demand for goods and services; what the scale of that demand, expressed as economic growth, implies for the global environment; and what constraints on growth might result from climate change policies. Proposed policies may be evaluated from a variety of perspectives; a mainstream approach usually includes growth-oriented economic analyses of the costs and benefits. Costs of mitigation in the near and medium term are weighed against often diffuse and uncertain benefits in the very long term, and must account for countries whose economic development may depend upon emissions-generating activities and who may thus be unwilling to trade off growth for emissions reductions. The result of most studies employing cost–benefit analysis is that relatively modest near-term actions are required, although the degree of intervention grows over time.

Global climate change is part of a class of problems that tend to exacerbate the shortcomings of the mainstream approaches to economics,

Other issues for economic analysis include valuing nonmarket (environmental) goods and nonmonetary transactions and assets; global efficiency, trade, and the implications of inequities in the global distribution of income; handling surprises; and the choice of time-cost discount rates, which must be based on social criteria that lie outside of the framework of economic analysis. Global climate change is part of a class of problems that tend to exacerbate the shortcomings of the mainstream approaches to economics, although economic analysis remains a powerful tool to evaluate candidate policy options.

Policymakers have readily adopted the economics approach to analyze future prospects for growth in greenhouse-related emissions and the consequences of attempts at intervention. This useful, if somewhat narrow, focus has been criticized from within and without the economics paradigm for ignoring shortcomings in the assumptions and methodology of economic growth, as well as the insights available from other fields of social science. Confronted with environmental degradation and resource exhaustion, growth practitioners have added depreciation of these resources to the depreciation of capital stock depicted in their models, thus reducing sustainability to a constraint in the optimizing problem of maximizing per capita income. Other practitioners have devised means of valuation for nonmarket effects and nonuse values. These values can be included in the conventional calculus of cost–benefit analysis, where they lose their visibility and are often discounted if they grow too large for comfort.

Iterated games may provide a parsimonious framework for thinking about cooperation and decisionmaking

Even in its expanded forms, the economic paradigm is essentially based on the concept of the rational individual decisionmaker—the rational actor paradigm. Chapter 2, "Games and simulations," describes frameworks for explicitly exploring the interactions among multiple decisionmakers, in this case nation states, each acting out of self-interest. The authors argue that, although one-shot games are recognized as having very limited application to continuing relations among states, iterated games may provide a parsimonious framework for thinking about cooperation and decisionmaking in situations that fall between the levels of a single benevolent dictator and an anonymous market populated by many well-behaved individuals.

Game theoretic approaches preserve the idea of uniform or universal rationality. Often they do not take account of tensions among rival viewpoints and values within a state that can cause it to change course during negotiations in ways that cannot be predicted. Where two-level games have been developed

(nesting intrastate games within interstate games), internal differences within states are still framed using the same assumptions about the universality of individual rationality. Simulations, involving human actors representing diverse experiences as well as interests within teams of players representing national actors, are one way of confronting this limitation. Simulation games, particularly when formal models are used within the simulation, can support focused communication among analysts and decisionmakers. Although significant risks accompany these benefits, principally bias and overgeneralization from small samples, simulation-gaming methods have potential value as devices for policy assessment, as supplements to conventional forms of analysis or sober critical reflection.

Both game-theoretic and simulation-gaming approaches move beyond atomistic rationality, but continue to rely on two core assumptions:

- Parties rationally perceive and act on self-interest.
- All of the participants share the same standards of rationality.

Generations of researchers have elaborated this universalistic notion of individual rationality to high levels of sophistication. One of its most prominent features is the rigid separation of reason and values. Chapter 3, "Decision analysis" explores the implications of this separation for global climate policymaking.

The separation of reason and values is deeply entrenched, not only in social science research but actually in the fabric of contemporary culture. Indeed, it has been suggested that the pervasiveness of behavioral sciences based on individualistic rationality derives from their role as *folk sciences*, providing security and guidance to their clientele, largely independent of their effectiveness in practice.

Beginning with the problem of climate risks from the viewpoint of a single decisionmaker who is able to control global greenhouse-related emissions, the authors of this chapter delve into the problems of multiple actors and multiple rationalities. The chapter surveys various social science approaches to the perception, communication, and management of technological and environmental risks, and assesses the potential role of risk assessments and decision rules in formulating climate change policy. In place of individual rationality, many of these approaches emphasize an analytic framework of social rationality in which collective or societal preferences are not merely aggregated from preexisting individual preferences, but are collectively formulated in daily life and stabilized by institutional arrangements of social solidarity, rather than by the atomized choices of individual human agents.

Embedding the expertise of risk professionals in a broader social discourse requires appropriate forms of public participation

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The authors argue that the basic problem of risk management, global and local, could be tackled in the emerging field of integrated assessment. For this purpose, advanced tools for integrated assessment need to combine the knowledge of experts, decisionmakers, stakeholders, and citizens. Such tools would reintegrate the faculty of reason with the intuition and emotional intelligence rooted in life experience and craft skills. Taking advantage of a broader range of human experiences in the integrated assessment of global climate change requires a critical appraisal of the historical process by which the rational actor paradigm has established an exclusive professional claim for objective knowledge in risk management. Embedding the expertise of risk professionals in a broader social discourse requires appropriate forms of public participation. This would profoundly move the role of science in society toward what is variously described as vernacular, civic, or postnormal science.

Predicting the degree of climate change, even quite accurately, is inadequate for deciding how important its consequences will be for human societies and what, if anything, should be done about it.

New forms of scientific collaboration engaging universal specialists (scientists) with local specialists (citizens) will require more than a broader decisionmaking framework. Such collaboration will also require more inclusive ideas of evidence and information. For example, Volume 1, Chapter 1 describes how climate change scientists tend to base much of their argument on mathematical modeling. On the other hand, citizens and politicians tend to draw more heavily on a holistic approach of reasoning by analogy (see for example, Gore 1992). This set of decisionmaking tools is explored in Chapter 4, "Reasoning by analogy." Past experience is a natural, inevitable source of human management strategies. All decisionmakers tend to compare present situations with past experience and adopt similar strategies for seemingly similar situations. Drawing on information about the past relationships between climate and society, researchers attempt to construct guidelines about possible future states, impacts, and coping strategies. The authors find that past climate and society interactions repay the attention of those seeking to understand the human dimensions of global climate change. Historically, the impact of climate as a hazard and a resource has been directly dependent on the adaptive capability of the society affected. It follows that predicting the degree of climate change, even quite accurately, is inadequate for deciding how important its consequences will be for human societies and what, if anything, should be done about it. It also suggests that changes in the characteristics of societies over time will alter the consequences of climate changes, and researchers should be very cautious about projecting potential long-term climate impacts onto the world as it is known today.

These useful insights notwithstanding, significant methodological difficulties arise in drawing rigorous analogies from past human experience of adaptation to climate. Although it is an enormously suggestive resource, the holistic philosophy of reasoning by analogy, almost by definition, makes it very difficult to draw valid comparisons across cases. Valid comparisons of future scenarios require greater formality than is provided by the analogue approach alone. Such formality turns inquiry back in the direction of simplifying models, although not necessarily so simple as the economic models discussed in the first chapter of the volume.

Integrated assessment models can help explore interactions and feedbacks in Earth and human systems.

The final chapter of Volume 3, "Integrated assessment," examines the current state of the various modeling tools that contribute to our understanding of the human dimensions of climate change and the operation of climate change policies. Integrated assessment is an issue-oriented approach to research that knits together diverse knowledge from many disciplines to focus holistically on climate change processes. Integrated assessment includes model-based systems, simulation gaming, scenario analysis, and qualitative studies. At present, the dominant integrated assessment activity is computer-based modeling, which draws on multiple disciplines to focus on climate change processes. In that sense, integrated assessment models attempt to emulate the holism of analogies within the more formalized frameworks of (predominantly economic) modeling. Integrated assessment models can help explore interactions and feedbacks in Earth and human systems, function as flexible and rapid simulation tools, foster insights (sometimes counterintuitive) that would not be available from a single disciplinary approach, and provide tools for mutual learning and communication among researchers and policymakers.

Integrated assessment has contributed to the climate change debate by exploring impacts of climate change, mitigation and abatement strategies, issues in cooperative implementation, the likely equity effects of candidate policies, and complicating factors such as aerosols. Models have also provided information on balancing the carbon budget and on various integrated aspects of land use.

However, existing models leave considerable room for improvement. In particular, more satisfactory and representative models of social dynamics and ecological systems, as well as improved treatments of uncertainty, are needed before integrated assessment models can be made more realistic. There is also a need to focus on the factors that shape policymakers' decisions and to include

policymakers and other stakeholders in the design and exercise of the models as advocated in Chapter 3.

As scientists develop modeling tools that are more open and flexible, policymakers will be able to use the model results and other insights from different integrated assessment approaches to inform decisions that bear on global climate change and on the social context in which climate change issues are to be considered.

A broad-based approach to integrated assessment embedded in a pluralistic and participatory decision process promises to be the best available guide to policymaking

As a whole, Volume 3 describes the existing toolkit of rational analysis and planning techniques available to scientific researchers and political elites. In so doing, the volume reveals a series of important shortcomings of the toolkit in the face of large complex problems facing multiple stakeholders over intergenerational timeframes. Under such conditions, the mainstream social science tools are presently incapable of providing a reliable basis for rational goal setting and policy implementation. They are overly dependent on a narrow concept of rationality and an approach to policy as the means for making the real world conform to a rational model. The dominant rational-actor approach is in many respects a normative framework masquerading as an analytic one. Social scientists have yet to develop any clearly superior alternatives, but a broad-based approach to integrated assessment embedded in a pluralistic and participatory decision process promises to be the best available guide to policymaking.

Human choice and climate change, volume 4: what have we learned?

The task of preparing *Human choice and climate change* has confirmed the conviction with which we started out, that a variety of social science theories, tools, and techniques, along with different ways of combining them, are essential to move climate change analysis and decisionmaking onto a robust foundation. In this fourth volume, we move into the realm of editorial commentary. We stress that responsibility for these interpretations belongs with the editors alone, although we are confident that all of our authors and contributors endorse most of our selections and emphases.

Our editorial chapters address three questions:

- How does climate change challenge the ability of social science to produce useful knowledge?
- What does social science have to say about global climate change and the debates that surround it?
- What might decisionmakers do differently in the light of our present knowledge of social science and climate change?

"The challenge of climate change for social science" sets out to explore how the intellectual organization of social science and its location in the larger framework of human intellectual inquiry may be constraining the ability of social scientists to realize the full potential of their contribution to climate change research and policy debate. The reasons may lie in the division of intellectual labor that has dominated Western science since the Enlightenment. In the social sciences, this division of labor has resulted in the emergence of two distinctive approaches to subject matter, research methods, and explanatory frameworks. We label these the descriptive and interpretive approaches. Although each potentially adds essential ingredients to humanity's understanding of climate change and related issues, the descriptive and interpretive practitioners of social science seldom communicate with each other, let alone integrate their insights.

Of the two approaches, the descriptive approach is usually considered to be more appealing to policymakers because of its apparent technical neutrality and its ability to generate a numerical bottom line. For example, quantitative analyses of responsiveness to tax rates or the effectiveness of regulation can, in principle, be directly translated into a set of policy choices about whether to implement a carbon tax or appliance efficiency standards and even at what level taxes or standards should be set. Interpretive social science tends to be less readily embraced by policymakers as lacking this potential to provide practical guidance.

But, in fact, the bottom-line solution provided by descriptive research is seldom adopted by policymakers, who actually use such studies to provide background or understanding to their own interpretations and decisionmaking inclinations. Hence, neither kind of social science has any real practical advantage. They merely provide different insights from different standpoints. Making space for both descriptive and interpretive social science in the process of reforming the relationship between scientific research and policymaking offers many advantages.

In "Social science insights into climate change," we draw on the whole of *Human choice and climate change* to elucidate some significant crosscutting themes in social science research related to global climate change. The research and analysis that underpins these themes is developed in detail in the earlier chapters—sometimes in several chapters, as they cover the same issues from different standpoints.

In the grand scheme of things, climate change is probably not the deciding

factor in whether humanity as a whole flourishes or declines. The resilience of human institutions and their ability to monitor and adapt to changing conditions seems to be more important. However, changes in regional patterns of habitability are likely to harm poor populations in environmentally fragile areas. Although aggregated global effects may be negligible, regional effects may be severe, including violent storms, inundation caused by sea level rise, and formerly fertile land becoming unsuitable for agriculture.

Global climate change will be set against a social, political, and economic background that is far different from the present.

Global climate change will be inexorable, but also incremental, and will be set against a social, political, and economic background that is far different from the present. In fact, social and political structures and processes will probably change faster than the IPCC projects for climate. This difference in rates of change may lead policymakers to delay taking action to mitigate or adapt to climate change until disaster overtakes them. However, the same difference also offers the potential to allow societies to stay ahead of climate change, that is, to build in the capability to monitor, anticipate, and respond effectively to changes in many Earth systems resulting from climate change.

Whether or not humanity realizes the potential to get ahead and stay ahead of climate change impacts depends on what happens at the level of decisionmaking in households, firms, and communities. Diversity, complexity, and uncertainty will frustrate the search for top-down global policymaking and implementation. Social science research in all disciplines indicates that policymakers should attempt to reach agreement on high-level environmental and associated social goals, then look for local and regional opportunities to use policy in various ways appropriate to the institutional arrangements, cultural values, economic and political conditions, and environmental changes.

Overall we find that social scientists have contributed to climate change research by identifying human activities that cause climate change, highlighting environmental changes that affect human welfare, and examining the research process itself and its relationship to policymaking.

Finally, we conclude *Human choice and climate change* with 10 suggestions of ways in which decisionmakers concerned with climate change might modify their goals and approaches to climate policy.

1. View the issue of climate change holistically, not just as the problem of emissions reductions.
2. Recognize that institutional limits to global sustainability are at least as important for climate policymaking as environmental limits.

3. Prepare for the likelihood that social, economic, and technological change will be more rapid and have greater direct impacts on human populations than climate change.
4. Recognize the limits of rational planning.
5. Employ the full range of analytic perspectives and decision aids from the natural and social sciences and the humanities in climate change policymaking.
6. Design policy instruments for real world conditions rather than try to make the world conform to a particular policy model.
7. Integrate climate change concerns with other, more immediate policies such as employment, defense, economic development, and public health.
8. Take a regional and local approach to climate policymaking and implementation.
9. Direct resources into identifying vulnerability and promoting resilience, especially where the impacts will be largest.
10. Use a pluralistic approach to decisionmaking.

Human choice and climate change thus begins with describing the human landscape of the Earth and centers on the role of human choice in the development of climate change as an issue, the definition of causes and likely effects, and the analysis of possible responses. Along with natural science assessments and other related assessments, this social science assessment brings together a wealth of information—but *Human choice and climate change* is not just a report on the state of the social sciences as they have been applied to climate change. Performing an assessment broadens the research focus and generates new insights by the multifaceted analyses and approaches presented here. Theoretical and practical insights that have grown out of the process of producing this assessment can also enlarge the potential application of social science insights and methods to global change—for social scientists, policymakers, and natural scientists.

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Science and decisionmaking

Sheila Jasanoff & Brian Wynne

Contributors
Frederick H. Buttel, Florian Charvolin, Paul N. Edwards, Aant Elzinga, Peter M. Haas, Chunglin Kwa, W. Henry Lambright, Michael Lynch, Clark A. Miller

Climate change emerged in the 1980s as a public policy issue posing apparently intractable challenges to science and politics (Gore 1992). The possible dangers of inaction seemed compelling, and policymakers around the world agreed on the need for more reliable data and assessments from the natural and social sciences. The move to constitute the Intergovernmental Panel on Climate Change (IPCC) and to ask for periodic state-of-the-art assessments followed a familiar conceptual model for linking science to politics or knowledge to action. It presupposed that scientific research could be targeted, in linear fashion, to fill gaps in the existing knowledge base. Once the gaps were filled, and uncertainties either reduced or eliminated, policymakers could rationally apply the products of science to formulating policy responses.

Confidence in the power of strategic or mission-oriented research to influence policy led to the commitment of substantial public funds to new climate change programs. Scientists and policymakers generally accepted that planetary changes could best be understood, and mastered, by identifying a collection of causal forces, both natural and social; by objectively mapping, measuring, and analyzing them; by predicting their effects; by aggregating them through large-scale quantitative techniques of modeling and assessment; and, finally, by using the assessments as inputs to policy. US global change research programs reflected the orientation toward studying objectively accessible large-scale patterns, with inquiry centered in the natural sciences. Whereas natural scientists studied interactions among the Earth's biogeophysical systems, social science research focused primarily on the aggregate social forces thought to produce environmental impacts on a global scale. (Table 1.1 presents funding for research in the social sciences in the US Global Change Research Program, including support from 11 federal agencies.)

Table 5.1 US federal funding for global change research (in millions of US$).

Fiscal year	1989	1990	1991	1992	1993	1994
Total Global Change Program, all agencies	133.9	659.3	953.7	1109.8	1326.0	1475.1
Total human interactions, all agencies	22.7	4.8	28.3	16.8	22.2	23.6
Percentage of total program, all agencies	16.4	0.7	3.0	1.5	1.7	1.7

Source: Human Dimensions Quarterly **1**(1), 12.

Almost immediately, however, it became clear that traditional policy-analytic approaches would not contain a problem of this dimension. The scale, complexity, and interconnectedness of the causes of climate change—and the fundamental links between climate change and other global processes—tested science's incremental and discipline-based approaches to investigating nature. Concurrently, the contested, open-ended, and geographically dispersed character of climate-linked phenomena strained the power of established policy

institutions, both national and international, to build scientific consensus or formulate adequate policy responses (Skolnikoff 1990, Mann 1991, Messner et al. 1992). Controversies about the IPCC's conclusions intensified, constituting a backlash not only against particular scientific findings and assessments but, more profoundly, against the politics of globalization (e.g., Seitz et al. 1989, Balling 1992, Michaels 1992, Bailey 1993).

This chapter draws on several decades of social science research on scientific knowledge and policymaking to show why initial assumptions about how to study and respond to climate change have proved inadequate and to present a richer accounting to guide future responses to this complex issue. The discussion draws upon and reinterprets several science–policy initiatives that have been extensively studied and that have instructive parallels to the science–policy relationship in climate change. These include the protection of stratospheric ozone, the Green Revolution, the International Biological Program, the International Geosphere–Biosphere Program, and environmental models such as general circulation models.

The relationship between natural and social science research on climate was initially conceived as a matter of mutual agenda setting: "Natural scientists help set the research agenda for social scientists by identifying human activities that are major, proximate causes of environmental change. . . . Social scientists help set the research agenda for natural scientists by highlighting environmental changes that would severely affect human welfare" (Young & Stern 1992: 2). This characterization validly represents one part of the social science research program, indeed the dominant part from the standpoint of state support.

However, social scientists also have complex stories to tell about the framing of problems for research, the production and validation of scientific knowledge, and its uptake into policy decisions. In addition, a considerable body of social science research has illuminated the origins of controversy and uncertainty in public policy. Given the prominence of backlash critiques of climate change, this line of work will grow in importance as policymakers confront the challenge of international cooperation on so indeterminate and potentially catastrophic a problem as climate change.

The early framing and funding of climate change research generally overlooked the contribution made by the qualitative social sciences to understanding the processes by which societies recognize new threats to their security or well-being, formulate responses, and collectively act upon them. Yet, knowledge about these issues has accumulated rapidly in the past two decades. A growing body of work—much of it located in social studies of science and technology (hereafter referred to as science and technology studies)—has challenged the notion that allegedly global problems such as climate change exist in a world that can be unproblematically accessed through direct observation

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CHAPTER 2

Population and climate change

F. Landis MacKellar, Wolfgang Lutz,
A. J. McMichael, Astri Suhrke

Contributors
Vinod Mishra, Brian O'Neill, Sanjeev Prakash, Lee Wexler

According to one school of thought (e.g., Myers 1993), population growth in less industrialized countries is the main cause of global environmental stress; according to another (e.g., Rahman et al. 1993), the major factor is the high level of personal consumption in the North. A hybrid view (e.g., Ehrlich & Ehrlich 1990) is that, given the tremendous difference in annual per capita levels of natural resource utilization, population growth in more industrialized countries, although slow, bears as much responsibility as rapid population growth in the South. This latter view has been marginalized in the debate, although there is no reason to do so a priori; at least the accounting that backs it up is sound. Thus, the population–consumption debate has remained essentially bipolar.

The most vehement authors in theimate policy debate (e.g., Agarwal & Nairan 1991) speak openly of "blame"; others use the more neutral terms "cause," "responsibility," or "share." Even thus watered down, however, the population–consumption debate is still about the equity of proposed mitigation policies in view of the skewed distribution of resources and responsibility for past accumulation of atmospheric carbon dioxide. What synthesis of the positions has occurred has consisted merely of putting all three (especially the first two) views together and calling for sacrifices—forgoing both desired consumption and fertility—all around (e.g., Harrison 1992).

The population–consumption debate came to dominate public discussions of climate change and of global environmental stress more broadly despite the existence of at least two well-developed alternative framings of the issue. Commoner (1971, 1991) continues to blame neither population nor mass consumption, but rather the promotion by entrenched interests of large-scale, centralized, energy- and capital-intensive, highly polluting industrial technologies, as well as the encouragement via advertising of consumption habits (such as the *throwaway culture*) that depend on them. Orthodox neoclassical economists, for their part, have stood aloof from the population–consumption debate, for at least three reasons. First, they trust markets can defuse and mediate pressures on the environment whatever their origins; the issue, according to this interpretation, is the removal of impediments to markets, not reducing the scale of human population or its level of consumption. (Hence, Ch. 4 distinguishes this diagnosis as a distinctive voice in climate change discourse, focused on pricing and property rights.) Second, the population–consumption debate explicitly or implicitly makes a distinction—empty from the point of view of utility theory—between luxurious or wasteful consumption and virtuous or necessary consumption (Ekins 1991, Durning 1992). This distinction is found to be insupportable (see Ch. 3). Third, participants in the debate commit the elementary mistake (from the standpoint of utility theory) of making interpersonal utility comparisons. We cannot know (rigorously) whether the couple in a more industrialized country who forgo a desired second car are giving up more or less

utility than a couple in a less industrialized country who forgo a desired birth.

In the international political arena, the population–consumption debate has become the focus of the broader debate about equity and fairness (see Ch. 4). For example, whenever Northern delegates at the UN Conference on Environment and Development (UNCED) in Rio raised the issue of rapid population growth in less industrialized countries, Southern delegates countered with the issue of overconsumption (Rowlands 1992). As a result, population issues were watered down: Principle 8 of the nonbinding Rio Declaration calls on states to reduce and eliminate unsustainable patterns of production and consumption and to promote to appropriate demographic policies, but this is purely hortatory. When delegates from less industrialized countries proposed even the modest step of monitoring consumption patterns, industrialized nations, led by the United States, not surprisingly vetoed the idea.

By focusing attention on responsibility for causing global climate change, the population–consumption debate diverts attention from the more important issue of coping with climate change. Obscured almost entirely in the debate is one of the most consistent findings to emerge from climate change research: that the populations most adversely affected will be poor, marginal populations in less industrialized countries who depend on ecologically fragile renewable natural resources. Only by focusing on means of adaptation can the needs of these seriously affected populations be addressed.

The first section of this chapter discusses the demographic situation and outlook, commenting on the decline in fertility now underway in less industrialized countries and the relative certainties: population will grow substantially beyond its current size, its distribution will continue to tilt toward less industrialized countries, and it will continue to age.

The second section assesses studies of the role of population in the global change debate and critically reviews the common model used in the population–consumption debate. This polarized debate adds little value to addressing the questions related to climate change and diverts attention from important issues of vulnerable populations and fragile ecosystems.

The third section extends the neoclassical economic model of population and the environment to incorporate poverty, insecurity, the low status of women, and the fragility of marginal environmental zones where many of the world's poor live. To use language introduced by Gunnar Myrdal in his classic An American dilemma (1944), this results in a vicious circle model in which societies find themselves captured in a high-fertility low-income trap. Because it is comprehensive and it addresses a range of concerns within a broadly orthodox neoclassical framework, this vicious circle model has become the dominant model for research on, and policy advice regarding, population–environment interactions in less industrialized countries.

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CHAPTER 3

Human needs and wants

Mary Douglas, Des Gasper,
Steven Ney, Michael Thompson

Contributors
Russell Hardin, Shaun Hargreaves-Heap, Saiful Islam, Denise Jodelet, Hélène Karmasin, Ota de Leonardis, Judith Mehta, Sanjeev Prakash, Zofia Sokolewitz, Thanh-dam Truong

Discussions of the underlying causes of climate change focus on two villains: one is population growth in the less industrialized world; the other is mindless consumption in the rich industrialized nations (see Ch. 4). Clearly, the issue of human needs and wants lies at the heart of the whole debate. Family and lifestyle shape population patterns and deplete natural resources. Aspirations to live well influence the selection of technologies and the rate of their adoption.

The study of human needs and wants appears to offer opportunities for policy to design means of reducing greenhouse gas emissions. To do this, policymakers have to know what human needs and wants are. So, they turn to the social sciences to provide answers to questions about wants and needs. Yet, surprisingly, attention has not been directed to these problems, neither by social scientists addressing global environmental change, nor by those who have specialized in needs theories. In default, needs and wants tend to have been subsumed under headings such as economic growth and technological change or, at best, as attitudes and beliefs about material goods (Stern et al. 1992). Within the international discourse on climate change, the distinction between needs and wants is used to justify different targets and burdens for emissions reductions in less industrialized and industrialized countries (see Chs 4 and 5). Yet, fundamental questions that need to be posed about the relationship between human needs and global climate change are not yet articulated.

The main question we will ask of human needs theories is, can they be of any use to policymakers concerned with global climate change? We will look at some of the assumptions that underpin theories of human needs and wants. We will show that there are grave difficulties in the way of making a coherent theory of poverty or affluence. Finally, we will propose a new approach: a cultural theory of human needs and wants that should be able at least to pose the questions relevant to the global climate change debate.

Wants and global climate change

It seems fair enough to pin responsibility for massive greenhouse gas emissions on human efforts to satisfy their wants. The branch of the social sciences where wants as such are studied is economics, and in economics "wants" have a specialized meaning. An agent, later to be known as "the consumer," was originally invented to solve theoretical problems about the market. Strictly speaking, the theory of consumer demand is not about wants at all, but is a technical device to explain market behavior. Sociology has a theory of needs, but it hardly connects at all with the market theory of wants.

In the history of economics the theory of demand completed the model of

flows and equilibria. The balance of power was an old idea in politics, and the balance of pain and pleasure an elementary idea in psychology. The idea of self-balancing counterflows of bullion and goods was used by eighteenth-century physiocrats against the protectionist policies of mercantilists. Hume (1711–76) using the hydraulic analogy ("All water, wherever it communicates, remains always at a level."), described international trade as a self-regulating balance achieved by flows of precious metals acting automatically on domestic price levels. This was the first systematic account of equilibrium based on prices (Hume 1777: 312).

So far, the idea of consumer demand had not appeared. Ideas of diminishing marginal utility were in the air, but not been applied to consumers: the Swiss mathematician, Bernouilli (1700–1782) proposed that the utility of wealth increases at a marginally decreasing rate (this in connection with probability calculations of risk); the theory of diminishing marginal returns was applied by Ricardo (1772–1823) to factors of production, but not to consumption; both the principle of market equilibrium and the principle of diminishing marginal utility were ready, but it took a hundred years after Hume to put them together into one system.

In the early 1870s economists in three different countries independently produced a model of the economy in which the wheels of trade are moved by buyers' demand, with prices as the pivot of interaction. In the model, producers' supply decisions are triggered by a comparison of marginal revenue with marginal cost, both of which ultimately depend on consumers' demand for the commodity in question and workers' supply of labor (balanced by their demand for leisure). Thus, diminishing marginal utility permeates the market-based model of the economic system. Without it the market theory would collapse in a jumble of arbitrary absurdities, and without the market theory the idea of demand for leisure or of satisfied demand would not be formulated.

If wants were unruly and irrational the market would not work, nor would it be possible to explain how it works. The central idea of diminishing marginal utility is simply that people split their expenditure between different items rather than plunging wildly from one to another, and that they split it consistently. This minimal rationality of humans is needed to make calculations about price movements, and that is all that it is needed for.

A highly technical concept of rationality might not have become the dominant principle of contemporary social theory had not those in favor of individual freedom and free markets won against those in favor of tariffs. The winners bequeathed to future generations the principle that the proper start for social theory is the rational individual. Wants are the desires of a rational being: they are ordered logically in a hierarchy of claims on resources. The ordering has no guaranteed connection with needs. The economists do not have an official

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CHAPTER 4

Cultural discourses

Michael Thompson & Steve Rayner

Contributors
Luther P. Gerlach, Michael Grubb, Denise Lach, Steven Ney,
Mathew Paterson, Adam Rose, Peter Timmerman

Who talks about climate change? The experts on climate change, obviously, but also ordinary folk; "lay people," as those who study citizens' grasp of things climatic call them. Our discussion begins with a detailed look at some of the recent studies that have framed the climate change discourse along the lines of an expert/lay dichotomy of understanding. This includes studies that have used a mental models approach and others that have used a sociodemographic framework to examine perceptions of global change in relationship to variables such as age, class, and gender.

These approaches, it turns out, are Procrustean, and have to cope with the plurality of views that characterize the discourses by reducing or oversimplifying the data. The trouble stems from two hard-to-avoid assumptions that are built into the expert/lay distinction: first, that experts are all the same and are different from lay people (who are also all the same) and, second, that the experts have a clear understanding of climate change and the laity are rather confused about it. Neither of these assumptions, as we will see, is able the stand up for long, but at least this oversimple expert/lay distinction does enable us to get started on the important business of discourse analysis. Once we have started, we can learn where the initial assumptions are invalid and cast about for other, less simple, assumptions that better fit the heterogeneity that exists within each realm of discourse—expert and lay—and the remarkable isomorphisms that exist between those two realms.

That, in essence, is the structure that underlies this chapter: a structure that carries us from the oversimple assumptions that are embedded in the conventional expert/lay distinction, through the problems that are encountered when this distinction is applied to a more complex understanding of the essential heterogeneity of climate change discourse (expert and lay). Competing ideas about nature and about equity inform climate change policy debates at all levels from the family hearth to the international negotiation of the Framework Convention on Climate Change (FCCC). The chapter argues that, rather than being obstacles to be overcome, the uneasy coexistence of different conceptions of natural vulnerability and societal fairness is a source of resilience and the key to the institutional plurality that actually enables us to apprehend and adapt to our ever-changing circumstances.

Expert and lay perceptions of climate change

Recent surveys have shown that public support for environmental protection is strong, particularly in the industrialized countries where there is an expressed willingness to pay for products that do not harm the environment

(Harris et al. 1989). Many people say they have witnessed the deterioration of their local environments in their lifetimes and therefore have a direct experience of environmental problems. In the same vein, Hays (1987) has noted that concern for the local environment and for personal health is an important factor in support for local environmental protection schemes. Such observations fit well with what is called the *knowledge-based approach*, the assumption that people worry about the things that are worth worrying about: a commonsense assumption which, as we will see, does not hold up well.

A contrasting approach sees the rising curve of environmental concern as stemming from changes in ethical frameworks. White (1967), for instance, argues that the moral basis for environmental protection derives from the animistic religions of small traditional cultures that are still closely dependent on the land, but not from the Judeo-Christian tradition which, he claims, is anthropocentric and supportive of the view that humanity can transcend and dominate nature. On this argument, the protection of nature under the moral framework of the Judeo-Christian tradition would be justified only as *resource management*. Others, Berry (1988) and Rolston (1988) for instance, reject White's claim, arguing that the Judeo-Christian tradition can (and should) accord nature an intrinsic value. Nash (1989) has pointed to many instances where the Western tradition has had no great difficulty in recognizing nature's intrinsic rights.

The knowledge-based and ethical approaches, of course, are not mutually exclusive, and Heberlein (1972), taking a social psychological approach, has combined them as a way of explaining the upsurge of environmental concern that swept across the United States in the 1960s. Public awareness of the effects of pollution, he argues, together with the pinning of blame on those responsible for that environmental harm, helped to develop a *land ethic*, a concept borrowed from Leopold. According to this view, a thing is right when it tends to preserve the integrity, community and beauty of the natural environment. It is wrong when it tends otherwise. Dunlap & Van Liere (1977), however, have taken Heberlein to task, pointing out that his research is concerned only with the harm that environmental destruction does to humans, not to nature. Heberlein, they argue, has not grasped the land ethic, nor has he found evidence of any environmental norms that are consistent with such an ethic. All he has done is trace out, through some environmental linkages, the old rule, "Do unto others as you would have them do unto you." Explaining environmental concern, clearly, is not a straightforward business.

A consideration that looms large for many people (but by no means all) is the welfare of future generations. They are concerned that, if we mistreat the environment, the quality of life of their children and grandchildren will diminish. Their discount rate, economists would say, is low or even negative. MacLean

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CHAPTER 5

Institutional frameworks for political action

Timothy O'Riordan, Chester L. Cooper,
Andrew Jordan, Steve Rayner, Kenneth R. Richards,
Paul Runci, Shira Yoffe

Contributors
Daniel Bodansky, Urs Luterbacher, Ronald Mitchell,
Kal Raustiala, Ian Rowlands, Paul Samson, Detlef Sprinz

Chapter 4 established the view of discourse, implicit or explicit, across a range of social sciences, as both the social glue and the solvent that we use to create and rearrange the social order, building and dismantling bonds of social solidarity among individuals, communities, and other institutions across both space and time. This chapter focuses on the political actions and frameworks for action that arise from and nourish the discourse about climate change and the rearrangement of societal solidarities around the climate change issue at all levels of human society. Thus, the focus of this chapter is on political action as institutional action.

The concept of institution is very broad. In many respects, it is an example of what Gallie (1955) termed an *essentially contested* concept; an idea that can be clarified only through regular argument, that is, through discourse. The notion of institution applies to both organizations with leaders, memberships, clients, resources, and knowledge, and also to socialized ways of looking at the world as shaped by communication, information transfer, and patterns of status and association.

Understanding and managing climate change has to take place through institutional arrangements. Any effort to identify the causes of that change, or to adapt to its consequences, must also address the medium of institutional behavior. Institutions permeate all aspects of society, both formal and informal. Society simply would not exist in the absence of institutional arrangements.

Climate policy is shaped by formal organizational structures, as well as by informal networks of communication that, in turn, are the products of values, norms and expectations. These institutions range from the formal deliberating bodies engaged in treaty making to the informal liaisons among policy analysts and policy executives, regulatory agencies, and the day-to-day actions of billions of people. Both the extent and the impacts of climate change will be determined by the willingness of those billions of decisionmakers to change their ways. This change of behavior could be achieved by persuasion, command, education, taxation, moral arguments, or changes in the notion of property rights (see the discussion of policy instruments, p. 401 ff.). Any combination of these responses involves institutional change, ranging from incremental adjustment to profound transformation.

No matter how chaotic all the relationships among climate policy actors may seem, they could not function without some sort of order and guiding principles of social solidarity. This solidarity is the essence of social institutions and it forms the basis of the analysis provided by this chapter.

The Blackwell encyclopaedia of political science defines an institution as a "locus of regularized or crystallized principle of conduct, action or behavior that governs a crucial area of social life and that endures over time" (Gould 1991: 290). In different disciplines, however, the term carries particular nuances. For

sociologists, the study of institutions is central to understanding the organization and functioning of all societies. Indeed, within the functionalist paradigm, sociology *is* "the science of institutions" and other "social facts" (Durkheim 1895: 1). Social theorists regard the concept of an institution as a socially organizing set of relationships that govern the basic problems of ordered social life. Eisenstadt (1968) visualized the characteristics of institutions as sets of normative rules that are shared by a society so as to retain cohesion and control, and also as patterns of behavior that operate according to norms and expectations, and in so doing give order and meaning to social life and government. Giddens (1986: 8) referred to institutions as "commonly adopted practices which persist in recognisably similar form across generations." "A society," he explained, "is a cluster, or system, of institutionalised modes of conduct . . . [which are] . . . modes of belief and behavior that occur and recur . . . across long spans of time and space." Smith (1988: 91) visualized institutions as "stable, valued, recurring patterns of behavior," a definition that encompasses fairly concrete organizations, such as governmental agencies, but also cognitive structures, such as the patterns of rhetorical legitimation characteristic of political discourse and belief systems. Although the term has been used in the field of international relations to refer specifically to formal structures, such as the United Nations, or specific treaty arrangements (e.g., Haas 1964), more recent scholars of international relations employ the term in a more sociological fashion (Haas et al. 1993).

Gould (1991) warned against confusing repeated or habitual activity with the more formal rules that are devised to regulate it. An activity may take place through informal arrangements, for example through kinship patterns or the evolution of expected codes of conduct. Examples would be the emergence of a car-pooling culture to cut driving needs, or the coordination of village communities in Bangladesh to provide single-band radios, platforms of refuge, and food redistribution schemes in the event of coastal flooding (Rahman 1996). These activities need no formal structure or external regulation, but they are most certainly institutions (Wynne 1993). Thus, despite disciplinary differences there seems to be convergence on a core set of ideas about institutions and their importance (Box 5.1).

It has been fashionable in recent years to regard institutions as mechanisms for offloading routine low-level day-to-day thinking that leaves the individual mind free to weigh important and difficult matters (Schotter 1981). However, Douglas (1986: 111) took the opposite view that "The individual tends to leave important decisions to his institutions while busying himself with tactics and details." From this standpoint, institutions are vital in the processes of identifying and responding to threats to survival or to conflict and social order. The mechanisms of predicting outcomes, of organizing response, of preparing for possible danger, and of accommodating to stress or hardship, are constitutive

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CHAPTER 1

The natural science of global climate change

Donald J. Wuebbles & Norman J. Rosenberg

The first volume of *Human choice and climate change* began with a social science analysis of the processes of scientific investigation and consensus formation as they influence the production of scientific knowledge of climate change and its relation to the national and international policymaking process. The remainder of Volume 1 focused on the broadly institutional framework of global society, including its discourses and decisionmaking, that is responsible for, and will experience, climate change and its impacts.

Volume 2 begins with a summary of the natural science of climate change because this focuses on the major resource systems, or *human support systems* (see Ch. 3) that enable people to live as they do on this planet; that is, land and water use, occupation of coastal zones, energy production and use, and the processes of technological change. As human systems, these are no less institutional systems than the ones treated in Volume 1. However, each is perhaps more directly dependent on constraints and opportunities presented by natural systems than the frameworks presented in Volume 1 (with the possible exception of population). Thus, it is appropriate at this point to introduce material from the natural sciences that social scientists should be aware of in analyzing and understanding the human dimensions of climate change. This chapter summarizes the present state of the international scientific consensus about climate change as represented, for example, in the findings of the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

The global mean surface temperature has increased by 0.3–0.6 degrees Kelvin (°K) over the past century (Houghton et al. 1992, 1996, Jones 1994a,b, Parker et al. 1995), with the warming evident in both land-based and sea-surface-based measurements. The global temperatures in recent years have been among the warmest in historical records. Available evidence indicates that this is one of the warmest periods in the past six centuries. However, the warming is not uniform over the globe, with some areas even showing a cooling. Understanding this climate change is a high priority in the science community. For some time, scientific studies have indicated that increasing emissions and concentrations of greenhouse gases could result in global warming and other associated changes in climate. Although the signal is still emerging from the noise of natural variability, recent studies (Santer et al. 1995, Houghton et al. 1996) suggest that the current changes in climate are indeed related to human activities, including the emissions of carbon dioxide (CO_2), plus other radiatively important gases and aerosols (particles).

Any human-induced effects on climate will be superimposed on a background of natural fluctuations in the climate system. An indisputable fact about climate is that it is always changing. However, over the past 10000 years, the globally averaged surface temperature has varied over a range of less than 2°K. Humanity is now undertaking an experiment, by emitting long-lived radiatively important gases into the atmosphere in unprecedented amounts, that could result in a warming of the global temperatures well beyond the natural variability. Numerical models of the climate system, considering changes in greenhouse gases and in aerosols, suggest that surface temperatures could increase 1–3.5°K over the next century (Houghton et al. 1996).

Of particular concern are the growing atmospheric concentrations of gases that absorb terrestrial infrared radiation, termed greenhouse gases. Much of this concern has centered around carbon dioxide (CO_2) because of its importance as a greenhouse gas and also because of the rapid rate at which its atmospheric concentration has been increasing. However, since the mid-1980s, it has been shown that other greenhouse gases are contributing to about half of the overall increase in the greenhouse effect on climate. In addition to these direct effects, research studies have shown that chemical interactions in the atmosphere can lead to additional indirect effects on climate. As an example, changes in stratospheric ozone have received much attention because of concerns about ultraviolet radiation, but ozone is also a greenhouse gas, and changes in its distribution can affect climate.

Another important influence on climate comes from the production and emission of sulfuric and other aerosols in the troposphere and stratosphere. Aerosols are suspensions of particles in the atmosphere. Such aerosols can influence climate in several different ways, directly by scattering and absorbing radiation, and indirectly by acting as cloud condensation nuclei, affecting their optical properties, extent, and lifetimes.

Many uncertainties remain in understanding the effects of the changing atmospheric composition on climate. Because of potential environmental and socioeconomic impacts from climate change, it is necessary to gain a much fuller understanding of the forces and interactions that affect climate. The purpose of this chapter is to describe the natural science of global climate change as presently understood. The chapter describes the greenhouse gases and other influences affecting climate, the processes affecting climate, the past climate record, and the future possibilities for climate change. Potential impacts from climate change are also discussed. Much of the discussion is based on recent international assessments of climate change by the scientific community under the auspices of the IPCC (Houghton et al. 1995, 1996).

Climate and radiative effects

Climate is generally defined as a description of the average (or typical) behavior of the atmosphere, and is thus the aggregation of the weather. Climate is usually expressed in terms of mean (or average) conditions and variances,

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CHAPTER 2

Land and water use

William B. Meyer, W. Neil Adger, Katrina Brown,
Dean Graetz, Peter Gleick, John F. Richards,
Antonio Maghalães

Land and water use generate resources vital to satisfying human needs and wants. These may be as diverse as food energy, fiber, construction material, recreation, aesthetic and spiritual satisfaction, and sense of identity. Intensification—increase in output gained through both physical manipulation and conscious management—has been the long-term global norm during the five centuries of the colonial, industrial, and postindustrial period. Today, every accessible hectare is managed—even if deliberately left untouched—for human ends. The most remote tundra in the Arctic North and the most forbidding reaches of the Sahara Desert are subject to decisions made by nation states (alone or in consortia), and subnational organizations, companies, and individuals. Even preservation is a form of human use, denying general access to nature reserves or similarly designated lands for aesthetic and scientific ends.

The exploitation of land and water can significantly alter these and other aspects of the environment. In AD 1500, humanity's imprint on the global landscape was already considerable, but the magnitude of anthropogenic change was modest compared to what was to come. If George Perkins Marsh (1864) could describe the Earth as modified by human action in the mid-nineteenth century, a late twentieth-century assessment found it transformed (Turner et al. 1990).

Land and water use is important to global climate change in at least three ways. First, land use affects the exchange of carbon dioxide between the Earth and atmosphere. Over the course of human history, land-use change has contributed as much to atmospheric increases of carbon dioxide as fossil fuel combustion has. The current terrestrial carbon reservoir (biota and soils) holds 2000 Pg (billion tonnes), almost three times the amount now in the atmosphere (Houghton & Skole 1990). As currently used, land is a major source of methane and nitrous oxide, two other important greenhouse gases, and an important emitter (through biomass burning) of aerosols, which can lessen net radiative forcing (Penner 1994). Changes in land use can also affect climate changing energy and water budgets at the Earth's surface. These considerations are important to analysts and policymakers considering strategies to prevent climate change. Land surface alterations offer opportunities to reduce greenhouse-related emissions or sequester carbon to offset those emissions.

Second, agriculture, forestry and other land-based productive activities depend crucially on surface energy and water balance, which are closely linked to climate. Hence, they are more likely than other human activities to be affected by climate change. Changes associated with climate change may harm or benefit land users. The ability to reap benefits rather than suffer losses may depend on the degree to which users can alter practices and change inputs in appropriate ways. Such considerations are directly relevant to the development of strategies for adapting to climate change.

Third, projected growth in both population and resource demands presents important challenges to land and water use in coming decades whether climate changes or not. Discussions of global environmental change have tended to subjugate the issues of sustainable development of land and water resources to the globally systemic changes of ozone depletion and climate change. Many analysts now seek to identify no-regrets strategies that would enhance sustainability while helping to prevent or adapt to climate change.

This chapter focuses on key social science concepts that contribute to an understanding of the way in which land and water are used, which we then relate to issues raised by global climate change. First, we examine conceptual and data issues regarding land use and water use. Second, we discuss the history and the current state of the world's lands. Third, we examine the principal theories and approaches used to explain why land is used in the way it is, with an emphasis on explaining the land uses closely related to greenhouse gas emissions and analyzing policy options for reducing these emissions. We conclude by considering the state of understanding of climate change impacts on land use.

Definitions and data

Distinguishing between *land use* and *land cover* is not only analytically useful but acknowledges an established division of labor in research. Land use denotes the human employment of land—both physical manipulation and the purposes underlying it. Sedentary agriculture, shifting cultivation, navigation, water supply, forest plantations, settlements, transportation corridors, mining, and habitat and scenery preservation are categories of land use and water use. Land-use research has traditionally been the purview of social scientists, but not of any single discipline. Human geographers, economists (particularly land, agricultural, and urban economists), anthropologists, political scientists, sociologists, historians, and legal scholars all contribute (although rarely together) to a literature that is more multidisciplinary than interdisciplinary.

Land cover has been a separate but related domain, which focuses on the physical features and biological characteristics of the land, affected or not by human land use. Aspects of land cover include the vegetation growing on the land surface, the underlying soil, and the surface and subsurface water features (rivers, canals, lakes, ponds, permanent icefields, aquifers). Research on land cover has been primarily the domain of natural scientists (e.g., ecologists, foresters, agronomists, hydrologists, soil scientists, physical geographers). Land use is the focus of this chapter, but most of the land-use activities releasing or

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CHAPTER 3

Coastal zones and oceans

Atiq Rahman & Saleemul Huq

Contributors
Ahsan Uddin Ahmed, Richard Klein, Virenda Asthana, Youba Sokona, Rob Koudstaal, Rob Misdorp, Mohammad El-Raey, Robert Nicholls, Stephen Leatherman, Thomas E. Downing, Han Mukang, Jacqueline McGlade, Dwijen Mullick, Mozaharul Alam, Lando Velasco

Approximately 15 percent of the world's land area can be classified as coastal zones, and about two-thirds of the Earth's surface is covered by oceans. The concept of coastal zones includes small islands, deltaic regions, mainland coastal regions, and inland seas. Smaller islands can be almost entirely coastal zone. Most river deltas are essentially coastal. Inland seas, such as the Caspian Sea, also can be considered to have a coastal zone similar to those of open seas. Fisheries and transportation activities ivolve both coastal zones and the oceans. The functions of oceans, coastal zones, and small islands, as well as probable impacts of climate change, have been addressed in the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) by Bijlsma et al. (1996) and Ittekkot et al. (1996).

Coastal zones have historically generated economic activities that allowed societies to flourish. The ancient Greek, Babylonian, Aryan, and Indus civilizations were built on the economic activities of their coastal zones. Similarly, deltaic areas attracted human settlements, with soil fertility as a principal element in agricultural productivity. Rivers were also centers of community life: the Hwang Ho in China, the Mekong for several Southeast Asian countries, the Ganges for the Indian subcontinent, and the Nile for Egypt.

Coastal zones remain important centers for human societies (Fig. 3.1). Currently, 50–70 percent of the world's estimated 5.6 billion people live in coastal zones, equal to the entire world's population of the 1950s. More than half of the world's rapidly growing population lives within 60km of the coast (Nicholls & Leatherman 1995a). The major deltaic floodplains of the Indo-Gangetic, Nile, Mississippi, Mekong, and Amazon rivers host major sources of agricultural productivity, rural employment, and many subsistence activities. Coastal zones contain extensive areas of specialized ecosystems that are the sources of a significant proportion of global food production. Human activities include not only agriculture and fisheries, but forestry, tourism, recreation, and transportation.

The interlinking of civilizations through marine routes and voyages is an important driving force behind the emergence of the colonial periods worldwide and subsequently the global village of the twentieth century. But different sets of villages exist; that is, societies are at different levels of empowerment, development, and control of their own destiny. Communities with varying capacities and different cultural identities live in coastal areas. The intense interaction between land and water enables the growth of different types of socioeconomic activities and opportunities for employment and livelihoods.

The growing intensity of development is already causing major stresses on the resources of coastal zones. In the recent past, many coastal areas have been modified and intensively developed; in the process, the natural resource base has reached a point that is perhaps beyond the limits of sustainability. The

added impacts of projected climate change on these resources and on the human societies that depend on them are therefore of great concern.

To ensure the sustainability of coastal zones, particularly in a climate-changed world, policymakers must address the following questions:

- How may society best develop the coastal areas and their resources so that the desired products and services to meet human needs are ensured while maintaining viable and diverse ecosystems?
- What are the best modalities through which a society may manage coastal areas and resources while maintaining the resilience of coastal systems?
- How may international communities work together to assist local communities in restoring the well-being of a coastal area and its resources?
- Which communities own what coastal and ocean resources and how can conflicts within and between societies be resolved?
- How can coastal societies mitigate and adapt to climate change despite all the uncertainties and long timescale?

Coastal zones, oceans, and inland seas

Many coastal problems that are now being encountered worldwide have resulted from the use of the terrestrial and aquatic resources by many people over a long period of mostly unrestricted development of coastal areas. These problems include the accumulation of contaminants in coastal areas, erosion, and the rapidly accelerating decline of habitats and natural resources. Population growth associated with economic development places additional demands on coastal areas and resources, posing another threat to the sustainability of these areas. The impacts of unsustainable and often uncoordinated coastal development are likely ultimately to result in the degradation of natural systems that provide protection against the sea, habitat for many species, and food for many people; these impacts could pose significant risks to public health.

Key characteristics of coastal systems: aquatic, terrestrial, and human interactions

The rich and complex processes of interaction between land and water affect the complexity and dynamics of societal interactions in these areas. The processes involved go far beyond national boundaries and are situations where several global processes and community- or family-based processes coexist (Box 3.1). Figure 3.2 shows several of the elements of each system and how the different

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CHAPTER 4

Energy and industry

John Weyant & Yukio Yanigisawa

Contributors
Igor Bashmakor, Chihpeng Chu, Tae Yong Jung, Nebojsa Nakicenovic, Luiz Piguelli Rosa, Michael J. Scott, P. R. Shukla, Kenji Yamaji

Over the past century, energy use has become the most important human-generated source of greenhouse gases, especially carbon dioxide produced by fossil-fueled energy generation. Moreover, most analysts predict steady increases in worldwide energy consumption over the next several decades. Thus, any attempt to limit greenhouse gas concentrations in the atmosphere must focus on energy supply and demand. As a consequence, the costs associated with reducing greenhouse gas emissions from fossil fuel combustion have been—and will probably continue to be—absolutely central in the international debate over appropriate climate change policy responses.

There is great uncertainty about what energy use and associated carbon dioxide emissions will be over the next century. Worldwide emissions of carbon from fossil fuel combustion are currently about 6 billion tonnes per yr. Projections in the absence of new policy initiatives range from a modest decrease to an increase by about a factor of 15 over the next century.

Researchers analyzing projections of future energy use and energy-related carbon emissions find it useful to decompose total energy use into the product of four factors:

- population
- economic output per capita
- energy use per unit of economic output
- carbon emissions per unit of energy use.

This particular decomposition is not unique and does not imply that the four terms are independent entities. Substantial interdependence exists, which is why more sophisticated models are developed for forecasting.

Although there are considerable uncertainties about future population growth (see Vol. 1, Ch. 2), some general observations can be made. Population in the more industrialized countries making up the Organisation for Economic Cooperation and Development (OECD), former Soviet Union, and eastern Europe appears to be close to peaking at slightly more than 1 billion people. Population in the rest of the world (currently about 4.5 billion) is still growing, although at a declining rate; thus, attempts to predict the population in these countries a century from now depend on relatively arbitrary assumptions about when their populations will peak.

In future economic growth (Vol. 3, Ch. 1), there is again a dichotomy between the outlook for OECD and non-OECD countries, but this time the former Soviet Union and eastern European countries fit into a separate category owing to the economic turmoil that has occurred in those regions since 1989. For the OECD, slow economic growth is typically forecast, driven by gradually declining productivity growth with no increase in population. Economic growth in the less industrialized countries should be greater than in the OECD as industrialization takes place, OECD technologies are adopted, and investment in capital

equipment increases accordingly. However, there is considerable uncertainty about whether or not the level of economic growth per capita will converge slowly or rapidly to that experienced in the OECD. It is much more difficult to project future economic growth in the former Soviet Union and eastern Europe. The economic output of those countries has declined by more than 50 percent over the past few years, as economic and political reforms have led to massive economic restructuring.

Reductions in energy use per unit of economic activity make it easier to meet any given target for reducing greenhouse-related emissions. The trend in energy use per unit of economic output reflects changes in technology, the removal of barriers to new technology introduction, and changes in the structure of the economy.

Three complementary methods have been used to forecast the evolution of these changes:

- a top-down economic approach, relating aggregate energy use to fuel prices, labor and capital prices, and various measures of economic activity
- a bottom-up approach, employing engineering calculations on a technology by technology basis
- a social–psychological approach, focusing on how and why decisions regarding energy use are made at a more micro level than the top-down approach, embodying a more human–behavioral approach than the bottom-up approach (see Ch. 5).

Ten years ago the top-down and bottom-up approaches produced dramatically different projections. Since then it has become evident that each approach has its strengths and weaknesses, and various hybrid approaches have been developed. Assumptions regarding the characteristics and likely rate of penetration of new technologies have been developed, and researchers have started sorting through the various explanations for slower than expected adoption of new technologies (see Ch. 6). There is still some debate about whether some of these explanations describe market failures or simply reflect indirect costs not typically included in the engineering estimates of using a new technology, but that debate has shifted from one about the analytic method to one about the fundamental assumptions employed. The social–psychological approach can help researchers assess the reasonableness of the assumptions used in the other two approaches, although formidable data and methodological requirements have thus far precluded its application to modeling the full spectrum of national energy uses.

The final component in the decomposition of carbon emissions projections is the carbon intensity of energy use (total carbon emissions divided by total energy use). In the short run, changes in this index primarily reflect changes in the mix of fuels used to satisfy energy demands. Given the dominance of oil,

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CHAPTER 5

Energy and social systems

Elizabeth Shove, Loren Lutzenhiser,
Bruce Hackett, Simon Guy, Harold Wilhite

Until recently, the changing seasons in northern Europe, America, and Asia had a direct impact on daily life. Flandrin's account of winter in rural nineteenth-century France is as good an illustration as any (Flandrin 1979: 107):

> In the Planèse, where there is absolutely no wood, the peasant would be horribly miserable during the winter and could not live there if he had not discovered the means to do without wood to get warm: he does it by living in the midst of his farm animals.

Eating and sleeping arrangements literally revolved around the seasons in a way that is now difficult to imagine in modern Western societies. Instead of waking up surrounded by a herd of cows, many people expect to tap into an impressive array of energy systems. Otnes' description (1988: 127) of morning activity illustrates contemporary expectations. As he heads for the kitchen, he encounters a series of systems lying in wait. Referring to electricity as system no. 4, he first finds "Its terminal, the kitchen stove, attached to the public electric power plant and its cable and wire network. . . ." He continues,

> On my way back . . . I check the heating, or system no. 5, going through the rooms turning on electric radiators, or fan ventilators . . . I return with the paper, brew my tea and toast two bread loaves. In five minutes breakfast is ready—tea with milk (from the fridge, another privately owned terminal of system no 4, electricity).

This account reminds us of the interpenetration of daily life, household infrastructures and the public and private organization of energy supply. More than that, it illustrates the socially embedded character of energy consumption and the amazingly simple presumption—so simple, so amazing that people rarely think about it—"that one will enjoy, want, come to take-for-granted daily hot showers followed by cold drinks or gas heating and electric cooling of entire dwellings, or the consumption of leftover food, and that one will understand this to be a proper use for money" (Hackett & Lutzenhiser 1991: 467). In looking ahead, people would do well to think about the patterns of daily life implicitly inscribed in present and future energy-consuming and energy-saving technologies. What way of life will they wake up to a few years hence and what else will they be taking for granted as they stand under their solar-powered showers or toss the coffee grounds into one of the five waste bins that have now taken up residence in the kitchen (de Laat 1996)?

Efforts to reduce energy consumption have been variously inspired by concern about the depletion of finite fossil fuel reserves, national security and dependence on oil, cost, and (more recently) the global environment. Recogni-

tion that atmospheric emissions from energy use are a principal cause of global environmental change introduces a new and different reason to save energy, but it does not seem to have redefined policy perceptions of the sorts of strategies that might be deployed, nor of the human and social issues at stake.

Whether we focus on the past, present, or future, or we compare patterns of daily life and energy consumption in different parts of the world, it is clear that energy is used by people, not by buildings, cars or refrigerators. Observers and commentators on the energy system rarely miss this point or its implications for global environmental change. Of course, recognizing that people are significant is only the start of the story. What is important is how people or the social world are subsequently represented and conceptualized in debates about energy efficiency and the shaping of environmental policy. This chapter reviews a range of conventional and alternative approaches to representation of the human factor in energy use and, in the process, outlines a series of different roles for sociology and other social sciences.

The chapter is in two parts. The first part reviews what we call conventional approaches, first to the analysis of energy within social science disciplines and second to the positioning of social science within energy analysis. This exercise suggests that there is something of a mismatch. Although energy does have a recognized home within certain areas of economics and applied psychology, it has yet to establish itself as a really exciting subject within sociology or social anthropology. As a result, opportunities to develop and deploy theories of culture, social change, and technology remain to be exploited. We suggest that this is in part because conventional policy analysis tends to adopt a somewhat restrictive view of the human dimension and with it a correspondingly limited view of what social science might have to offer.

The second part of this chapter highlights examples and cases that illuminate alternative ways of conceptualizing the social and that offer accounts of the meaning and evolution of energy-consuming practice in everyday life quite different from those of the conventional approach. Alternative approaches variously acknowledge the cultural and sociotechnical embedding of energy-related practices, highlight the variety of institutional interests at stake, and grapple, in different ways, with the coevolution of energy use and social life. In so doing, these lines of inquiry open up other issues for examination. Conventional understandings of the relationship between tools, technologies, and users or consumers blur as new policy agendas emerge and as new and more legitimate roles for social science begin to take shape.

Taken together, the messages emerging from sociological and anthropological research suggest the need for forms of policy intervention based on authentically social theories of change. Among other things, this involves paying attention to local, situationally specific opportunities for change, to

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CHAPTER 6

Technological change

Arie Rip & René Kemp

Contributors
Gerrit Jan Schaeffer, Harro van Lente

Technology is implicated in global climate change in various ways–as a source of the problem, a possible solution, and an instrument of measurement and analysis. Coal-fired power plants and gasoline-fueled automobiles produce carbon dioxide emissions, the most important greenhouse-related gas. These emissions may be reduced, for example, by more energy-efficient combustion technologies, storing carbon dioxide emissions in empty gasfields, devising tools and methods to fertilize and irrigate crops more efficiently, or developing technologies that do not produce greenhouse gas emissions such as wind turbines and nuclear power. Technologies such as air conditioning and improved building design may enable people to adapt to climate changes.

This chapter focuses on the nature and the dynamics of technical change; how technology is shaped by social, economic, and political forces alike; and how, in the same process, technologies and technology systems shape human relations and societies. Such an understanding is vital if deliberate technological change is to be part of the solution to climate change problems.

Central to this understanding is the link between global climate change and what we will call evolving sociotechnical landscapes, which are part and parcel of overall transformations of societies. Particular technologies and artifacts are parts of larger systems and elements of a sociotechnical landscape. Their manufacture and efficient use depends on other technologies and skills that may or may not be available. They must compete with existing technologies that, unlike the new technologies, have benefited from scale and learning economies and from institutional adaptations. The diffusion of new technologies is connected not only with improvements in the technology compared to competing technologies, but also with the costs and availability of complementary technologies and with institutional changes in organization, ideas, norms, and values.

Differences among social science approaches to analyzing technological change are treated in the first section as building blocks for an overall framework. Perspectives from economics, sociology, and history provide powerful images of what technology is and does, but each image is only a partial picture. Our effort in this chapter is to note the strengths and weaknesses in each perspective and to find aspects that converge and support a broad and realistic understanding of technology and technical change. Within this convergence, we emphasize evolutionary and quasi-evolutionary approaches, which have contributed much to understanding technology and technological change. The second section, therefore, also examines the key role of coevolution of technological supply and demand. Dynamics and outcomes of technological changes are parts of the same process; each research emphasis yields insights but only partial explanations. The predictive capability of such research is strongest for incremental changes and situations where technologies have achieved stability. Evolutionary approaches are the most promising for the question of managing

technical change, the subject matter of the third section. The concluding section summarizes the main findings and draws out further perspectives.

Conceptualizations of technology

The traditional meaning of the word technology is said to be the study of arts and crafts. The term referred to what, for instance, masons or painters should know in order to be good and qualified masons or painters (Singer et al. 1954). At the beginning of the nineteenth century, the knowledge of trades and skills became more and more standardized. The advent of engineering schools in the eighteenth and nineteenth centuries was another important ingredient of change. In the same period, the meaning of the term "technology" shifted from the study of arts and crafts to include and emphasize purposeful invention and, by implication, the strategic deployment of such inventions.

Although the idea of technology as artifacts (gadgets and gizmos) is still widespread in our culture, we will argue that a broader understanding has greater explanatory power in understanding the complexity of technology and its dynamics. Artifacts can be used without an indication of their history and their inner working; this is called "black boxing." The material aspect of black boxing in modern household appliances is evident in the sleek surfaces that hide from view how the appliances work. The cultural aspect is exemplified by the absence of any need to inquire into the world behind the electrical outlet as described in Chapter 5 of this volume. (Also, see Vol. 1, Ch. 1 for other discussions of black boxing.) The division of labor contributes to the black boxing of technology in such a way that technology actually appears primarily as a set of tools. This division of labor in making and using tools dates from ancient times, but became very strong with the Industrial Revolution in the eighteenth and nineteenth centuries, and the increasing role of research and development (R&D) in the twentieth century.

Recent economics and sociology of technology have recognized the intellectual as well as political risks of treating technology as an exogenous factor, and attempt to endogenize it—with some success. Technology is studied as part of the world and its dynamics, suggesting that it may be a malleable aspect of social life. Although there is something hard, fixed, structuring about technology, these qualities are not attributes of technology as such. In Latour's (1987) phrase, artifacts are *immutable mobiles.* Their immutability is the outcome of material and sociocultural configuring, not a property of the artifact as such.

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CHAPTER 1

Economic analysis

Robin Cantor & Gary Yohe

Contributors
Bayard Catron, Larry Boyer, Robert Costanza, Edward Crenshaw, Robert Deacon, Wayne Gray, Nick Hanley, Frank Hole, Craig Jenkins, Michael Lovell, Vernon Ruttan, P. R. Shukla, Clive Spash, John Whalley

The problem of climate change exists because the scale of human activity has expanded to the point where the unintended byproducts of those human activities, namely the emissions of greenhouse-related gases, have reached a magnitude at which they are significant compared with global-scale natural processes. The scale and composition of human activities will also frame the conditions under which an altered climate will be experienced. For example, the nature, extent, and distribution of resources risk, as well as those available to societies for coping with climate change, will be largely shaped by human choices.

The field of economics has made substantial contributions to the current understanding of climate change. Indeed, the policy community has relatively uncritically adopted the tools of economics to analyze prospects for greenhouse gas emissions and the consequences of potential emissions mitigation. In this chapter, we will review the state of the art with regard to the social science understanding of the foundations of economic activity and the associated tools of analysis. Although this understanding and the analytic tool kit come largely from the discipline of economics, the chapter will examine contributions from other social sciences and consider opportunities to deepen and extend our knowledge and tools.

We begin with the insight from economic history that human economic and social institutions coevolve in response to challenges posed by both the natural environment and human wants, by generating both technological and social innovations to satisfy these needs (these topic areas are the focus of Vol. 1, Ch. 3 and Vol. 2, Ch. 6.). Of particular interest is the historical relationship between climate, economy, and society. In modern economic thinking, innovation is usually linked with the idea of growth. However, throughout much of human history, economic growth has not been seen as inevitable. Both economic growth and the study of the causes of economic growth are relatively recent, and the models are still relatively simple.

In the second section, we deal with changes in the way economics has modeled the growth process, beginning with Malthus's observations on the growth of human population, with its demands on the natural environment and the constraints on growth imposed by the environment. From the point of view of economics, climate change and the overall environmental carrying capacity of the planet are really the latest in a long series of concerns about the constraints on human activity imposed by nature. The simple Malthusian view has undergone considerable revision, as appreciation of the roles of produced capital and human learning has advanced. But concern remains about the constraints imposed by nature and (perhaps less obvious) by social organization.

The third section of the chapter documents the tools and insights that are provided by standard economic analytic principles as they have been applied

to the climate change problem, showing what has been learned about the issue itself and what could be the consequences of intervention.

The next section takes up the conceptual and measurement shortcomings of the standard economic paradigm as it has been applied to climate change, and discusses how resolving some of these shortcomings might affect the analysis.

The final section focuses the broad discussion in these previous sections on the current international process of studying climate change, which is tied to the Framework Convention on Climate Change (FCCC). In this context, the standard view of the economics paradigm, a view that regards climate as a constraint on economic development, may not be the best approach to achieving international agreement. However, expanding the standard view is likely to prove difficult, given the current situation in the international science and policy communities.

Historical perspective—climate, economy, and society

Humans have interacted with their environments and their climates for millennia, over which time the climate has been constantly subject to changes, although none so dramatic or rapid as that potentially to be encountered in the next centuries. What can humans learn from past experiences? What do they offer researchers and decisionmakers concerned with climate policy? Economic history records that human institutions have both prospered and declined as a result of climate. However, technological, social, and economic adaptations are extremely important intervening factors. A glimpse at the historical record demonstrates just how difficult it is even to correctly frame the issues involved in climate change. A little historical context can help researchers determine if they are even confronting the right set of questions. A few episodes are sufficient to show that most of the human economic activity has involved adapting to change, notably adaptations in agriculture:

- The systematic planting of crops first took place in the Near East around 8000 BC. Several authors, notably Byrne (1987), Blumler & Byrne (1991), and McCorriston & Hole (1991), have argued that this strongly seasonal Mediterranean climate, complete with mild and wet winters followed by rainless summers, was the key to the expansion of cereal agriculture in the Near East. Agricultural economies, in fact, expanded throughout the Near East and into regions of North Africa that today are too dry to support agriculture.

Hole (1997) recorded that the sea rose rapidly from around 9000 BC until about 4000 BC, when it stabilized at approximately today's levels.

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CHAPTER 2

Games and simulations

Edward A. Parson & Hugh Ward

In the previous chapter we saw how economic discussions of decisionmaking are deeply rooted in methodological assumptions of atomistic rationality; that is to say, they tend to treat decisions as if they are made by a unitary actor based on rational expectations. Hence, as Chapter 3 describes, the kind of information that is generated to help societal decisionmaking about climate change (or, indeed any other issue of public policy concern) is often structured as if addressed to a benevolent dictator seeking to make the most efficient decision on behalf of us all. In this chapter, we begin to explore the limitations of analysis based on this kind of assumption. We use game theory and simulations to introduce the problem of how multiple decisionmakers acting in their own self-interest may or may not produce an outcome that is rational from a global standpoint.

The first half of the chapter discusses this problem from the standpoint of formal game theoretic analyses. This body of social science research and writing explores decisionmaking among limited numbers of unitary rational actors. In game-theoretic explorations of international relations, these actors are nation states. Although one-shot games are recognized as having very limited application to ongoing relations among states, iterated games do provide a parsimonious framework for thinking about cooperation and decisionmaking at levels between the benevolent dictator, on the one hand, and the anonymous market characterized by many well-behaved individuals, on the other.

However, nowithstanding efforts to develop nested or two-level games (e.g., Putnam 1988), game-theoretic approaches are generally not so well adapted to explore the effect on decisionmaking of nonunitary actors; that is, they do not take account of the tensions among rival viewpoints and values within a state that can cause it to change course during negotiations in ways that cannot be predicted within the parameters of the game. This is one of the issues that is used in the second half of the chapter to justify supplementing formal game theoretic analyses with actual simulations involving human actors representing diverse interests within teams of players representing national positions in iterated cooperation games.

Game theoretic approaches to international cooperation

Global environmental change issues raise the question of international cooperation and collaboration to overcome the problems associated with them. In contrast to local environmental questions that affect specific regions or countries, global environmental change results from activities by individuals, firms, social groups, or entire countries—activities that have global consequences. This is true in particular for climate change, where local emissions of greenhouse gases, resulting from a variety of human activities, have global effects: the mixing of these gases in the atmosphere is so thorough that they may contribute to global climate change by increasing the greenhouse effect on the Earth. This process means that there is no a priori relation between the quantity of greenhouse gases that a region or a country emits and the climate change consequences that it experiences as a result of these emissions.

Hardin's metaphor of the "tragedy of the commons" (1968), in which self-interest and the lack of any constraints on access lead to the overexploitation of open access grazing seems, at first sight, to be a useful way of thinking about the dilemma faced by the international community on global climate change.

Stabilization of the global climate system can be conceptualized as a relatively pure international public good: nations not paying for the cost of stabilizing emissions cannot be excluded from the benefits of a stable climate; climate stability is a good in joint supply, because all countries can enjoy it without prejudice to others' consumption (Weale 1992). Framed thus, the problem is that, because the benefits cannot be limited to those who pay for stabilization, countries may rationally free ride, that is, take advantage of the benefits produced by sacrifices (made by other nations) at no cost to themselves.

National self-interest seems to pressure many nations toward free riding, so that we are currently failing by a wide margin to do what may be required for long-run stability of greenhouse-related emissions. However, just as many small communities over the millennia have developed institutions that have prevented the tragedy of the commons from occurring (Berkes 1989, Ostrom 1990), many hope that the international community will develop the necessary institutions and agreements to restrain the pursuit of national interests.

Game theoretic models offer a way to examine issues of international cooperation, negotiation, and bargaining—especially in the context of international public goods. One of the assumptions included in the practical use of game theoretic models is that participants in international interactions (either nations, or subnational or transnational groups) can be viewed as unitary actors making choices between strategies so as to maximize their expected payoffs. This assumption is made mostly for practical reasons. Elaborated game theoretic models can be constructed from the bottom up, starting with individuals or small groups, and then generate preferences for large groups as well as national preferences. However, because of their size and complexity, models constructed in this way would be excessively difficult to handle.

Generally, a nation's payoff from adopting a particular strategy will vary, depending on the strategies chosen by other nations. To make a rational choice among strategies, a nation has to be able to predict the responses of other nations. The simplest models assume that nations know not only their own payoffs but also those of all the other nations or groups. Also, they assume that all

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CHAPTER 3

Decision analysis and rational action[1]

Carlo C. Jaeger, Ortwin Renn,
Eugene A. Rosa, Tom Webler

Contributors
Robin Cantor, Ottmar Edenhofer, Silvio O. Funtowicz, Gavan McDonell,
Jerome R. Ravetz, Steve Rayner, Galina Sergen

1. For helpful discussions we are indebted to Hadi Dowlatabadi, Larry Goulder, Jean-Charles Hourcade, Ray Kopp, Irene Peters, Jan Rotmans, and Matthias Waechter. A more extensive elaboration of the theoretical argument made in the chapter will be developed in a forthcoming book by the principal authors.

Climate change is representative of a class of issues that raise tough challenges for individual and collective decisionmaking. It is perhaps surprising, therefore, that the fundamental conceptual framework for climate change decisionmaking has received so very little scrutiny in such a large literature.

An exception is Arrow et al. (1996a: 62) who adumbrated the fairly restrictive set of assumptions under which standard decision analytic perspectives and tools operate. They include a unique decisionmaker faced by a limited number of alternatives which can be compared by an unambiguous quantitative criterion. Of course, it is widely recognized that these conditions will not be perfectly satisfied for most real-world decisions. Provided that the violations are minor, decision analysis may still offer a solution close to the optimal outcome desired by a rational actor. What is less generally agreed upon is the problem of how to distinguish which violations are minor and which are major, as well as what level of cumulative minor violations synergize to invalidate the approach.

For climate change, the same authors recognize significant violations. In particular, there is no single decisionmaker. Differences in values and objectives prevent collectives of decisionmakers from using the same selection criterion for decision alternatives—so decision analysis cannot yield a universally preferred solution. Moreover, uncertainties in climate change are so pervasive and far reaching that the tools for handling uncertainty provided by decision analysis are no longer sufficient.

The problem of multiple decisionmakers leads Arrow and his coauthors to recommend a less formal approach to the choice of climate policy at the intergovernmental level: a structured incremental negotiation framework designed to produce a solution acceptable to multiple parties, rather than an impossible optimum. This framework embodies various formal decision analytic techniques designed to maintain the rationality of the decision process. The extent to which such processes of structuring negotiations violate the assumptions of decision theory is not explored in detail, raising the question of whether sustaining the relevance of formal decision analysis in spite of significant violations is a prudent preservation of insights from a potentially powerful tool or, rather, a misleading procedure somewhat akin to looking for one's keys under a street lamp because that is where the light is.

In the context of the Intergovernmental Panel on Climate Change and the negotiations that it is designed to serve, the parties to decisionmaking are not citizens but national governments. "Decision analysis suffers fewer problems when used by individual countries to identify optimal national policies" (Arrow et al. 1996a: 65). However, the authors were not explicit about how it is that an intergovernmental decision involving fewer than 200 decisionmaking parties poses greater problems for applying decision analysis than the shaping of national policy by governments representing millions of households,

thousands of firms and nongovernmental organizations, hundreds of communities, dozens of economic sectors, and multiple regions. Even the legislatures of most countries have more members than there are parties to the Framework Convention on Climate Change. The presumption of a unitary national interest seldom withstands close scrutiny, particularly in a world of economic, political, and cultural interdependence across national boundaries.

Furthermore, it is clear that decision analytic perspectives and tools continue to be applied uncritically by a large segment of the technical community that advises government decisionmakers. The climate policy literature almost universally shares the fundamental assumption underlying the application of rational analysis and decision analytic tools: that climate change can be decomposed into a conceptually simple (if still practically challenging) problem, for which a rational solution can be constructed and implemented within the existing framework of political power and technical expertise. In other words, climate change can be distilled down to the problem of controlling greenhouse-related emissions, the relevant actors are national governments, and the relevant action required is coordinated regulation (through whatever policy instruments) of the emission of greenhouse-related gases by firms and households at an optimum level from the standpoint of the general welfare, expressed as a proportion of gross domestic (or global) product.

This persistence of analysts in using conventional decision analytic perspectives, and the continued focus on optimization where no optimum can exist, suggest that the fundamentals of decision analysis are worth a closer look to get a handle on how to decide where and when decision analytic insights are useful or misleading, as well as to investigate possible alternative or supplementary approaches that currently may be underutilized.

As uncertainty is a salient feature of climate change, the tools of risk analysis need special attention here. Combined with the issue of uncertainty, however, are additional difficulties. In particular, decisions relating to climate change are not oriented by a unique consistent value system. Even a single actor may be influenced by several value systems that contradict each other. The classical result by Arrow (1951) on the impossibility of a general procedure for aggregating given individual preferences in a democratic fashion is exacerbated by such conditions (see Sen 1995 for a recent discussion). Obviously, aggregation may be performed by a technocratic rule system, but this is neither a desirable nor a reliable institutional setting for climate policy.

Democratic institutions aggregate individual preferences by enabling individuals to modify their preferences through the combination of voting procedures and public debate. The role of public debate reminds us of the need for interpretive approaches such as that of the Frankfurt School (Bottomore 1984), to complement the reductionist analysis of conventional mathematical

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CHAPTER 4

Reasoning by analogy

William B. Meyer, Karl W. Butzer, Thomas E. Downing,
B. L. Turner II, George W. Wenzel, James L. Wescoat

Researchers can assess the novel challenges and opportunities that global climate change may present to human beings and activities by examining how similar challenges and opportunities already posed have been met. Using the experiences of individuals, groups, and places in other times and in the contemporary world as analogues for climate change may help to refine our sense of how important such climate changes would be, help "to determine how flexible (or rigid) societies are or have been in dealing with climate-related environmental changes," and "help us to identify societal strengths and weaknesses in coping . . . so that we can reinforce those strengths and reduce the weaknesses" (Glantz 1988: 3–4). Reasoning by analogy has dangers and limitations as well as uses. That analogues are likely to be employed in discussions of climate change makes an assessment of the method all the more important.

Innumerable past situations may be compared or contrasted to aspects of global climate change and its human dimensions. Chapters in this assessment invoke specific analogues ranging from the demographic transition in Europe (Vol. 1, Ch. 2) to past diffusion of new technologies (Vol. 2, Ch. 5) to experience with international agreements and successes and failures with the use of particular regulatory control instruments (Vol. 2, Ch. 5). The possible scope of a chapter on analogues is enormous. For the sake of manageability and of thematic unity, the actual scope of this chapter is much narrower, focusing on past human interactions with climate and environmental realms closely related to it. The chapter further homes in on integrated assessments—that is, on studies that deal with the interaction of areas ordinarily treated by topical specialists in different fields—and on studies primarily qualitative in method and regional or local in scale. (More formal methods of integrated assessment are dealt with in Ch. 5.)

Bounding the topic of climate change analogues in this way still encompasses a large literature and the bulk of what the human sciences have said about actual human interaction with climate and its variations to date. We examine that literature with two goals in mind. The first is to illustrate the uses and limitations of reasoning by analogy as a method for assessing global climate change. The second is to present such lessons about climate and society relevant to global climate change as can be derived from the analogies that we examine.

Climate, human affairs, and the human sciences

The climate and society literature that we review in this chapter consists of two bodies of work. Some studies explicitly draw analogies between the material analyzed and the human dimensions of global climate change. Others analyze

the material in ways that permit such analogies to be drawn. The former literature is much smaller than the latter, but neither is as large as it might be. An inventory of climate and society analogues does not have a rich or well-tested body of work on which to draw, because the social sciences during the twentieth century have paid little attention to climate–society interaction.

Most disciplines have done so deliberately rather than by mere neglect. The trend of Western sociological theory and research during most of the twentieth century has been, on principle, to exclude the biophysical environment ever more thoroughly from consideration (Catton & Dunlap 1980, Guterbock 1990). In development economics, early excesses of climatic determinism gave way by mid-century to a tendency to reject climate a priori as a significant factor (Myrdal 1968). Seasonality in economic data is not necessarily attributable to climate but is a good place to look for climatic influences; forsaking earlier traditions (e.g., Kuznets 1933), however, macroeconomists after mid-century devoted much more effort to removing seasonal trends from data than to accounting for them (Barsky & Miron 1989). Even in geography, the social science most attentive to climate and the biophysical world, an early school of thought that assigned them a large role in controlling human affairs provoked a reaction that discouraged any attention to the environmental dimensions of human activity (Rostlund 1956, Lewthwaite 1966, Hewitt & Hare 1973). Although social scientists clearly showed the biophysical environment to be less overwhelmingly important in human affairs than environmental determinists had painted it, they did not show conclusively that it was unimportant. In geography, "environmentalism was not disproved, only disapproved" (Rostlund 1956). There appear to be two main reasons for its banishment: the first was a desire to claim a subject matter for the social sciences independent of the natural sciences; the second was a widespread distaste for what many took to be the reactionary, racist, or imperialist implications of asserting the environment's importance, and particularly that of climate (Guterbock 1990, Bassin 1992).

The general trend notwithstanding, climate–society interactions remained of interest to many individuals and even subfields in the mid-twentieth-century human sciences, such as the Annales school in history, crop–climate modeling in agricultural economics, cultural ecology in anthropology and geography, and multidisciplinary research on natural hazards. A wider interest became evident during the 1970s. Schneider & Mesirow (1976) and Bryson & Murray (1977) warned of the threat that climate change and instability might pose to society. Several major syntheses of existing research appeared early in the next decade. Rotberg & Rabb (1981) and Wigley et al. (1981) took stock of the methods, findings, and further agenda of work on prehistoric and historic climate–society interactions. Kates et al. (1985) reviewed the application of diverse

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CHAPTER 5

Integrated assessment modeling

Jan Rotmans & Hadi Dowlatabadi

Contributors
Marjolein B. A. van Asselt, Edward A. Parson, Marco Janssen

The term "integrated assessment" is no longer new and its use is growing rapidly, partly because it has been loosely defined so far. Although many definitions of integrated assessment circulate (Weyant et al. 1996), we have adopted the following definition: integrated assessment is an interdisciplinary process of combining, interpreting, and communicating knowledge from diverse scientific disciplines in such a way that the whole set of cause–effect interactions of a problem can be evaluated from a synoptic perspective with two characteristics (Rotmans & van Asselt 1996):

- It should have added value compared to single disciplinary oriented assessment.
- It should provide useful information to decisionmakers.

This definition of integrated assessment requires that the full range of various causes, mechanisms, and impacts of climate change should be addressed. Integration of just two disciplines, for example, demographics and economics, would not qualify as integrated assessment of climate change; at a minimum, all key policy criteria raised in Article 2 of the Framework Convention onClimate Change have to be addressed (Box 5.1).

Box 5.1 Policy criteria from Article 2 of the Framework Convention on Climate Change

> The ultimate objection of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, *stabilization of greenhouse gas concentrations* in the atmosphere at a level that would *prevent dangerous anthropogenic interference* with the climate system. Such a level should be achieved *within a time frame sufficient to allow ecosystems to adapt naturally* to climate change, to *ensure that food production is not threatened* and to *enable economic development to proceed in a sustainable manner.* (UN 1992) [emphasis added].

Alternatively, integrated assessment can be defined broadly by its assembly of knowledge from a diverse set of sources, relevant to one or more aspects of the climate change issue, for the purpose of gaining insights that would not otherwise be available from traditional, disciplinary research. (These insights could contribute to the scientific community as well as to decisionmakers.)

The discipline-spanning nature of integrated assessment is an important aspect. At the very least, the activity is *multidisciplinary*, encompassing information generated by the full array of disciplines at work in specialized fields of endeavor. When done well, integrated assessment is *interdisciplinary*. That is, the researchers participating in the integrated assessment activity spend enough time learning about the work of the other participants to anticipate the information, scale, and format needs of the other researchers. They are able to

see the interconnections of the integrated assessment problems, not simply their own individual research elements. They move beyond the usual cartoon understanding of each other to a point where new understanding of the problem is possible.

Integrated assessment emerged as a new field in climate change research because the traditional reductionist approach to global change research has been unable to meet two significant challenges central to understanding global phenomena. The first challenge is the development of an adequate characterization of the complex interactions and feedback mechanisms among the various facets of global change. Without exception, such feedbacks and interactions are defined away or treated parametrically in reductionist disciplinary research. Scientists and decisionmakers are increasingly aware that the various pieces of the global change puzzle can no longer be examined in isolation. Integrated assessment endeavors to keep track of how the pieces of the puzzle are fitting together, indicating priorities for narrower disciplinary research. The second challenge is that of providing support for public decisionmaking. Integrated assessment offers an opportunity to develop a coherent framework for consideration of multiple objectives of decisionmaking and identification of possible policy criteria.

The issue orientation of integrated assessment research has led to significant progress in interdisciplinary areas. Most of the effort is being expended in building bridges across disciplinary boundaries. In this bridge-building process, new disciplinary challenges are being identified. Resolving these challenges is central to improving researchers' capacity to inform decisionmaking in the future.

From a practical perspective, integrated social, economic, and environmental conditions demand integrated policies. Despite an early history of isolated regulatory initiatives related to air, water, soil, and so on, over the past two decades environmental policies have become increasingly integrated. In Europe, for instance, the European Union has developed integrated environmental policies. In the United States, interdisciplinary research supports the development of environmental impact statements. Integrated assessments make it possible to be better informed in the continued trend to develop more integrated regulatory structures.

This chapter first discusses integrated assessment broadly. Three recent or current integrated assessment efforts are described. The chapter moves on to focus on *integrated assessment modeling*, that is, efforts that are based on linked computer models of different facets of the human–climate system. Models have certain advantages and limitations, and they embody certain frameworks or definitions of the whole system. Indeed, both the strengths and weaknesses of integrated assessment models tend to be related to the simplifications (especially simplified relationships) expressed in the underlying frameworks

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CHAPTER 1

Why study human choice and climate change?

Steve Rayner & Elizabeth Malone

Why the concern with climate change?

Time and again over the course of the past decade, climate change has been described by scientists, environmentalists, and politicians as a threat unprecedented in human experience. Tolba's (1991: 3) statement is representative of such concerns: "We all know that the world faces a threat potentially more catastrophic than any other threat in human history: climate change and global warming." Many reasons and combinations of reasons are advanced for this claim, especially the potential rapidity of temperature rise, the irreversibility of change once the forces are set in motion, the geographical scale of the threat, the complexity and nonlinearity of the natural systems involved, the ubiquity and strength of human commitment to combustion technologies, and the political challenges of global cooperation that climate change seems to demand. The real danger, say many, lies in the potential for catastrophic surprise.

Similarly, several candidate causes have been identified. Emissions of greenhouse-related gases from human activities constitute the proximate cause, of course. In the background lurk possible underlying causes: population growth, overconsumption, humans' inability to control the technologies they have created, their inability to implement environmentally benign technologies, their unwillingness to spend current wealth to benefit future generations, their powerlessness to forge effective international agreements and abide by them. Whatever the cause, climate change is framed as a problem, which admits the possibility of solution.

Solutions come in many forms and approach the problem from different angles. Solutions to scientific problems take the form of improved knowledge, understanding, and predictability of natural systems. Solutions to technological problems require innovation and commitment of resources. Solutions to problems of societal cooperation and coordination are offered in the form of international treaties and policy instruments such as taxes or emissions controls. However, all solutions imply choices that must be made, consciously or unconsciously, enthusiastically or reluctantly, and with levels of information that may be satisfactory or unsatisfactory to the choosers.

Why the concern with human choice?

The possibility of human choice, albeit constrained, underlies all of these discussions; that is, humans can choose to respond to the prospect of climate change and can decide, with undetermined and perhaps undeterminable degrees of freedom, what steps to take. However, choice does not merely under-

lie any possible solution to climate change; it also underlies the problem itself. Increasing global greenhouse gas concentrations are the result of myriad choices that compose the history and contemporary operation of industrial society. Any attempt to change the course upon which human society appears to be embarked requires not only new choices about future actions, but also understanding of past choices—the existing social commitments that have set the world on its present course. The possibility, indeed the inevitability, of choice lies at the core of the climate change issue.

Everyone makes choices about accepting participation in any sort of society (even rebelling against it). Much of human life is devoted to negotiating within families, laboratories, firms, communities, nations, and other institutions the particular balance of independence and interdependence that each person is willing to accept. This tension, characteristic of all forms of social existence, is thrown into stark relief by the controversies that rage and the choices that must be made about the potential for climate change. Questions of choice, therefore, lie at the heart of not only the climate change issue but also the social sciences.

Possible choices with reference to climate change can be grouped into three broad categories, which can be combined in various ways:

- Do nothing. Some say that concern about climate change is unwarranted; the science is unproven, based on speculation bolstered by models so inaccurate they cannot reproduce historical shifts in climate. Others believe that impacts will be gradual, easily accommodated through technology, or insignificant on a global scale. If climate change does occur, then piecemeal adaptation will suffice. Even some who do believe that climate change is likely and may be disruptive suggest that the aggregate benefits of allowing climate change to run its course would outweigh the costs.
- Mitigate, that is, lessen emissions to reduce the magnitude of climate change. If one is convinced that anthropogenic emissions are giving rise to climate change, the obvious direct solution to the problem is to reduce net emissions. Motivations for preferring this option include not only its directness but also, perhaps more importantly, that it can be conjoined with favored solutions to other perceived problems, such as population growth or the income disparities between industrialized and less industrialized nations.
- Anticipate and adapt; that is, change crops and growing regions, retreat from or defend coastal areas, prepare for population shifts and health impacts. Advocates of anticipatory adaptation also regard it as an opportunity to develop policies and technologies that would be beneficial in any event, such as infrastructure that is more resilient to extreme weather events.

For all three strategies, or any combination of them, it makes sense to invest

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CHAPTER 2

The challenge of climate change to the social sciences

Steve Rayner & Elizabeth Malone

The climate change issue has challenged the appropriateness of social science paradigms and tools, and the effectiveness of its disciplinary organization. Some types of social science research have fitted in well with the highly visible and influential research into atmospheric chemistry, and physical and chemical processes affected by human activities. For example, computerized climate and environment models have been joined by energy use and economic models. However, other kinds of social science research have remained at the margins of the political and scholarly debate. Although research results are available on, for example, human needs and land tenure systems, these results have not informed the policy dialogue to any great degree. In this chapter we explore an underlying reason why this situation exists. We begin by revisiting the emergence of climate change in the research agenda of the natural sciences and its gradual opening up to social science collaboration.

Following the stimulus of the International Geophysical Year of 1956, the natural sciences evolved an extensive network of research programs focusing on climate and other global environmental changes. Through these efforts, scientists have developed an extensive knowledge base on topics related to climate change in an astonishingly short time. The insights that the natural sciences have provided into the physical and chemical processes involved in climate change and its impacts are necessary inputs for human decisionmaking in these areas. However, prominent natural scientists participating in these programs (e.g., Malone 1985, Clark 1986, Schneider 1987, di Castri 1989) were conspicuous among the voices arguing that natural science information is not fully sufficient to explain the human activities and institutional responses that shape the pattern and extent of greenhouse gas emissions. Natural science information is even less complete with respect to understanding human responses to real and potential impacts of climate change. To address these topics and to inform human decisionmaking in the context of human-induced changes to the atmosphere, they argued, social science research is essential.

Opportunities for social science collaboration in major international scientific research programs addressing climate change, such as the Intergovernmental Panel on Climate Change (IPCC), have been largely focused on extending the framework already established by the natural sciences. The most basic framework consists of a four-box conceptual model: quantified emissions of greenhouse gases, atmospheric chemistry, climate and sea level, and ecosystems. Within this framework (Fig. 2.1), the social sciences provide highly aggregated data on human activities leading to greenhouse gas emissions. These data can be used to drive natural science models of global atmospheric chemistry and physics. In turn, the natural sciences aim to model climatic impacts on managed and unmanaged ecosystems upon which humans depend. At this point, social scientists are invited to project the outcomes of these changes for large-scale

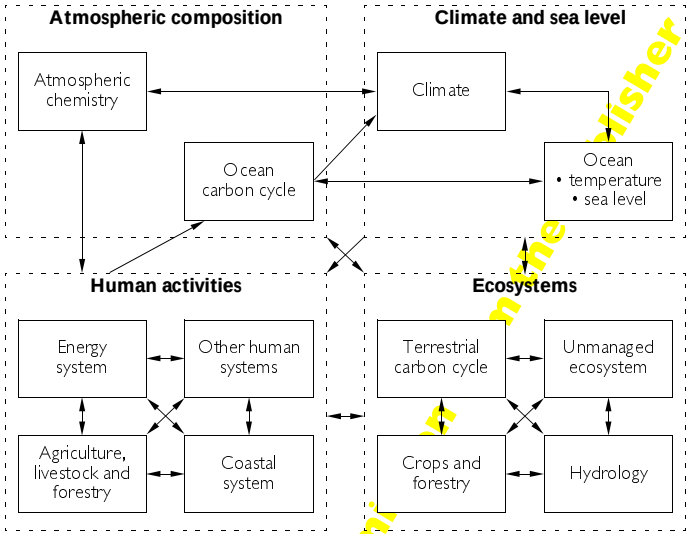

Figure 2.1 Elements of the climate change problem (*source*: Watson et al. 1996).

patterns of agricultural and industrial activity, stimulating macroeconomic and technological responses, which, in turn, may eventually alter anthropogenic emissions estimates. The outputs of such research are presented as data: grist to the decisionmaker's mill. The same framework shapes the bulk of research undertaken within the international social science programs of climate and global change research, such as the Human Dimensions Program of the International Social Science Council (ISSC), which emphasizes stocks, flows, and driving forces of change.

Even though the style of social science emphasized in these programs seems quite compatible with the cyclical framework postulated by the natural sciences, there has been significant concern about the issue of bridging the gap between natural and social sciences, a gap that is invariably taken for granted and associated with much hand wringing. Much is often made of the differences between the two intellectual traditions, exemplified in the distinction between the experimental tradition (including "bench" or laboratory science) and the study of human nature and the history of ideas.

The comparisons inevitably find the social sciences wanting with respect to the characteristics of theoretical consensus about fundamentals, including the nature of phenomena, their measurability and the computability of relation

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CHAPTER 3

Social science insights into climate change

Steve Rayner & Elizabeth Malone

Contributors
Chester L. Cooper, James A. Edmonds

From the methodological challenges that climate change and other large complex issues present to the intellectual organization of the social sciences and their analytical tools, we now return to the social science insights into climate change. In Chapter 1 we listed a sample of questions about how humans exercise choice in relation to understanding, causing, and responding to climate change. Although these are by no means exhaustive, they represent a sufficiently broad cross-section of issues upon which to assess the current state of social science knowledge about human choice and climate change. To recap, the questions are:

- How do scientists choose to study climate change? How do they form a scientific consensus?
- How do people decide that climate change is worthy of attention?
- How do people attribute blame for climate change and choose solutions?
- How do people choose whom to believe about climate change and at what level of risk do they or should they choose to act?
- How do people and institutions mobilize support for (or against) policy action on climate change?
- What is the relationship between resource management choices and climate change?
- How do governments establish where climate change stands in relation to other political priorities? How do they choose the climate change issues around which to formulate goals?
- How are climate change policy instruments chosen?
- Why and how did the international community choose to address climate change?
- How do societies select technologies that cause, mitigate, or assist adaptation to climate change?
- How can research on social or collective action be useful to the global climate change debate?

In this chapter we, the editors of *Human choice and climate change*, draw upon the work of our authors and contributors to see what kind of light the social sciences can shed upon questions such as these. In so doing, we elucidate what we regard as some of the most significant crosscutting themes of the assessment, although we do not claim to be exhaustive. Readers can find the fuller arguments and supporting data in the appropriate chapters, where there is much more information to be mined than we can possibly summarize here. Our goal is to summarize what social science has to say about global climate change and the debates that surround it, and how this information can be used both to set the future research agenda and to inform the policy process. However, we reserve actual suggestions to policymakers for the final chapter.

How do scientists choose to study climate change?
How do they form a scientific consensus?

Contemporary science and technology studies suggest that the issue of climate change, like other global environmental issues, has emerged from an interplay among scientific and political agendas. "Science and decision-making" describes how scientific knowledge and political order are routinely co-produced at multiple stages in their joint evolution, from the moment when scientific findings are stabilized in laboratories and field studies to the time when nations and international institutions accept the explanations offered by science for use in decisionmaking. This process of co-production does not invalidate scientific findings, but it does tend to invest science for policy with a Janus-like character. On the one hand, scientific knowledge, even in the physical sciences and mathematics, develops through significant processes of social negotiation and consensus building. On the other hand, policymakers, scientists, and lay publics all share an explicit commitment to the idea of science as objective—providing value-free facts to policymakers in a kind of black box whose origins cannot be discerned. For example, "In American politics there is constant pressure to convert political questions into technical questions, so that they can be referred to experts without actually confronting the value differences that frequently are the real origin of conflict" (Brooks 1976: 244). The same process can be seen at work on a global scale in the case of climate change.

Political questions are often posed as technical questions that can be referred to experts without confronting the value differences that are the real origin of conflict

Scientific consensus about climate change has been built through strategic alliances among those investigating a variety of processes and topics to frame an "Earth systems science." This alliance has matured through the creation of scientific advisory committees, by the standardization of inquiry (most notably in computer models), and pre-eminently by the processes of the Intergovernmental Panel on Climate Change (IPCC). These are the means by which scientific knowledge and practices become standardized and widely accepted. Scientific internationalism is not simply a matter of cooperation across existing research agendas. International institutions also produce new forms of knowledge, beliefs, and political action; they are not just passive facilitators of convergence toward an independently optimal end-point of international bargaining.

Scientific advisory committees in general offer a powerful way to legitimize knowledge claims. For climate change, the IPCC has played this role, providing a great deal of agreed-upon knowledge and criteria for evaluating "good"

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CHAPTER 4

Ten suggestions for policymakers

Steve Rayner & Elizabeth Malone

If public and private decisionmakers find any merit in the four volumes of *Human choice and climate change*, what might they do differently? What have we learned from a wide-ranging look at the social sciences and the issue of human choice and climate change that illuminates the evaluation of policy goals, implementation strategies, and choices about paths forward? At present, proposed policies are heavily focused on the development and implementation of intergovernmental agreements on immediate emissions reductions. In the spirit of cognitive and analytic pluralism that has guided the our project, we look beyond the present policy priorities to see if there are adjustments, or even wholesale changes, to the present course that could be made on the basis of a social science perspective. To this end we offer ten suggestions to complement and challenge existing approaches to public and private sector decisionmaking:

- **View the issue of climate change holistically, not just as the problem of emissions reductions.**
- **Recognize that, for climate policymaking, institutional limits to global sustainability are at least as important as environmental limits.**
- **Prepare for the likelihood that social, economic, and technological change will be more rapid and have greater direct impacts on human populations than climate change.**
- **Recognize the limits of rational planning.**
- **Employ the full range of analytic perspectives and decision aids from the natural and social sciences and the humanities in climate change policymaking.**
- **Design policy instruments for real world conditions rather than try to make the world conform to a particular policy model.**
- **Incorporate climate change concerns into other more immediate issues, such as employment, defense, economic development, and public health.**
- **Take a regional and local approach to climate policymaking and implementation.**
- **Direct resources into identifying vulnerability and promoting resilience, especially where the impacts will be largest.**
- **Use a pluralistic approach to decisionmaking.**

We begin with the current focus of climate change policy research and practice on emissions reductions.

View the issue of climate change holistically, not just as the problem of emissions reductions

A re-examination of the present policy path seems particularly pertinent at the time *Human choice and climate change* is going to press. The overwhelming priority placed on emissions reduction since emissions reduction goals of 20 percent by 2005 were proposed at the 1988 Toronto Conference on Climate Change has almost entirely displaced attention to the evaluation and development of adaptive policy responses (and entirely eliminated consideration of any possibilities of geoengineering responses). Since the Toronto conference the additional radiative forcing effect of greenhouse-related gases on the planet's surface has risen by a little more than half a watt per m^2, about one-fifth of the total increase in the forcing effect from the beginning of the Industrial Revolution up to 1990. Concentrations of carbon dioxide have risen about five times the historical average for the decades between the onset of the Industrial Revolution and 1988. Emissions have fallen substantially in some countries, but only because of economic collapse that has added to the sum of human misery. Of the economically healthy countries that have set themselves voluntary emissions reduction targets of returning to 1990 emission levels, only Britain and Germany have succeeded, but for reasons unconnected to climate change; a Conservative British government having broken the political power of the National Union of Mineworkers by switching from coal to nuclear electricity generation and the so-called dash for gas, and Germany by reaping the unintended consequences of the restructuring of the economy of the former German Democratic Republic.

An emissions limitation strategy has the distinct advantage that it is reasonably easy to get one's arms around conceptually. The justification of such measures is that they represent at least a start down the right road. However, in practice, the 20 percent level of emissions reductions currently under discussion for the industrialized countries seems to have little, if any, basis in the levels actually required for stabilization of atmospheric concentrations of greenhouse-related gases. The target seems to be entirely a negotiating construct based on the participants' assessment of what is achievable politically.

The targets and timetables approach has also proven to be extremely divisive in the United States, which is presently the largest total and per capita emitter. Such division is likely to endure so long as people with a broad cross-section of world views and economic interests lack compelling evidence that emissions reductions would be cost effective. There is also a likelihood that emissions reductions at levels that fail to provide the environmental benefits sought will gives rise to a backlash against such policies. Such a backlash could be exacerbated in countries that make economic sacrifices to meet targets if other

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