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CLIMATE AS AN INPUT INTO DECISIONS

(By Robert S. Chen, Climate Research Board, National Academy of Sciences [1])

I appreciate this opportunity to discuss the importance of climate to decisions in agriculture and other economic sectors. This is a topic about which little is well known, but which nevertheless affects all of us greatly. Let me first review briefly what does seem to be known, and then highlight some of the opportunities and initiatives now available.

The climate is perhaps best viewed as a dynamic global system consisting of the Earth's atmosphere, powered primarily by the Sun's energy, and influenced strongly by the Earth's oceans, ice masses, soils, and organic life. We directly experience this system on a day-to-day, local basis as the particular atmospheric conditions of temperature, humidity, rainfall, windiness, cloudiness, and so on at any point in time and space—that is, the weather. However, the system is further characterized by the longer term, dynamic behavior of the system on regional and global scales. Thus, both the average of conditions and the variability of conditions about this average over periods ranging from days to seasons to decades and over geographic regions characterized by topography, latitude, hydrologic conditions, and so forth are important attributes of the climatic system.

Our knowledge of the climate and its influence on human activities is extremely limited. Of the billions of years of the atmosphere's existence, we have systematic, direct observations for only about 200 years, and then only for a few parameters such as temperature, precipitation, and sea level pressure at a few stations. Indirect evidence provided by tree rings, ice and sediment cores, fossils, lake levels, written records, and a variety of other ingenious natural and human sources give our best look globally at time scales of centuries or millenia. These records tell us that the Earth's climate has indeed changed substantially in the past, both in its average behavior and its variability, and that human activities have throughout recorded history been affected by such changes. However, we do not know much more than this in terms of the mechanisms and modes of climate changes or their impacts. It is important to note here that, unlike many other sciences, there is not now any single, or even leading, theory of climate change which can explain our observations or make reliable predictions into the future. In fact, even short-term, local climatic predictions using continuous local data may be subject to considerable error because of regional or global effects or longer term trends.

Despite this general lack of explicit understanding, many decisions which arise in modern society are greatly influenced by the climate.

[1] This paper is presently in Mr. Chen's personal capacity and does not necessarily represent the views of the Climate Research Board or its parent organizations.

Siting and design decisions for energy and transportation facilities, for urban and rural water supply, waste disposal, and flood protection systems, and for commercial and residential structures are sensitive to a variety of climatic factors. Agricultural planning reflects the influence of climate not only on the growth of crops, but also on the prevalence of fires, pests, and plant diseases and on the costs of food transportation and storage. For an individual, choices of clothing, recreation, and area of residence entail personal decisions concerning climate. All of these decisions implicitly or explicitly involve "taking risks" on climate—that is, dealing with the possibility of adverse consequences in order to obtain some benefit, given uncertain future conditions of weather or climate.

Many ways of dealing with climatic risks are available. Physical measures to prevent or ameliorate adverse climatic effects or to take advantage of climatic opportunities range from the selection of crops for planting to construction and land use requirements for development. Choosing among these requires knowledge of their costs, benefits, and often their social and legal ramifications. Institutional planning and finance mechanisms can facilitate such choices through incentives, trade regulations, quality standards, and so forth. Insurance, for example, not only compensates for losses, but also generally encourages minimization of risks—and thereby insurance premiums. Government usually plays a key role, whether through the establishment of codes and standards, the design of public infrastructure such as dams and sewers, or the provision of disaster relief services. Thus, decisions involving climatic risks often entail extensive consideration of many complex and uncertain alternatives with various social, legal, and political aspects as well as technical and economic ones.

We are increasingly calling upon our understanding of climate to help us deal more effectively with climatic risks. In agriculture, realization of the potential value of climatic knowledge is growing around the world. Many examples can be cited:

A recent commodity research report from Merrill Lynch, Pierce, Fenner & Smith describes in detail the state-of-the-art understanding of "blocking," an as yet unexplained phenomenon of the climatic system with important local implications, and applies this knowledge to predicting agricultural production in the U.S.S.R.

An interactive computer information system in Nebraska and nearby States is providing advice to farmers on the scheduling of irrigations based on climatological data such as evaporation and soil moisture.

The Agency for International Development's Office of Foreign Disaster Assistance operates an early warning program which combines climatic data, weather information, satellite photographs, and other sources to provide advanced warning of potentially abnormal climatic conditions that might impact upon food supplies in developing countries.

Climatological information has been extensively used in the hail insurance industry to help determine potential damage to crops.

Allocation of reservoir water in California watersheds are based in part on actual and mean precipitation levels.

Although efforts such as these are quite exploratory and experimental, they give an inkling of the broad potential of climate information as an input into decisionmaking. However, it is important to point out here that in many cases other nonclimatic factors may also constrain the improvement of decisions. For example, substantial new technical knowledge about plant growth and nutrient use may be needed in combination with climatic information in order to supply advice suitable for agricultural users. The ability to use climatic predictions may be only as great as the ability to enforce the responsible management of resources, as may well be the case in the Peruvian anchovy fishing industry and the distribution of water rights in several Western watersheds. Thus, what will be needed in the future is greater experience in the development, dissemination, and application of usable climate information; increased ability to make such inputs explicitly and systematically in various modes of decisionmaking; and considerable development of not only technical, but also economic, social, political, and institutional mechanisms for responding effectively to climatic risks. Interdisciplinary efforts which directly link current scientific knowledge with policy applications are crucial to progress in these areas. Moreover, the societal contexts and assumptions underlying decisions may have to be reexamined critically in light of changing environmental and social conditions. A few of the areas relevant to agriculture in which some basic questions are likely to arise can be listed:

The influence of climate on major agricultural policy decisions by the United States, other nations, and international organizations such as the Food and Agriculture Organization and the World Bank, with implications for world food security. Third World development, farm income, and so on.

The role of climate in watershed management and the distribution of water rights, involving the planning of such organizations as the U.S. Army Corps of Engineers, the Soil Conservation Service, and the Bureaus of Reclamation and Land Management, the rights of States and other nations, and mechanisms for assigning costs and benefits of climatic risks among various societal units.

The impacts of climate variability and change on fisheries (e.g., cod spawning near Iceland and the anchovies off Peru), their international implications, and questions of the value of predictions.

The influence of climate on plant pests and diseases (e.g., the recent outbreak of grasshoppers in many western States may have been largely due to a series of dry years) and ways of dealing with such indirect effects.

Clearly, we will need much more time and experience before we can deal effectively with such complex and often controversial issues.

OPPORTUNITIES AND INITIATIVES

The national climate program is an effort to come to grips with many different climatic risks and opportunities. The original legislation, the National Climate Program Act of 1978, establishes the pro-

gram to "assist the Nation and the world to understand and respond to natural and man-induced climate processes and their implications." Among the program's key provisions are:

> Assessment of the effect of climate on the natural environment, agricultural production, energy supply and demand, land and water resources, transportation, human health, and national security.
>
> Methods for improving climate forecasts on a monthly, seasonal, yearly, and longer basis.
>
> Systems for the management and active dissemination of climatological data, information and assessments, including mechanisms for consultation with current and potential users.
>
> A program for Federal and State cooperative activities in climate studies and advisory services.

A National Climate Program Office has been set up within the National Oceanic and Atmospheric Administration to plan for and administer the program. It has released a preliminary 5-year plan which outlines the program goals and structures.

The Climate Research Board of the National Academy of Sciences has been quite active in assisting the Government in the development of the program. It has concluded two summer workshops to review the Government's plans. The report of the most recent workshop, "A Strategy for the National Climate Program," has just been delivered to the Government and is being published by the Academy. This report proposes a strategy to guide and motivate the efforts of the national climate program. It states:

> The national climate program should emphasize early production of useful outputs on the basis of our present understanding of climate, while simultaneously expanding the understanding of climate and its relationship to society.

It suggests three basic types of activities or "streams" which would consist of continuing efforts aimed at improving:

> The use of existing climate knowledge for a wide range of users;
>
> Our understanding of both natural and manmade climatic changes and of the potential impacts of such changes on society; and
>
> Our ability to predict climatic fluctuations and to use these predictions effectively.

These "streams" of activities would focus on three major program areas or "themes," considered important to the national welfare; the areas of energy, food, and water resources seemed most appropriate. Thus, the strategy would guide planning for the national climate program toward the development and application of climatic knowledge in areas of considerable national concern. It would lay the foundation for continuing dialog between researchers, users, and Government.

The workshop report also strongly supports the development of an active intergovernmental program as called for in the legislation to aid delivery of climate services at a local level and to communicate local needs back to the Federal Government. The role of the Federal Government would be in part to help demonstrate the needs for and potential of such a program by initiating demonstration projects and

by pulling together existing, but scattered, climate-related services now provided by State climatologists, agricultural extension units, universities, and others. Support for this program is needed from all users and throughout local, State, and Federal Government.

In addition to advising the Government on the national climate program, the Climate Research Board is also taking an active role. For example, its Panel on the Effective Use of Climate Information in Decisionmaking, chaired by Dr. Sylan Wittwer, of Michigan State University's Agricultural Experiment Station, is conducting several case studies of the ways in which climatic knowledge can improve the management of agricultural, water, and energy resources. The Panel is also assisting the Center for Advanced Engineering Study of the Massachusetts Institute of Technology in convening a conference on "Climate and Risk." This conference, scheduled for May 27–29, 1980, here in Washington, D.C., will bring together representatives from industry, Government, and academia from all across the country to discuss actual cases in which climatic knowledge has aided major decisions. It will focus specifically on the three main themes of energy, food, and water resources. Among the topics related to agriculture which will be discussed are:

The use of climatic data to schedule irrigations;

Acreage set-aside decisions by the U.S. Department of Agriculture;

Snow management;

Agricultural drought assessment; and

Adaptation of western water rights systems to climate variability.

We anticipate that this conference will be a substantive and timely contribution to the general topic of climate and decisionmaking.

In the international arena, the World Meteorological Organization has established a world climate program with many of the same objectives and goals as the U.S. national climate program. The National Climate Program Office and the Climate Research Board expect that the United States will make substantial contributions to the global program and will assist in the coordination of research and applications worldwide. Some of the opportunities under discussion are:

An international climate data referral and exchange system;

Global monitoring efforts, including ocean monitoring;

A global carbon dioxide effort; and

International efforts in research on global biogeochemical cycles.

These international activities should provide substantial knowledge about the global climatic system and its relationship to human activities throughout the world.

In conclusion, I would like to reiterate my belief in the potential value of improved understanding of climate for aiding our management of resources. Yet for such potential to be realized fully, we will have to improve simultaneously our understanding of related technical, economic, and social areas and of decisionmaking processes, as well as our ability to respond effectively to this knowledge. Although many current activities and initiatives, of which I have mentioned only a few, are excellent first steps in this direction, continued efforts and support will be needed. But the results should be well worth the investment.