ICSU/SCOPE WORKSHOP

ON

CLIMATE/SOCIETY INTERFACE

December 10-14, 1978, Toronto, Ontario

Co-Sponsors:

Canadian Climate Centre
Atmospheric Environment Service

Institute for Environmental Studies
University of Toronto

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Preface

The World Meteorological Organization (WMO) has responded to the challenge of attempting to understand climatic change and variability and the subsequent impacts on human society by establishing the World Climate Program (WCP). There are three components in WCP. These are:

1) climate-related data and applications;
2) research on climate change and variability;
3) climatic impact assessment on human society.

The International Council of Scientific Unions (ICSU) has agreed to a joint undertaking, with WMO, of the second component of WCP. However, it is not clear how ISCU (specifically its component body the Scientific Committee on Problems of the Environment: SCOPE) is to play a role in the third WCP component, the assessment of climatic impacts on society. It becomes obvious, however, that in order to carry out climate impact assessments, social scientists need to be involved, as well as a broad range of natural and physical scientists.

The SCOPE Workshop, which took place in Toronto from December 10 to 14, 1978, was organized to examine the climate/society interface in terms of the above mentioned problems. Representatives from social and natural sciences were brought together from various parts of the world, to quote the chairman of the Workshop, Professor F.K. Hare, "to try to help in bringing the scientific analysis of climate and the responses of society much closer together".

The Workshop began with the following lectures:

1) "On Problems and Non-Problems"
   C. Ian Jackson, U.N. Economic Commission for Europe
2) "The Impacts of Climatic Change on Human Society"
   S. Ichimura, Director, Centre for Southeast Asian Studies, Kyoto University
3) "Estimating Social Impacts of Climate Change"
   H. Margolis, Centre for International Studies, MIT
4) "Impact Transfer from Advertent Weather Modification to Climate Changes"
   R. List, Physics Department, University of Toronto

These lectures provided a basis for plenary sessions where the main Workshop discussion took place. Small drafting committees were then established, and their reports were considered and approved in principle by a final plenary. The task of preparing a report was left with a small committee consisting of F. K. Hare, R. E. Munn, I. Burton, R. Williams and K. Higuchi. A list of participants is given in Appendix A.

The Workshop was co-sponsored by the Canadian Climate Centre (Atmospheric Environment Service of the Government of Canada) and the Institute of Environmental Studies (University of Toronto).

EXECUTIVE SUMMARY

1. *Preamble*

An ICSU-SCOPE Workshop on Climate-Society Interfaces was held in Toronto, December 10-14, 1978. Co-sponsors included the Canadian Climate Centre and the Institute for Environmental Studies (the University of Toronto). The main conclusions of the Workshop are as follows:

2. *Climatic Impacts*

2.1 A distinction needs to be drawn between:

a) short-term responses of society to climatic variability, particularly rare events (droughts, floods, etc.); and ,

b) long-term adjustments of society to climatic change.

Both climatologists and planners have difficulty in distinguishing between climatic variability and climatic change.

2.2 The influence of climatic variability/change can be traced down into the fabric of society through the following chain:

Level zero: climatic variability/change

Level one: responses/adjustments of the biosphere

Level two: responses/adjustments of various climate-sensitive sectors of the human economy (agriculture, energy use, tourism, etc.).

Level three: responses/adjustments in social systems (patterns of employment, migration, culture, etc.)

Level four: responses/adjustments in political systems (legislation, regulation, international trade, wars, etc.).

Society adjusts to long-term climatic change by:

1) political-social-economic actions,

2) efforts to modify the climate (if the change is unfavourable).

2.3 Climate-society interactions can flow in both directions. Political actions (level four) can advertently or inadvertently lead back to changes in climate (local, regional or possibly even global changes) (level zero).

2.4 Political and social actions (levels four and three) can sometimes reduce the resilience of society (level two) and of the biosphere (level one) to naturally-occurring climatic fluctuations (level zero).

2.5 *Human perceptions of climate variability/change are poorly understood. Yet there is evidence that the most important term in the climate-society equation is the way in which decision-makers at all levels perceive the risks to be faced, as well as the opportunities to be exploited, in connection with climatic variability/change. It makes little sense to allocate large sums of money for studying the atmosphere and for assessing socio-economic impacts, without parallel studies of the ways in which decision-makers respond to the climatic information provided.*

3. *The Study of Climatic Impacts*

3.1 *A wide range of disciplines is required in order to undertake climatic impact assessments. Both the physical and the social sciences have important contributions to make.*

3.2 *The "consecutive" or "linear" approach to assessments, in which each discipline provides an output to be used as input by the next, is likely to fail. An integrated assessment process is recommended, in which the social scientists are involved at the outset. One of the participants should be an expert in public policy.*

3.3 *Climatic impact assessments contain uncertainty. These uncertainties should be clearly indicated, and where possible should be specified quantitatively. It is undesirable to use assessment strategies that must lead to consensus, "forcing the system to yield answers before it is ready to offer them".*

4. *The Role of ICSU-SCOPE*

4.1 *Climate-related research is important and intellectually challenging. The WMO World Climate Programme (WCP) deserves the full support of ICSU-SCOPE.*

4.2 *At its General Assembly in Athens in September 1978, ICSU approved a resolution calling for cooperation with WMO in the WCP, and proposing a mechanism for implementing the subprogramme on Research in Climate Change and Variability. This includes the establishment of a Joint WMO/ICSU Scientific Committee (JSC). The agreement provides an effective mechanism for cooperation and should be supported. Although detailed arrangements between ICSU and WMO with respect to the other subprogrammes of the WCP have not yet been formulated, the draft agreement calls for cooperation.*

4.3 *Climate-Related Data and Applications Subprogramme of WCP*

a) ICSU/SCOPE should be kept advised of WMO activities in the Applications area, which will provide important inputs to the climate impact studies.

b) ICSU/SCOPE should offer to participate in WCP Working Groups concerned with Climate-Related Data. ICSU/SCOPE can make significant contributions through the ICSU World Data Centres, the SCOPE Monitoring and Assessment Centre at Chelsea College, etc. SCOPE could offer to develop design criteria for climate-related monitoring networks but should not have any operational responsibilities.

4.4 *Climatic Impact Studies*

a) SCOPE should establish a standing activity on methods of climatic impact analysis.

b) SCOPE should ensure that the Unions, the other ICSU Committees, and the SCOPE National Committees are fully informed and have an opportunity to participate.

c) SCOPE should strengthen the input from social scientists, through both informal and institutional channels.

d) SCOPE should seek close working relations with governmental and non-governmental bodies engaged in climatic impact studies.

e) SCOPE should work towards the creation of a mechanism for cooperation between ICSU/SCOPE and WMO in the field of climatic impact studies.

f) SCOPE should:

(1) undertake to design within the framework of WCP, appropriate methodologies for climatic impact assessments; and then,

(2) select a few themes for in-depth surveys, synthesizing existing knowledge and identifying gaps.

5. *Expansion of the Workshop Report*

This Workshop report plus the commissioned background papers will form the basis for a book on Climatic Impact Assessment, to be submitted to the Editor of SCOPE for publication in the John Wiley series.

THE CLIMATE-SOCIETY INTERFACE

Report of the Toronto ICSU/SCOPE Workshop
December 10 - 14, 1978, Downsview, Ontario

I. The Problem Introduced

The impact of climate on society became a very public question in the 1970's. The Sahelian drought, and the disturbance of the world's food system following the 1972 climatic anomalies, led to widespread anxiety that world climate was becoming a hazard to economic and social well-being. Media coverage and political actions, rather than action by atmospheric scientists, have propelled this matter forward. Nevertheless, the scientists have responded, and climate is now the centre of much professional attention.

The context of the SCOPE Toronto Workshop was the World Climate Conference, organized by WMO with the support of several other UN Agencies. This Conference (Geneva, February 12-23, 1979), is likely to influence plans for the World Climate Program (WCP) whose objectives have already been established in principle. ICSU, SCOPE's parent, is likely to be a partner with WMO in the conduct of the component of WCP concerned with research into the processes of natural and human-induced climatic change or variability.

Much less clear is ICSU's role - and that of the scholarly and scientific community generally - in a second WCP component, the assessment of the impacts of climatic change and variability on human society. This assessment goes well beyond the normal activities of WMO, the lead agency, and those of the atmospheric sciences. Obviously such assessment involves

socioeconomic disciplines, as well as many of the natural sciences represented in ICSU. For this component of WCP to be undertaken successfully, it will be necessary to foster new intellectual developments, and perhaps to create new institutional structures.

The institutional arrangements will certainly involve collaboration between several UN agencies, such as UNEP (which might wish to play a leading role), UNESCO, FAO, WHO and WMO itself. These will be worked out fairly quickly, as will the necessary links with ICSU. What is not so clear is the nature of the new intellectual developments required. They will be highly interdisciplinary, and should be similar in nature to those required to study other environmental problems tackled by SCOPE, on ICSU's behalf. Hence we concluded that an examination of the climate/society interface in terms of the intellectual and scientific problems presented would be a suitable subject for a SCOPE Workshop. The Canadian Climate Centre (CCC) decided to support the Workshop because exactly the same interdisciplinary problem exists inside Canada, as indeed it does in every country that tries to mount a national climate program.

The SCOPE Workshop is not alone in seeking the right answers to these questions. WMO convened an Informal Planning Meeting on Climatic Impacts at the National Academy of Sciences, Washington, on October 22-24, 1978. The report of that meeting includes a draft plan of action in the field of climatic impact assessment. After review by the World Climate Conference (February, 1979), an amended plan will be considered by the WMO Congress in April. The Washington first draft of that plan is based on a set of principles which includes the statement -

> There are many non-governmental scientific research organizations which are active in projects closely related to climate impact studies and which have demonstrated an interest in the conduct of such studies or the capability to become involved in them. Among these is the International Council of Scientific Unions, through its Scientific Committee on Problems of the Environment (SCOPE).... The capabilities of these and other institutions should be used extensively in the conduct of these international climatic impact studies.

One objective of the Toronto Workshop was hence to suggest a role for SCOPE and ICSU with respect to the impact component of the World Climate Program. A second objective was to prepare a report outlining the issues involved in climatic impact assessment, possibly for transmittal to the World Climate Conference. It could not, at such a late date, be a formal Conference document, but informally might be of real value to the Conference Working Groups.

The Workshop did not strictly confine itself to the WCP component concerning the assessment of climatic impacts on man. It briefly considered the reverse process, i.e., of man's impact on climate. However, this topic appears to be well in hand by the natural scientists, and is supported internationally by the GARP program.

The study of climatic impact on human affairs should not merely describe the direct, first-order effects (for example the destruction of crops by hail, drought or floods). It must trace the consequences well into the fabric of society, exposing the benefits as well as the costs of the climatic impacts. Developing the techniques for such analysis in depth is a major challenge to the economic and social disciplines, and to the entire process of interdisciplinarity.

The more we commit ourselves to interdisciplinary analyses, the more difficult it appears to be to separate man-to-climate from climate-to-man relationships. In the carbon cycle, for example, we are concerned with the effect of rising CO_2 content on world temperature and rainfall distribution, and hence on crops - and also with the fact that it is the economic structure that is creating the rise of CO_2 in the first place. Clearly this cuts both ways. Can one validly separate the two directions of impact, given that they are so closely connected?

In summary, the SCOPE Workshop tried to help in bringing the scientific analysis of climate and the responses of society much closer together. We attempted answers to the following series of questions: -

A. What disciplines, and what established forms of inter-disciplinary activity, can help in the analysis of climatic impact? How well are these represented in the ICSU family?

B. How well-developed, within these areas, is the study of environmental impact assessment in general, and climatic impact assessment in particular? Are suitable techniques available, for example, in economic analysis, or in management studies?

C. Can we attempt a suitable taxonomy or hierarchy of impacts that may help in policy formation and the design of management systems? Is there a distinction to be drawn between climate as hazard, climate as chronic stress, and climate as a resource? Can we trace climatic impact through the socioeconomic system?

D. What is the relation between the level of socioeconomic development and the vulnerability or resilience of a given society to climatic impact?

E. What should be the ICSU/SCOPE attitude to the World Climate Program, and what role should it offer to play?

F. What summary of conclusions should it offer to WCP, via the SCOPE executive?

G. Is there a case for an ICSU/SCOPE project in this area, and should SCOPE prepare a book on climatic impact assessment?

After debating these questions, the Workshop reached a key conclusion. All of the questions touch on how climatic impact should be assessed. We concluded that this is a secondary question. The main point is that climatic impact needs to be defined, and an intellectual framework capable of expanding that definition must precede any discussion of "how".

II. The Nature of Climatic Impact

The view - that the Workshop should be concerned with problem-definition before it looked at problem-solving - was forcefully put by Ian Jackson in his background paper. He questioned the use of the term "impact" suggesting that climate and society always interact; social adjustment proceeds as soon as the climatic anomaly is perceived. In subsequent discussions the Workshop agreed on the following points:

- that the impact of climate on the human economy during the 1970s achieved high visibility because of widespread media coverage, some of it inaccurate and superficial;
- that some atmospheric scientists had moved rapidly from a position where climate was almost ignored to one where its economic and social significance was possibly being exaggerated;
- that social and behavioural scientists, especially economists, usually rank climate as a minor determinant of social and economic activities; and
- that attempts to assess the impact of specific climatic anomalies had not been fully satisfactory, in part because the nature of the impact had been prejudged, and in part because of the lack of effective methodologies.

If the impact component of the World Climate Program is to succeed, these deficiencies must be corrected. This will demand a detailed picture of the nature of climatic impact (or climate-society interaction). Such a picture will require much further research, chiefly of a socio-economic kind. The impact component of WCP hence involves a large research commitment that is distinct from the program of research into the causes of climatic variation and variability already proposed by WMO and ICSU.

The Workshop reviewed the nature of climatic impact under the heading "a taxonomy of impact". It quickly concluded that a taxonomy was not needed. Instead it sought to examine the ordering or stratification of climatic impacts, recognizing that such impacts may spread throughout the economy of an affected society. A working group consisting of Meyer-Abich, List and Williams proposed the stratification shown in Table 1.

In the table, five levels of impact are identified. The three columns left of the central dividing axis define (i) the level of impact, (ii) the disciplines relevant to the analysis of the response; and (iii) examples of the items in which change is observed at each level. The three right-hand columns illustrate typical impact-chains. Feedbacks are ignored.

TABLE 1: Stratification of Climatic Impact

No.	Level of Impact	Disciplines relevant to analysis	Change occuring in	Examples of Specific Impacts		
				1 (natural fluctuation)	2 (natural fluctuation)	3 (man-induced change)
1	Climatic parameters	Climatology, Oceanography	Temperature, rainfall, radiation, etc.	Change of temperature	Reduced cloudiness	Increased CO_2 content and rising temperatures
2	Potential related environmental change	Ecology, Physical Geography	Ecosystem and habitat changes etc.	Change in length of growing season	Better recreational climate	Altered energy and water balances
3	Human activity	Economics, Sociology, Psychology, Geography, Anthropology	Agriculture, energy use, tourism, transport, construction, manufacturing, etc.	Altered agricultural production: redistribution of such production	Tourism gains	Altered agricultural production, redistribution on such production
	////////// PERCEPTION //////////					
4	Social response & interaction	Sociology, Psychology, Geography, Anthropology	Employment level, migration, culture, social conflict, etc.	Human migration, social conflict, employment changes	Employment gain	Human migration, social conflict; employment changes
5	Political processes & responses	Economics, Political Science Law	Legislation and regulation, legal action, research & development programs, international action and policies	Incentive programs for industry, agriculture, forestry	Expanded infrastructure, etc.	Energy conservation, change of power sources, precipitation enhancement, genetic research etc.

Impact Level 0 contains the change in the purely climatic arena - the things measurable in climatological or oceanographic terms, such as changes of temperature, rainfall, radiation and many others. No socio-economic considerations arise. Climatic impacts ordinarily (but not invariably) begin with a trend or sudden fluctuation in one or more of these physical parameters.

Impact Level 1 refers to the changes in living organisms, the ecosystems to which they belong, and the purely physical non-atmospheric parts of the human habitat. All such changes are detectable by means of ecological or physical geographical techniques. Changes in this level are normally induced by changes at level 0, but not always; ecosystem change due to natural disasters (e.g., fire, flood, erosion) can certainly induce microclimatic change.

Impact-Level 2 contains the primary levels of human economic and social activity, as exemplified by the list in the third column. Changes in levels 0 and 1 will in general induce changes in these activities, which are those of direct impact. Once again, however, the forcing may be reversed. Significant land-use changes, for example, alter soils, natural vegetation and microclimate, which belong to lower levels in the table.

Impact-Level 3 referring to social response and interaction, arises because of the perception by society of the direct impacts visible in level 2. These social responses may include, for example, migration (typical of the nomadic pastoralist societies), cultural adaptation, altered employment characteristics and others. Both here and in level 2 the main relevant disciplines are sociology, psychology, geography and anthropology. The study of environmental perception, which leads to this response level, has been developed mainly by geographers and psychologists.

Impact-Level 4 is concerned with the political processes that come into play when the social responses and interactions of level 3 make such action necessary. The result may be altered legislation or regulation, international action programs and so on. In highly evolved societies it may be necessary to split this level between policy change (essentially political) and management processes (mostly bureaucratic). The relevant disciplines seem to be economics, political science (or political economy) and law.

The three examples to the right of the central dividing axis are intended only to illustrate the meaning of the general structure proposed in the left-hand columns. Clearly Table 1 is neither a matrix nor a flow diagram. Instead it is a suggested structuring of climatic impact, taking into account that such impact is actually an interaction with society.

In its discussion of the Meyer-Abich-List-Williams proposal, the Workshop arrived at three important conclusions:-

(i) Short-term variability internal to the existing climate has impacts on society quite distinct from the adjustments due to persistent, longer-term climatic change. The former includes large and unexpected extremes, calling for emergency measures. Technology remains little changed, except in direct response to the specific fluctuation (such as the Sahelian drought, or the cold 1976-78 winters in North America). Longer-term climatic change (for example response to CO_2 build-up) will in general be visible, and will be accompanied by significant but unpredictable technological change, and alteration of economic circumstances. Hence it will be very difficult to predict climatic impact due to these longer-term changes (to which many previous specific studies have been addressed).

(ii) On either time-scale, however, climatic impact may be induced by cultural or technological change, even in the absence of any initial climatic fluctuation (i.e., zero initial change at level zero in Table 1). Such changes in human practice may alter the vulnerability of the economy to climatic variability. For example, discouragement of nomadism in the Sahelian republics, and the spread of veterinary medicine, both rendered the Sahelian economies less resilient to drought, which is a normal part of the climate. These changes also represent an alteration in the normal, stable equilibrium between human practice and ambient climate. Hybrid corn in the U.S. mid-west, for example, enabled a rapid rise of agricultural production, but simultaneously induced a great sensitivity to certain kinds of climate-induced disease (which struck during cool, humid summers in the 1970s). Such impacts are quasi-climatic rather than climatic, but they may induce real microclimatic changes at level 0, thus demonstrating that <u>climatic impact</u> is partially a misnomer. What changes is the climate-society interaction system.

(iii) A real distinction can similarly be drawn between three categories: -

(a) climatic hazards, due to unforeseen climatic extremes of low probability and high direct impact, such as floods, hurricanes, ice storms and extreme cold. These are weather events rather than climate, but the proneness of a region to such hazards is part of that region's climate. Much research into environmental hazard perception deals with such events and their perceived consequences;

(b) climatic stress, due to the habitual, chronic, expected impact of adverse climate. In all economies there is a high measure of adjustment between technology and "normal" climate (including extremes with a reasonably high probability, such as occasional droughts or cold spells). Much agricultural, forestry and land management practice is directed at such adjustment. Where climate is unfavourable, adjustment is difficult, and induces significant social and ecosystem stress (though this term is ambiguous, and is "loaded" to many people);

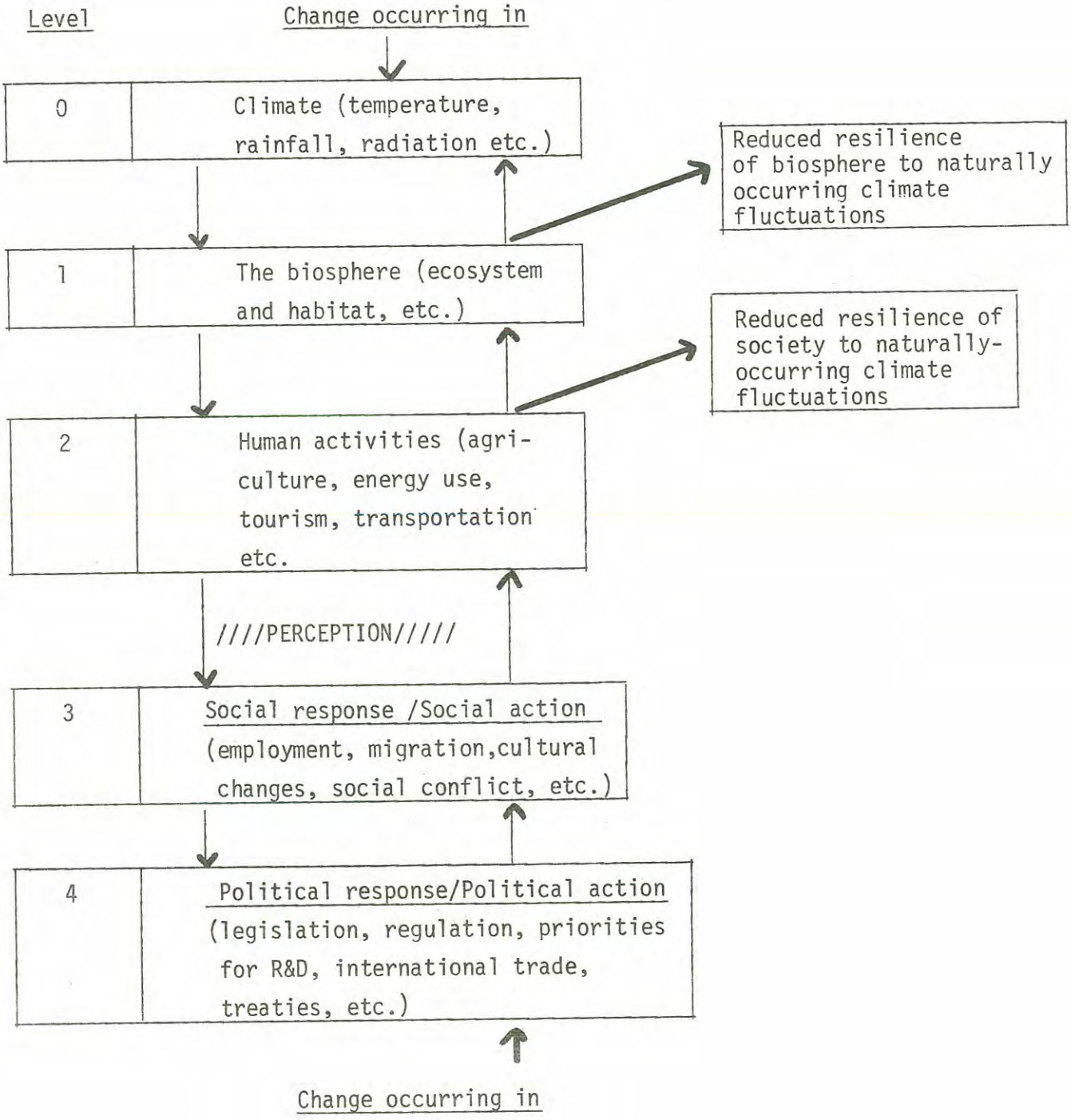
(c) climatic resources, which are those aspects of climate that can be economically exploited, and are hence the objects of competing claims. The farmer who occupies a section in the U.S. Middle West, or a plot of land on the floodplains of the Nile, is able to exploit resources such as solar radiation, local rain, imported rainfall (by irrigation), atmospheric gases and nutrients, all of which might be put to other uses. Hence it is realistic to call them resources. Climatic impact alters the value of these resources, and alters the competitive advantage of those who control or exploit them.

Following the Workshop, Table 2 was prepared to reflect the points mentioned above. Table 2 is a modification of the left-hand columns of Table 1, and is intended to emphasize that: -

(1) climate/society interactions can flow in both directions;

(2) political and social action can sometimes reduce the resilience of society and of the biosphere to naturally-occurring short-term climatic fluctuations and long-term climatic oscillations.

Table 2


Level
Change occurring in
0
Climate (temperature, rainfall, radiation etc.)
Reduced resilience of biosphere to naturally occurring climate fluctuations
1
The biosphere (ecosystem and habitat, etc.)
Reduced resilience of society to naturally-occurring climate fluctuations
2
Human activities (agriculture, energy use, tourism, transportation etc.
////PERCEPTION/////
3
Social response /Social action
(employment, migration,cultural changes, social conflict, etc.)
4
Political response/Political action
(legislation, regulation, priorities for R&D, international trade, treaties, etc.)
Change occurring in

The Workshop concluded that a major research opportunity exists to explore these ideas, and to provide a theoretical framework within which climatic impact analyses can be given more meaning and depth. Existing *ad hoc* studies are of interest and value, but what is needed is a general framework of understanding into which they can be fitted. SCOPE could make a significant contribution by providing this framework.

III Vulnerability and Resilience

Human societies differ markedly in the extent to which they suffer damage and loss through climatic events. This variation seems to be at least as much due to the varied attributes of human societies as to the variations in global climate. The extent to which a human community is susceptible to damage by climatic causes can be termed its *vulnerability*. There is now no satisfactory quantitative scale of measurement for degrees of vulnerability, but a description can be given in qualitative terms. Broadly speaking a society is more vulnerable:

(a) the more its economic activity depends upon weather-sensitive factors of production;

(b) the greater the unreliability and variability of certain key climatic variables (e.g., moisture availability);

(c) the lower its level of reserves of food, and other materials;

(d) the less developed the capacity of its transport system to move supplies from surplus areas to deficit areas;

(e) the less it has planned and prepared to deal with adverse climatic impacts.

Closely related to vulnerability is the concept of *resilience*. Resilience refers to the ability of a society to "bounce-back" when adversely affected by climatic impacts. There is at present also no quantitative scale for resilience, but it is generally known that resilience depends upon a similar set of factors as vulnerability. A society is likely to "bounce-back" more effectively if it has accumulated stocks or reserves; if it has spare capacity build into the design of its infrastructure; if it has great command of resources, transportation, technology, and accumulated wealth with which to combat the impact. Also less tangible factors may be

important such as social cohesion, morale, and the trust and confidence enjoyed by governments and social institutions. Where these are lacking, impacts may be greater, and resilience much reduced.

It follows that the capacity of any society to absorb climatic impacts is not a simple linear function of its degree of development. Relatively poor and underdeveloped societies may be stronger and in some respects better able to absorb the shock of a climatic impact than some wealthier and more developed societies.

The relationship between vulnerability and socioeconomic development is not well understood and requires a lot of careful research. It has been hypothesized (Burton, Kates and White, 1977) that the most vulnerable societies are neither the poorest and least developed, nor the wealthiest and most highly developed, but those societies in process of rapid transition or modernization, where the traditional social mechanisms for absorbing losses and sharing them among the community have been eroded away and have not yet been replaced by the accumulated wealth and response capacities of more modern societies. This is a tentative hypothesis which merits further testing.

If this finding is valid, it means that extra care needs to be taken to guard against adverse climatic impact in precisely those situations where development is taking place more rapidly and <u>apparently</u> most successfully. If attention is not paid to this problem, then the hypothesis suggests that <u>apparent</u> success may quickly be turned into disaster. The world is not without recent experience that suggests that exacerbation of impacts by development that is innocent of the climatic dangers that may be generated, is a common, indeed a widespread occurrence.

From this discussion it can be inferred that considerable opportunity may well exist to <u>reduce climatic impacts</u> and to <u>increase resilience</u>; in a minor way through attempts to modify or control climate; in a major way through a clearer understanding of the resilience of the pattern and character of development activities themselves. Remarkably little is known in detail, however, about the increase or decrease in vulnerability that comes with types and levels of socioeconomic development, and it is crucial that more systematic observations and measurements be made as a basis for improved understanding and action.

The relationship between climate and society is often thought of in terms of a simple model (Figure 1a) in which climatic variation has an impact on society, and society in turn has an impact on climate. While this model may be useful for some purposes, it is more accurate to recognize that impact is a function of the interaction, simultaneously, of social and climatic variation (Figure 1b).

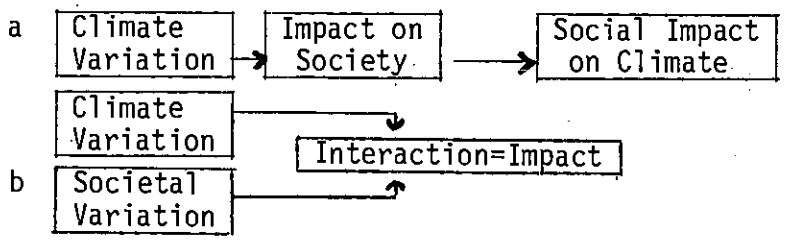


Figure 1 a+b

The implication of Figure 1b is that a change in either climate or society affects impact. Since both climate and society are constantly changing, the magnitude and character of impacts is also not constant. Impact studies must therefore involve investigations of climatic variability and of social change. The question to be addressed to any society at any time is: "Is the society becoming more or less vulnerable to climatic variability?" Or to put the matter differently, "Will any specific proposed social change or development have the effect of increasing or decreasing vulnerability?"

The climate/society interface may be thought of in terms of adjustment. Adjustment means the extent and ways in which a society functions in a harmonious way with its climate (and the rest of its environment). Development activity which leads to the overstocking of range land and thus greater impact of moisture deficit in times of drought, can be described as diminishing adjustment or increasing maladjustment.

When any climatic impact is felt, therefore, a human society is faced with choices of response or adjustment. Responses are likely to be both short-term (disaster relief and emergency aid to those affected), and long-term (rehabilitation of the economy and livelihood of the population). Both short-term and long-term adjustment choices need to be examined for the extent to which they increase or decrease vulnerability.

Choices of adjustment broadly fall into two categories (Figure 2): feedback to change in climate and feedback to change in societal characteristics. Examples of the former are shelter belts, terraced slopes, and oil smoke to protect against frost. An example of the latter is the decision not to grow frost-sensitive species in a frost-prone area.

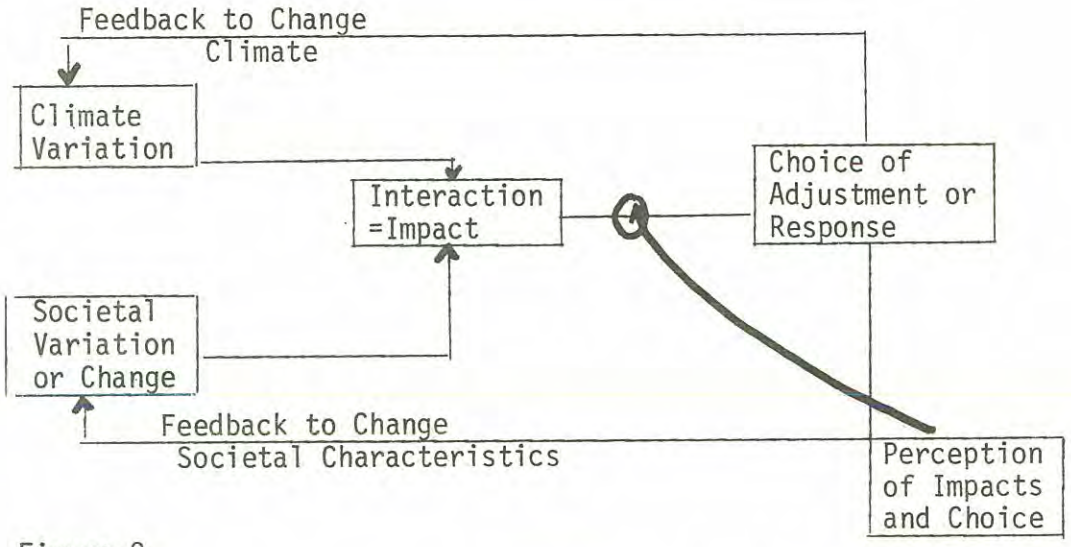


Figure 2

Research investigations are needed into the different kinds of adjustment that may be made, and the relative costs and benefits of each or each possible combination.

Economic analysis may therefore be used to suggest or prescribe the most cost-effective sets of adjustment.

In addition to such prescriptive studies, it is desirable to gain better understanding of the present process of societal (and individual) choice of response. Experience suggests that many social choices are made without considering their implication for human interaction with climate and hence the possible impacts. Climate is assumed to be benign, harmless or irrelevant and development activities (choices) are made regardless of the climate/society consequences. Thus at the same time that a society's capacity to absorb climatic impact is being increased by the creation of new wealth (building dams, expanding irrigation projects, using new crops or new varieties, etc.), the developments may also increase the vulnerability by inviting adverse consequences or serious impacts from future climatic variation. Thus the same climatic events (a moisture deficiency of a

specified amount with a 0.1 probability of occurrence) which previously caused little trouble may in fact turn out to have devastating consequences.

It has not been customary in project evaluation or other development activities to examine net long-term effects in terms of increased vulnerability to climatic impacts. The appropriate methodology and procedures for such studies need to be developed as a matter of urgency. Objective economic assessments of impact are important in the choice of adjustments to climate. So too are the perceptions of those who make decisions about economic and social activity.

Choice of societal response or action depends upon the perceptions of likely impacts and the perceptions of the choices available to them, on the part of the "decision-makers". For this purpose "decision-maker" can mean anybody from national government ministers or officials, the managers of large corporate enterprises such as the state energy-producing body, large-scale agri-business including commercial livestock operations, collective and cooperative farms, down to the level of the peasant farmer or the semi-nomadic pastoral herdsmen of the Sahel.

In addition to prescriptive economic studies, it would be useful in the World Climate Program to carry out empirical investigations of the way in which choices are made in relation to climatic variability: the perception of climatic variability, and the perception of increased or decreased vulnerability according to choices made.

In trying to devise ways to incorporate information about climate into economic decisions, it is important to recognize that many economic decisions (with profound implications for environment) are made by literally millions of small-scale decision-makers. It is generally not decisions by national governments or planning agencies or large corporations that determine the damage from floods or droughts, or the process of desertification, deforestation, soil loss, land degradation and the like. It is much more the cumulative effect of the decisions of many people. It seems important therefore to attempt to gain better understanding of the decisions, choices and perceptions of such people. Often to the external observer, or to the national planner, the decisions seem to reflect ignorance, shortsightedness, irrationality or downright intentional contrariness. Looked at from the point of view of the peasant farmer, pastoralist, or other

decision-maker, the behaviour adopted and the choices made may seem entirely rational, or unavoidable. From the same perspective the advice of the soil scientist, or agricultural extension agent may seem similarly irrational, perverse or mischievious.

An important role therefore exists for perception studies in trying to gain improved understanding of the problems of communication and miscommunication between scientists and decision-makers. It makes little sense to allocate large sums of money to scientific studies of the atmosphere, and to the assessment of social and economic impacts, in the absence of adequate understanding of how decision-makers at all levels will respond to information provided or be able to utilize and apply the new knowledge gained. The impact of climatic variability can be less, sometimes far less, than the impact of variability in perceptions and understanding.

Social scientific studies of the factors that increase or reduce the vulnerability of societies to climatic variation are deficient if they focus solely on total or aggregate impact and apply economic efficiency criteria in a search for solutions. There are important differences both within societies and between societies. As far as variability of climate is concerned, it is not true that all are affected equally. Within a given society, important questions arise of who suffers the impact. Questions of fairness, equity, distributive justice, and of compensation necessarily arise. Experience with floods, droughts and the like suggests that it is often the poorest sections of a society that suffer most. Those people, those regions, and those economic activities that have least resilience are least able to cope. Poorer people have less accumulated reserves to withstand impacts.

The distributional question applies to segments of society (agriculture may lose while industry gains) to socioeconomic groups (high income farmers may benefit while low income farmers may lose) and between regions (the humid regions may benefit while the sub-arid or the semi-arid lose). Similar discrepancies also occur between nations as well as within nations. Where the territory of a nation falls completely within the region of impact of a climatic fluctuation e.g., a country entirely or largely in

the Sahel), the effect will be much greater than on a similar country which nevertheless has national territory extending into savannah and rain-forest areas. In international studies of climatic impact, the factors of equity must be taken into account. They must also be considered in the formulation of any programme of action to prevent, prepare for, or alleviate the adverse effects of climatic variability.

Any programme of studies into the impacts of climatic variability must therefore include not simply aggregate studies, but also assessments of how the benefits and costs of change are distributed.

IV The Necessary Disciplines and Interdisciplinary Structures

A general framework of understanding into which studies of climatic impact can be fitted will involve many academic disciplines, and will require the development of suitable interdisciplinary arrangements. The Workshop asked itself what the various disciplines could offer, and what kind of interdisciplinary structures might be best suited. It considered whether ICSU in general and SCOPE in particular have access to the necessary range of expertise, which clearly includes many socioeconomic areas.

There was general agreement that the present membership of ICSU constitutes a critical reservoir of expertise supporting research programs in the natural and physical sciences for the forthcoming World Climate Program. If, however, we accept the notion that the study of climatic impact on human affairs must trace the consequences well into the fabric of society, then the research associated with the World Climate Program will extend beyond the present programmes of ICSU into the traditional domains and interests of the social sciences. The need to move beyond first-order effects for an accurate, complete assessment of climatic impact draws one into evermore intimate contact with economic systems, social institutions, cultural values, and decision processes. The most critical effects, in terms of systemic viability and behaviour, may be grounded far from the immediate, observable impacts, and the economic or non-economic costs and benefits to society may emerge at multiple levels. It may clearly be difficult or impossible to achieve such an assessment for the longer-term types of impact, but to attempt

such a penetrating analysis remains the ideal.

Although ICSU may think it desirable to develop working relations with the social sciences to strengthen climatic impact assessment, short-term success may be limited by the lack of readily-mobilized linkages to and within the social sciences, though this view was challenged by one participant. Three problems in the social sciences impede interaction. First, institutional arrangements, particularly at the international level, lag behind those of ICSU member organizations, reducing organizational and problem-solving capabilities. Fragmentation along disciplinary lines, between applied and theoretical research, and between methodological and substantive orientations, inhibits communication and collaboration. Language barriers, political doctrines, and resource stringencies are generally more serious constraints to research on the international level in the social sciences than in the natural sciences. It should be noted, however, that this heterogeneity offers a valuable resource if properly exploited.

In addition to the organizational problems noted above, there may be strains attributable to aspirations of the social sciences to be regarded as hard sciences, and possible reluctance of others to concede this status. Communication among social scientists and with natural scientists is difficult: maximum use of the latters' findings is therefore impossible. In turn many natural scientists fail to appreciate the societal implications of their research, or of advances in state-of-the-art applications of technology. Moreover, concerns defined by scholars in the west as "social science issues" may be regarded as technical matters or non-issues by scientists from some of the socialist and centrally-planned countries.

Furthermore, there are continuing difficulties in linking scientific research, especially research in the natural sciences, to decision output. In part this may reflect the inability or unwillingness of scientists to cast research results in terms intelligible to those facing personal or public choice, a view that was hotly debated by the Workshop. It is highly desirable for climatic impact assessment research to investigate how research findings may be integrated effectively into problem-solving and decision-making.

Another linkage problem underscores several other considerations important in framing research topics. It is necessary to examine the social

institutions and social contexts that affect perceptions and responses to climatic variability or change. Identical phenomena may be perceived as different in character by differing social, economic or political systems. Impacts attributed to climate variability or change may represent, as mentioned above, the consequences of human choices.

The ICSU family includes the International Geographic Union, in which the behavioural and social content of the matters studied is high. Geographers have played a leading role in the study of environmental impact as a whole, and have a tradition of interdisciplinary involvement. But ICSU and its committee SCOPE will need much contact with the other social sciences, especially economics. Hence the problems just discussed must be overcome. Several members of the Workshop - including its Chairman - were confident that this could be done. We return to this point in Section VI.

The Workshop arrived at no firm conclusion concerning interdisciplinary structures. There can be no unique solution to anything as complex as the study of climatic impact. No one pattern so far tested seems markedly superior to all others. The background paper by Ichimura gives details of the interdisciplinary approach to the study of contemporary climate-agricultural links in South-East Asia. Ichimura believes (with the support of some members of the Workshop) that in such multidisciplinary approaches there must always be one core science around which other disciplines can be combined. The social science which may be important, in Ichimura's view, is economics, and in particular econometrics. But there is not enough interest among econometricians in climatic factors, although there are a few exploratory studies, and some significant works in the field of agricultural economics.

Econometric works so far have emphasized short-term analysis and forecast capabilities. Since there are some outstanding long-term analyses in agricultural fields, attempts should be made to incorporate climatic variables into such models, and to extend the analysis into new fields where other relevant variables can be brought in.

V Climatic Impact Assessments: General Principles

The problems of climatic impact are broader than economics. They require the cooperation of sociologists, political scientists, geographers, medical scientists, and many others. The extent to which each field can

contribute is not certain. Combatting the adverse effects of climatic impact involves policy-making or decision-making, so that the techniques developed by management science and systems analysis are of value. Decision-making in the presence of uncertainty may be most relevant here.

Climatic factors can be regarded as a kind of resource, which can have a certain productivity and be controllable, or as a boundary condition that influences economic activities. The choice between these two views is a matter of convenience, depending on the problems and approaches that one adopts. It is naive to think that simple-minded spurious correlations (common in economic analyses) can allow one to predict. What one needs is a careful theory or theoretical analysis of the interaction of climate and human society. Even if, however, we have a carefully framed flow-chart of causal relations among various variables related to climate and human activities, and the relations are estimated with significant skill, the analysis may still not be good enough to predict, unless the behaviour of exogeneous variables like climatic factors are based on reliable theory.

To answer the question "How well-developed, within the relevant disciplines and interdisciplinary areas, is the study of environmental impact assessment in general, and climatic impact assessment in particular?" it is useful first to scrutinize the actual research work in the impact study itself. One should closely examine the context in which the studies are performed, as well as the internal question of how well-developed the disciplines are themselves.

A variety of pressures tends to bias the results of impact analyses towards outcomes that seem likely to minimize controversy, and which are quantitative rather than qualitative. Pressure to produce quantitative estimates is always present, coming at one extreme from technical specialists working on other parts of the issue, who are demanding inputs to their own studies. In the U.S. Climatic Impact Assessment Program, CIAP, for example, there was pressure on chemists to produce best estimates of reaction rates. At the other extreme those who pay for research are always anxious to show their own sponsors the results that the expenditures have obtained. Naturally, these pressures for quantitative results will be particularly strong when an issue has become politically visible, with politicians and the press adding to the demand for answers.

Such effects are likely to be peculiarly perverse in the context of these issues. Uncertainties are bound to be enormous; and the prospect of near-term new information that can clearly prove an answer either right or wrong is minimal. Investigators will be under great pressure to produce results that accord with general expectations.

It is for that reason that we view the design of arrangements which will protect inquiry from these pervasive pressures as an essential feature of the design of efforts to estimate the effects of long-term climatic variation. The scientific community, and the atmospheric sciences in particular, need to be especially sensitive to this matter in the light of the revisions made to CIAP estimates only two years after that elaborate effort was completed.

The Workshop took special account of the differences between analysis of the climatic impact of short-term internal variability of climate (which can use historical or retrospective approaches, on the assumption that internal climatic anomalies repeat themselves), and the impact due to long-term variation or changes of the basic climate itself.

Table 3 (following page) illustrates some of the contrasts between demands of studies focused on short-run variability (e.g., phenomena such as the Sahel drought) and those focused on long-run climatic change (e.g., the CO_2 problem). As may be seen, the differences are very marked, making it critical that the two categories be distinguished, and treated differently with regard to the choice of studies likely to yield useful results.

We can sum up the contrasts as follows: -

- the short-run variability problem is likely to demand information that can be used as the basis of action programs intended to improve the resiliency of regions and economic sectors to the effect of climatic anomalies. Studies will have a strong empirical component (field studies, statistical analyses).

- in contrast, the crucial factor in the long-run impact problem is likely to be technology change; and the crucial problem facing such studies is that of seeing what can be done to say <u>useful</u> things in the light of the inherent uncertainty about long or even medium-term technological futures.

Table 3

Differences Between Short- and Long-term Cases

Item	Short-term variability cases	Long-term change cases
Empirical data sources	Abundant (current, historical, new)	Some (historical has limited relevance)
Technological Change	Extensions of current technology	Major changes certain; exact nature highly uncertain. Timing also doubtful.
Methodologies	Field investigations Statistical studies	Historical reviews. Reviews of technological prediction (lessons learned from success and failures)
Policy Analysis	Action-oriented	Research-strategy oriented

Climatic impact analyses will be of varying degrees of completeness. An integrated assessment will include study of all relevant physical, biological, economic, and social factors. A partial assessment will be limited to a smaller spectrum. Though in some cases important feedbacks may take place, in many studies the output of one stage of the study will become the input of the next. This "consecutive" approach to interdisciplinary studies has dominated much previous work. In such cases, the availability of the input may be more important than the real needs of the next discipline in line. Moreover, as work is summarized and reduced at each stage in order to be passed on to the next, there is a tendency for the qualifying uncertainties associated with the conclusions of each stage to disappear.

Thus, each discipline tends to regard the numerical values it receives as more trustworthy than they are. Though each discipline recognizes the uncertainty in its own contribution, the uncertainty of others tends to be ignored. In such consecutive multi-disciplinary studies, one therefore finds the disturbing phenomenon that uncertainty claimed for final results is assumed to be no greather than that associated with any one stage, whereas

the uncertainties have in fact been multiplying.

For impact studies of possible future climatic change, it would ideally be desirable to assess the difference between the future state of society if the change takes place, and the state if no climatic change occurs. The fact that almost no discipline (or responsible member of it) would claim to be able to describe (with the certainty necessary for policy decisons) the state of society 50 years hence without climatic change indicates the very fundamental difficulty impeding an analysis of impacts of possible long-term climatic change.

The widely-felt dissatisfaction with past climatic impact studies suggests that certain specific guidelines may be helpful in improving the quality of future efforts. These include a close identification of human concerns (both needs and demands) and a listing of impact indicators, with a prominent explanation of the methods used to determine their scales of magnitude and relative weights. The quality and credibility of the results, especially in the socio-economic area, are dependent on careful work of this kind.

For a climatic impact assessment to be coherent and useful, it is important that one member of the team be an expert in public policy. His reputation should be contingent on the quality of the work. There must be someone (or a group) who is as concerned with the quality of the overall work, as the individual expert or group are with the performance of their own disciplines.

All such attempts may suffer from lack of familiarity with previous efforts in climatic impact assessment. A catalogue of previous efforts would be useful. Such a catalogue must include some critical reviews of past efforts, in order that knowledge of assessment methods may be improved. Research on methods suitable for assessing climatic impacts should be encouraged.

There is often a tendency in questions of science and public policy to believe that it is above all important to reach consensus on important issues. This may ultimately be true; but it is undesirable to use strategies which generate a false consensus. This point was stressed by Margolis in his background paper: "it is important not to force the system to yield answers before it is ready to offer them."

The topic of environmental impact assessment is treated in considerable detail in a recent SCOPE book (SCOPE, 1979).

VI The Role of ICSU-SCOPE

1. The Draft ICSU-WMO Agreement

At its General Assembly in Athens, September, 1978, ICSU* approved a resolution calling for cooperation with WMO in the World Climate Program, and proposing a mechanism for implementing the third subprogramme (Research on Climate Change and Variability) of the Programme. This includes the establishment of a Joint WMO/ICSU Scientific Committee (JSC). Although detailed arrangements between ICSU and WMO with respect to the other two subprogrammes of the WCP have not yet been formulated, the draft agreement calls for cooperation.

The draft agreement will be considered by the WMO Congress in the Spring of 1979.

2. General Principles

a) Climate-related research is important and intellectually challenging. It requires inputs from a wide range of scientific disciplines.

b) ICSU can make a significant contribution to the research components of all three subprogrammes of the WCP.

c) As specifically mentioned in the draft ICSU-WMO agreement, "there should be only one World Climate Research Programme, and it should be sponsored jointly by the two organization".

d) Provided that there is adequate information exchange, ICSU welcomes the participation of other governmental and non-governmental bodies (e.g., IFIAS, IIASA) in the field of climate-related research.

e) ICSU has an important role to play in bringing the WCP to the attention of the Unions, the ICSU Scientific Committees and the world community of scientists.

3. Climate-Related Data and Applications

This subprogramme of the World Climate Program is two separate activities:

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*ICSU is composed of 19 Unions, 13 Scientific Associates, 10 Scientific Committees and 69 National Committees. This represents a wide cross-section of scientific disciplines and activities.

a) Climate-related data (the data required not only for applications [(b) below] but also for the other two subprogrammes of the World Climate Program);

b) Climatological applications (engineering applications of existing knowledge of climate and of the climatic sensitivity of various sectors of society).

For many years, the WMO has been active in the field of climatological applications, and its continuing program is commended. There does not appear to be a need for ICSU involvement, although ICSU should be kept informed of the WMO subprogramme; the results will be extremely useful inputs to the Climate Impact subprogramme of WCP.

Activity (a) insofar as it relates to the impact and the climate-change subprogrammes, would clearly benefit from an involvement by ICSU, which already operates the World Data Centres. The design of networks in space and time, e.g., to monitor the biogeochemical cycle of carbon, is a complex research problem requiring the cooperation of many scientific disciplines. The SCOPE activity at MARC Chelsea is relevant in this connection.

ICSU should offer to participate in WCP working groups concerned with the climate-related data requirements for: (a) climatic impacts on human activities, and (b) research on climatic change and variability. ICSU should develop design criteria for monitoring networks but should not have an operational responsibility.

4. The Study of Impacts of Climate on Human Activities

The following Unions and Associations are among those that can make significant and in some cases substantial contributions to a climatic impact programme:

a) Unions

IGU	(International Geographical Union)
IUGG	(International Union of Geodesy & Geophysics)
IUBS	(International Union of Biological Sciences)
IUPAC	(International Union of Pure & Applied Chemistry)
IUPS	(International Union of Physiological Sciences)
IUTAM	(International Union of Theoretical & Applied Mechanics)

b) Scientific Associates

INQUA (Union Internationale pour l'Etude du Quaternaire)
ISSS (International Society of Soil Science)

c) Committees

CODATA (Committee on Data for Science and Technology)
COSPAR (Committee on Space Research)
COWAR (Committee on Water Research)
SCAR (Scientific Committee on Antarctic Research)
SCOPE (Scientific Committee on Problems of the Environment)
SCOR (Scientific Committee on Oceanic Research)
SCOSTEP (Special Committee on Solar Terrestrial Physics)

Among these, SCOPE has a special role because of its competence in multi-dimensional impact analyses (see, for example, SCOPE publications 5,8 and 14). In fact, ICSU has recently designated SCOPE as its focal point for climatic impact studies.

In developing its expertise in this area, SCOPE has been able to attract inputs from the social sciences. However, the involvement has not been institutionalized and ICSU/SCOPE should be encouraged to establish working relations with various bodies in the fields of economics, political science, engineering, management science, etc. In addition, SCOPE should seek to draw on the very considerable resources existing within the Unions and other ICSU Committees that could be brought to bear on the climatic impact field. In summary: -

1) SCOPE should establish a standing activity on methods of climatic impact analysis;

2) SCOPE should ensure that the Unions, the other ICSU Committes, and the SCOPE National Committees are fully informed and have an opportunity to participate in climatic impact activity;

3) SCOPE should strengthen the input from social scientists, through both informal and institutional channels;

4) SCOPE should seek close working relations with the UN family and with non-governmental bodies engaged in climatic impact studies;

5) SCOPE should work towards the creation of a mechanism for cooperation between ICSU/SCOPE and WMO in the field of climatic impact studies, calling attention to the ICSU Athens resolution.

6) SCOPE should (a) undertake to design within the framework of WCP, appropriate methodologies for climatic impact assessments, and then (b) select a few themes for in-depth surveys, synthesizing existing knowledge and identifying gaps.

5. Research on Climatic Change and Variability

The strength of ICSU in the natural sciences is well-known. Not only are the traditional fields of meteorology, oceanography and glaciology represented (largely through IUGG, SCOR and COSPAR) but also some important disciplines (e.g., biology, forestry, biogeochemical cycling, etc.) that complement the areas of interest of WMO. The recent ICSU resolution provides an effective mechanism for cooperation with WMO in the field of research on climatic change and variability, and is a natural extension of GARP. In addition, however, it would be useful to draw upon the resources of INQUA (International Union for Q Quaternary Research) and other bodies and institutes to foster international coordination in the historical reconstructions of climate. Such endeavours could provide useful data banks for testing numerical models of climate.

VII The Proposed SCOPE Book on Climatic Impact Assessment

The Workshop noted that the Executive Committee of SCOPE had authorized the preparation of a book on climatic impact assessment, and indeed expected it. The commissioned background papers would serve as a nucleus for this book but would clearly need to be amplified and perhaps incorporated directly into the text. The papers are available upon request from the Workshop Organizing Committee.

Accordingly, the Workshop decided to prepare -

- a Report, based on the Workshop discussions, which is the present document.

- a book, to be edited by F.K. Hare (who would also contribute a substantial synthesis) which would include the above papers, and such

others as the Organizing Committee might commission to elaborate on the Workshop's conclusions. This book would be submitted to Dr. Frank Fenner, SCOPE editor, for publication by John Wiley & Sons, U.K.

It was agreed to formalize the contents of the book by April 1, 1979 and to have drafts available for discussion by late August, 1979. It was proposed that there should be a second meeting (of authors only) to consolidate the draft.

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Appendix B

List of Abbreviations

AES	Atmospheric Environment Service
CCC	Canadian Climate Centre
ECE	U.N. Economic Commission for Europe
FAO	U.N. Food and Agriculture Organization
GARP	Global Atmospheric Research Program
ICSU	International Council of Scientific Unions
IEA	Institute for Environmental Studies (University of Toronto)
IIASA	International Institute for Applied Systems Analysis
MIT	Massachusetts Institute of Technology
NAS	National Academy of Science
NCAR	National Centre for Atmospheric Research
NOAA	National Oceanic and Atmospheric Administration
SCOPE	Scientific Committee on Problems of the Environment
UNEP	United Nations Environmental Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCP	World Climate Program
WHO	World Health Organization
WMO	World Meteorological Organization

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