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IMPROVING THE SCIENCE OF CLIMATE IMPACT STUDY

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The decade of the 70's was marked by a growing climate consciousness, both popular and scientific. It was sparked by a series of extreme climatic events and related disruptions and by scientific speculation as to increased climatic variability and possible climatic change. The decade of the 80's will produce major national and global efforts to enhance basic understanding of climatic mechanisms, to examine the sensitivity of organic life and social systems to climatic fluctuations, and to apply recent and forthcoming climate knowledge to productive human activity and to the mitigations of hazardous outcomes.

The Scientific Committee on Problems of the Environment (SCOPE) of the International Council of Scientific Unions (ICSU) has undertaken to organize a major effort to review current methodology and to develop new methodology for understanding the interactions between climate, nature and society. I serve as coordinator for this review, guided by a scientific advisory committee under the leadership of F.K. Hare (Canada). In this paper I describe the underlying conceptual questions around which our review is organized.

At least three central issues of concept and method need to be explored if the science of impact study is to be advanced. Stated simply as questions of theory, substance, and method, they are:

1) What is assumed as to the relationship between climate, organic life, and human activity and society?
2) What are the specific objects or elements of study that comprise impact studies?
3) What modes of analyses and techniques are both useful and appropriate for impact studies?

Models of Relationships

All assessments of climatic impact assume, explicitly or implicitly, certain underlying relationships between climatic events and impacted populations, activities, societies and regions. These relationships can be described as a series of four models of increasing complexity: (1) the input-output model; (2) the interactive model; (3) the interactive model with feedback; and (4) the interactive model with feedback and underlying process.

The most common model of climate impact assessment is an input-output process where climate events (input) impinge upon population, activities, societies or regions and "cause" impacts (output)--changes in state that would not have occurred in the absence of some variation in climate state (Figure 1). A more realistic model is that which views impact as a function of the simultaneous interaction of societal and climatic variation (Figure 2).

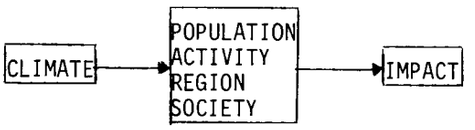

Figure 1

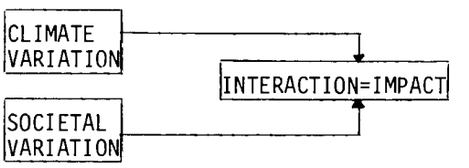

Figure 2

Much of the variation in both climate and society is exogenous to the interaction between them; essentially the variation in climate or society is independent of what transpires at their interface. Nonetheless, over time a change in either state can take place through conscious human decision and intervention in the form of adjustments. Choices of adjustment broadly fall into two categories (Figure 3): feedback to change the biophysical impacts of climate variation and feedback to change societal characteristics and vulnerability.

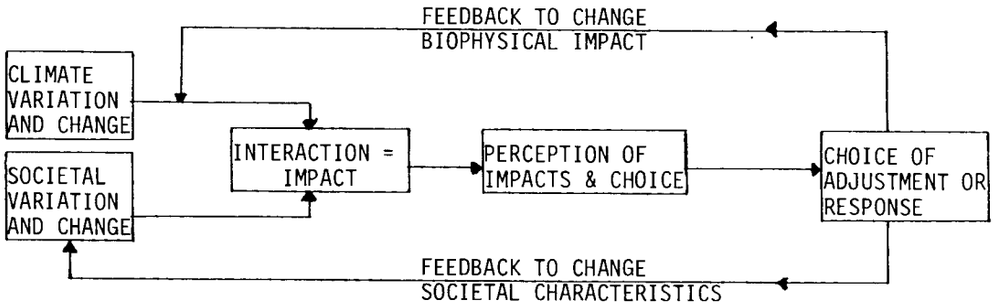

Figure 3

It is easier to draw schematics than to describe what actually occurs. Variables described as "climatic variation" or "societal change" are themselves products of underlying processes of nature and society. Thus one can consider the "nature" system from which climate variation is derived and the "society" system that provides social change. Such consideration is often best done as an historical process.

The choice of model is clearly related to the problem addressed and one should employ a principle of parsimony. If simple models will suffise, use them, for the interactive models while clearly more realistic are more difficult to implement.

Elements of study

Even with the simplest of relationship models (the input-output model), would-be impact assessors have a wide choice of study elements. Much simplified, the model still offers a large number of choices of study elements. These choices consist of the selection of climate events, the identification of targets or receptors of impacts and exposure, the type of impacts or consequences to be considered, and the extent of their propagation through human socio-economic and political systems.

Climate events. In general, climate impact studies focus on three different scales of events: weather extremes within a single year; persistent periods of multi-year events; and decade-to-century long climate trends. These three types of temporal periods grade into each other, and the choice of temporal scale to study is a necessary but not a simple undertaking.

Exposure receptors. Whatever the choice of events for which the impacts are to be studied, an impacted group, activity or area must be selected. In general the focus is on individuals or populations (human and non-human), or on activities in the form of livelihoods or specific sectors (in more differentiated economies), or on both the groups and activities found within a specific society, region or nation-state. Some impact studies use a nested approach, building, for example, on models of a regional economy based on economic sectors, which in turn are based on the activity of individual people or economic units participating in that sector. As with the choice of climate events, it is not easy to decide how to select the exposure receptor groups, which activities to include or exclude, or how extensive the area of impact should be.

Impacts and consequences. But the most difficult choices of study elements are the choices

of impacts and consequences. Here it is helpful to assign an order of propagation (1st, 2nd, ... nth order) even though these may be arbitrary, in the sense that a real time process takes place simultaneously or the sequence is actually unknown. Thus, it is useful to distinguish first-order impacts, usually of a biophysical nature, from higher-order impacts consisting of socio-economic valuation, adjustment-responses, and long-term "change." It is also important to recognize the dual nature of impacts: gains as well as losses are experienced, and growth as well as decline takes place.

Modes of Analysis

Climate impact assessment often begins with sensitivity studies that attempt to identify the climate-sensitive sectors of an economy essentially linking climate events to the chosen exposure receptors. The direct impacts experienced by such exposed groups of activities are identified through biophysical impact studies. Examining how biophysical impacts are propagated into human socio-economic and political systems is the task of social impact assessment. Studies of perception, choice, and decision-making responses can be described as adjustment-response studies. Integrated assessments include at least three links: sensitivity studies, biophysical impact studies and social impact studies and correspond to the simple input-output model. Assessment/adjustment studies include feedback in the form of adjustment-response and correspond to the interactive model with feedback. Finally, a mode of analysis labeled as comprehensive impact assessment can be envisioned. It corresponds to the interactive model with feedback and to studies of underlying historical natural and social process.

In actual process, many attempts at assessment do not follow this carefully linked causal system; rather, they attempt to "jump" study elements, going directly from climate events to inferences of higher-order consequences. These are probably less reliable than the more carefully specified and linked analyses. In general, reliability seems greatest at the mid-level of the causal chain--more is known about biophysical impacts, least of all about long-term social or ecological change.

Techniques of Analysis

The techniques of analysis used to implement these various modes are in general poorly developed or poorly utilized by an array of disciplines unaccustomed to working together. In addition to the geophysical sciences of air, ocean and land-mass, impact assessment brings together biological and human sciences. In the human sciences, for example, depending on the study choices made, anthropologists, demographers, economists, geographers, political scientists, psychologists or sociologists find themselves substituting for each other or more rarely working together. And by extension into the past, historians and archaeologists become potential key participants.

Running across this disciplinary warp are approaches or techniques variously described as case studies (including historical, current, and future studies) and simulation and modeling techniques of both the short and long term variety. A prime function of the SCOPE Review will be to characterize the strength and weaknesses of various techniques for scientific workers in neighboring disciplines.

The SCOPE Review

Over the next two years some 25 institutions and individual authors will undertake major review papers detailing what is known, what has been done and what needs to be learned to improve the science of climatic input study. Authors will meet next year in a workshop to review their papers and these will be presented in the form of scientific papers prior to the SCOPE General Assembly in 1982 and in published form soon thereafter. This bare outline does not adequately describe this process for it is intended not merely to enrich our understanding of climate impact assessment but to encourage new collaborative national and international scientific ventures designed to assist humankind to reduce the toll of climatic hazard and to increase our utilization of climatic resources.