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NOAA Technical Report NCPO 002



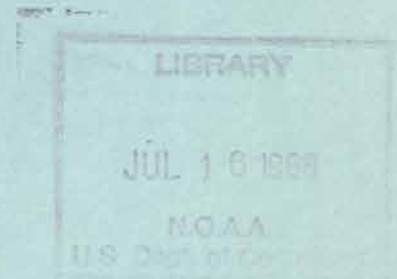
A Selected Annotated Bibliography of Climate and Society Research

Peter M. Morrisette, Editor

Natural Hazards Research and
Applications Information Center
University of Colorado, Boulder

NHRAIC Topical Bibliography Number 14

September 1987



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Climate Program Office

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Bruce Smart, Acting Secretary of Commerce

National Oceanic and Atmospheric Administration

Anthony J. Calio, Under Secretary

National Climate Program Office

Alan D. Hecht, Director

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The production of this volume has been a team effort. The assistance of David Green, William Steinhilber, and Jeff Carter in the production of illustrations, and the assistance of David Threlkeld in collection and entry of data is gratefully acknowledged. Support for the development of this bibliography was provided by the National Climate Program Office and the National Hazards Research and Applications Information Center at the University of Colorado, Boulder.

The National Hazards Research and Applications Information Center is funded by a consortium of Federal agencies, including the National Science Foundation, Federal Emergency Management Agency, National Oceanic and Atmospheric Administration, U.S. Geological Survey, U.S. Army Corps of Engineers, Environmental Protection Agency, National Institute of Mental Health, and Tobacco Tax Authority.

INTRODUCTION

The study of the interaction of climate and society is a growing area of research among social and physical scientists. This research is concerned both with the impact of fluctuations or changes in climatic conditions on natural resource and socioeconomic systems, and on the means by which society responds and adjusts to these changes. This annotated bibliography is a selected review of the literature from this diverse, interdisciplinary field of research. Each of the 281 entries includes either an annotation or an edited version of the author's original abstract, and a set of keywords. The bibliography is divided into eight sections. The first five sections are concerned with the impact of climatic fluctuation and change on sensitive natural and socioeconomic systems (e.g., agriculture, water resources, etc.). The sixth section is a limited review of the extensive literature dealing with climate and history. The seventh section includes material on perception of climatic change and problems of policy and decision making. The final section is a large and diverse collection of the relevant methodological and theoretical literature. Included in this section are articles and papers on the techniques of climate impact assessment, research reviews and assessments, and a number of wide-ranging papers on how society might respond and adjust to climatic change. Author and subject indexes based on entry numbers are provided at the end of the final section.

This bibliography was derived from a computer bibliographic database which is being developed at the Natural Hazards Research and Applications Information Center. The user should note that this bibliography is a selective, rather than exhaustive, survey of the literature identified through 1986 as important and relevant to questions of climate and society interaction. As the literature and computer database grow, future versions of this bibliography may be published.

The production of this volume has been a team effort. The assistance of David Smith, William Riebsame, and Jeff Carter in the preparation of annotations, and the assistance of David Theobald in collation and entry of data is gratefully acknowledged. Support for the development of this bibliography was provided by the National Climate Program Office and the Natural Hazards Research and Applications Information Center¹ at the University of Colorado, Boulder.

¹The Natural Hazards Research and Applications Information Center is funded by a consortium of federal agencies, including the National Science Foundation, Federal Emergency Management Agency, National Oceanic and Atmospheric Administration, U.S. Geological Survey, U.S. Army Corps of Engineers, Environmental Protection Agency, National Institute of Mental Health, and Tennessee Valley Authority.

AGRICULTURE

- 1 Bergthorsson, Pall. 1985. Sensitivity of Icelandic Agriculture to Climatic Variations. Climatic Change 7: 111-127.

KEYWORDS Agriculture, forestry.

Haymaking and grazing in summer and winter are fundamental to Icelandic agriculture. This paper shows that the growth of grass depends very much on the climate, particularly the temperature, and that winter temperatures are especially important. The climate of Iceland is highly variable, and the long-term variations are great in comparison with most other European weather regions. This may be attributed partly to the role of the sea ice, which lags behind the variations in atmospheric temperature. The paper also discusses the growth of barley and forests, which is barely possible in the cold climate and reacts strongly to climatic variations and changes.

- 2 Biswas, A.K. 1980. Crop-Climate Models: A Review of the State of the Art. In J. Ausubel and A.K. Biswas, eds., Climatic Constraints and Human Activities, 75-92. Oxford: Pergamon Press.

KEYWORDS Crop yields, agriculture.

One of several reviews of crop-climate models available, but this one is somewhat different in its focus on more integrated modelling efforts (e.g., those by Peter Haigh and G.D.V. Williams and the Institute of Ecology) which go beyond simply making correlational connections between climate and yield. For example, the Haigh modelling project was designed specifically to separate climate from technological signals in yield--a continuing problem in climate modelling.

- 3 Borchert, John R. 1971. The Dust Bowl in the 1970s. Annals of the Association of American Geographers 61:1-22.

KEYWORDS Drought, agriculture, response.

Major droughts in the Grassland region of the central United States have occurred rhythmically during the period of instrumental record. The time for the next one may be near. Early droughts disastrously reduced farm income through loss of crops and livestock. Since the 1930s they have accelerated--within this region--contemporary basic changes in America: fewer, bigger, and more fragmented farms, public controls and subsidies, consolidation of urban business and services, and greater management. The next major drought will again accelerate long-term agriculture changes in settlement could be initiated. The Grassland is a unique interaction zone between physical and human circulation systems. It has long attracted geographers of widely varied interests. Their collective works illustrate

the importance of combining concept, technique, and specific regional problem in fashioning geography's contribution to the scientific quest.

- 4 Bryson, Reid A. 1974. Heyuppskera: An Heuristic Model for Hay Yield in Iceland. University of Wisconsin-Madison, Institute for Environmental Studies, Report 22. Madison, Wisc.

KEYWORDS Agriculture, climate analysis, crop yields, historical analysis.

Focus on climate change in areas of agricultural marginality, simple economy, dramatic effects of climate change evident as representative of larger subarctic areas of maximum climate change. Data sources matched with climate models to reveal that Iceland's agricultural economy is sensitively dependent on climate, especially temperature, and that the heavy use of nitrogen fertilizers to compensate poor crop yields actually reduces yields even further in such a climate.

- 5 Burgos, J.J. 1979. Renewable Resources and Agriculture in Latin America in Relation to the Stability of Climate. In Proceedings of the World Climate Conference, World Meteorological Organization, no. 537, 525-551.

KEYWORDS Agriculture, developing countries, environmental impacts, natural resources.

Offers a series of observations on the actions of man in exploiting renewable natural resources and changing them to obtain artificial renewable resources, such as forestry, agriculture and husbandry, in order to satisfy present and future needs. Such actions are believed to affect climate on the micro-, meso- and macro-scales. Focuses on climate as an economic resource, soil productivity, area climate factors, and land use changes.

- 6 Canadian Climate Program. 1984. Drought Workshop Proceedings, August 29-30, 1983, Regina, Saskatchewan. Canadian Climate Program, Downsview, Ontario.

KEYWORDS Drought, economic impacts, agriculture.

This workshop, jointly sponsored by the Canadian Climate Planning Board and the Prairie Farm Rehabilitation Administration (PFRA) produced a fascinating mixture of papers on the predictability and impact of droughts, along with reports on economic studies of drought impact and remedial measures conducted under the Canada (PFRA)-Manitoba and Saskatchewan drought agreements.

- 7 Dyer, J.A. 1984. Monitoring Drought for Grazing Land Management. Journal of Soil and Water Conservation 39: 176-179.

KEYWORDS Range land, drought, livestock, climate forecasts, mitigation, ecological impacts.

Range land managers in western Canada use the Forage Drought Early Warning System (FoDEWS) to make prediction of May 31 soil moisture. Early forecasts of drought probability help them select strategies for preventing degradation of the range and for keeping the beef market as stable as possible. Major components of the computer model are described and its performance, limitations, and advantages briefly discussed. Among the available adjustments to drought, direct financial assistance to ranchers is considered least conducive to range conservation, and early warning enables managers to choose other strategies for preserving drought-stricken pastures.

- 8 Eddy, Amos and Ellen Cooter. 1978. A Drought Probability Model for the U.S.A. Northern Plains. University of Oklahoma, Oklahoma Climatological Survey. Norman. 83 pp.

KEYWORDS Drought, crop yields.

The purpose of the study which led to this report was to develop a model of drought probabilities which would apply to the wheat and corn belts of the U.S.A. north-central plains. Daily temperature and precipitation data taken over the past three quarters of a century at some 135 reporting stations were available to represent North Dakota, Kansas, Iowa and Illinois climatology. Drought "signatures" were sought for the 1930s, the early 1950s, and the early 1960s. The first two were found to show up dramatically in data which had been transformed to soil moisture, evapotranspiration and crop moisture index values and then filtered to remove fluctuations. A statistical model of the filtered series was formulated and used to produce monte carlo simulation answers to questions concerning drought frequencies during given time periods.

- 9 Escudero, Jose Carlos. 1985. Health, Nutrition, and Human Development. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 251-272. New York: John Wiley and Sons.

KEYWORDS Health effects, food, famine.

A rare and brief look at climate impacts from a public health/nutrition point of view. Offers a useful comparison of two neighboring countries: Cuba and Haiti. Some comments on ability of world food system to absorb climate change impacts.

- 10 Fukui, H. 1979. Climatic Variability and Agriculture in Tropical Moist Regions. In Proceedings of the World Climate Conference, World Meteorological Organization, no. 537, 426-474.

KEYWORDS Agriculture, developing countries, crop yields, societal vulnerability.

Offers a series of observations about various factors relevant to the study of climate and agriculture in tropical regions of major population pressure. Suggests that: 1) climate data involving changes in the means

of various parameters must also have records of changes in the distribution pattern of such data; 2) the impact of climate change on agriculture is linked to amplitude and agricultural vulnerability; 3) agricultural production in the humid tropics is affected by yearly variations in precipitation; 4) the cultivation of annual grains in such areas is highly risky due to land deterioration and precipitation variability; 5) root crops hold potential in such areas, as do forest crops; 6) rick cultivation is the best agricultural system for humid tropical conditions; and 7) population pressure is increasing the vulnerability of existing agricultural systems in these areas.

- 11 Hall, Jerry A. 1983. The Place of Climatic Hazards in Food Scarcity: A Case Study of Belize. In Interpretations of Calamity, ed. K. Hewitt, 140-161. Boston: Allen and Unwin.

KEYWORDS Self-provisioning societies, developing countries, response, agriculture, extreme events, drought.

Societal vulnerability to agro-climatic hazards is seen as a result of a forestry-garden economy that no longer exists, state emphasis on large scale commercial agriculture, and the biases of a colonial legacy. These factors support the use of an agro-climate calendar for subsistence agriculture which increases the vulnerability of subsistence farmers and their crops to climatic hazards and fluctuations in climatic conditions.

- 12 Hewitt, Kenneth. 1983. Climatic Hazards and Agricultural Development: Some Aspects of the Problem in the Indo-Pakistan Subcontinent. In Interpretations of Calamity, ed. K. Hewitt, 181-201. Boston: Allen and Unwin.

KEYWORDS Developing countries, response, agriculture, famine, drought, floods.

Famine and food shortages in the Indo-Pakistan subcontinent due to climate hazards are not seen as a result of overpopulation, rather they are seen as a result of a political economy which emphasizes urban, industrial, and commercial development rather than agricultural self-sufficiency during times of climatic stress. Thus drought and famine cannot be seen simply as natural events, rather they are the result of complicated social, political, and economic circumstances.

- 13 Hill, Jerry D., Norton D. Strommen, Clarence M. Sakamoto, and Sharon K. Leduc. 1980. LACIE--An Application of Meteorology for United States and Foreign Wheat Assessment. Journal of Applied Meteorology 19: 22-34.

KEYWORDS Crop yields, meteorological services, climate information.

The development of a critical world food situation during the early 1970s was the background leading to the Large Area Crop Inventory Experiment (LACIE). The need was to develop a capability for timely monitoring of crops on a global scale. Three U.S. Government agencies, NASA, NOAA, and

USDA, undertook the task of developing technology to extract the crop-related information available from the global weather-reporting network and the Landsat satellite. This paper describes the overall LACIE technical approach to make a quasi-operational application of existing research results and the accomplishments of this cooperative experiment in utilizing the weather information. Using available agrometeorological data, techniques were implemented to estimate crop development, assess relative crop vigor and estimate yield for wheat, the crop of principal interest to the experiment. Global weather data were utilized in preparing timely yield estimates for selected areas of the U.S. Great Plains, the U.S.S.R. and Canada. Additionally, wheat yield models were developed and pilot tested for Brazil, Australia, India and Argentina. The results of the work show that heading dates for wheat in North America can be predicted with an average absolute error of about 5 days for winter wheat and 4 days for spring wheat. Independent tests of wheat yield models over a 10-year period for the U.S. Great Plains produced a root-mean-square error of 1.12 quintals per hectare while similar tests in the USSR produced an error of 1.31 q/h.

- 14 Huff, Floyd A. and James C. Neill. 1982. Effects of Natural Climate Fluctuations on the Temporal and Spatial Variation in Crop Yields. Journal of Applied Meteorology 21: 540-550.

KEYWORDS Crop yields, agriculture.

An investigation was made of variations in corn and soybean yields resulting from natural fluctuations in weather conditions between years in a five-state area in the Midwest. Analyses were performed for crop districts within each state and for various combinations of the five states when crop yields are evaluated over periods of 1-5 years. Results were presented in the form of temporal-spatial probability distributions, in which the distributions were based on deviations from "expected" yield after adjustment for technology advancements during the period of record (1931-75). In general, it was found that weather-related deviations in corn yields were greater than in soybeans, a decrease in temporal variability occurs from west to east, negative deviations tend to be greater than positive deviations, but that the five-state area seldom experiences large deviations from expected yield and the occasional large deviations do not usually persist long.

- 15 Karl, Thomas R. 1983. Some Spatial Characteristics of Drought Duration in the United States. Journal of Climate and Applied Meteorology 22: 1356-1366.

KEYWORDS Drought.

Using the Palmer Drought Severity Index (PDSI) as calculated from state averages of temperature and precipitation and from numerous single station analyses, it has been demonstrated that droughts (as defined by the PDSI) persist longer in the interior United States than areas further east or west (Karl and Koscielny, 1982; Walsh et al. 1982). The question arises whether this is merely an artifact of the PDSI calculations themselves, or

whether there is actually more persistence of abnormally dry (wet) weather in the interior United States. The sensitivity of the PDSI was tested in relation to changes of derived and prescribed parameters included in the PDSI calculations (Palmer, 1965) in order to determine their effect on the spatial characteristics of drought duration. The sensitivity tests indicated a negligible effect. Contingency tables using the PDSI as a proxy for the following one-month, six-month and 12-month precipitation anomalies (and also anomalies of precipitation minus potential evapotranspiration) however, are generally characterized by significantly greater skill in the interior portions of the United States, confirming the notion that spells of abnormally dry or wet weather do have more persistence in the Rocky Mountain and High Plain states than states further east or west. Unfortunately, the persistence derived from the "operational" PDSIs were not a significant improvement from what would have been obtained by using precipitation persistence forecasts.

- 16 Katz, Richard W. 1977. Assessing the Impact of Climatic Change on Food Production. Climatic Change 1: 85-96.

KEYWORDS Food.

Attempts to assess the impact of a hypothetical climatic change on food production have relied on the use of statistical models which predict crop yields using various climatic variables. It is emphasized that the coefficients of these models are not universal constants, but rather statistical estimates subject to several sources of error. Thus, any statement regarding the estimated impact of climatic change on food production must be qualified appropriately.

- 17 Kolb, L.L. and R.R. Rapp. 1962. The Utility of Weather Forecasts to Raisin Industry. Journal of Applied Meteorology 1: 8-12.

KEYWORDS Climate forecasts, agriculture.

It is not possible to state at present just how much economic value either is derived or could be derived from present weather forecasts. It is, however, possible to analyze the weather factors that affect an industry. In this paper, the practices of the raisin-drying industry are found to agree with a theoretical optimum derived from climatological data. The paper goes on to show that weather forecasts properly tailored to this industry may be usable in maximizing gains and minimizing losses.

- 18 Le Houerou, Henri N. 1985. Pastoralism. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 155-185. New York: John Wiley and Sons.

KEYWORDS Livestock, rangeland, Sahelian drought, self-provisioning societies, desertification.

Valuable review and synthesis of current knowledge of climate impacts on grassland production and livestock herding throughout the world. Makes

available findings from a diverse literature, much of it not in english. Works up from primary biophysical impacts to social impacts, with a focus on Third world pastoralism.

- 19 Liverman, D.M., W.H. Terjung, J.T. Hayes, and L.O. Mearns. 1986. Climatic Change and Grain Corn Yields in the North American Great plains. Climatic Change 9: 327-347.

KEYWORDS Crop yields, agriculture.

A basic parametric crop yield model (YIELD) that uses climatic and environmental data to calculate yield and associated parameters for grain corn (maize) was applied to a transect through the North American Great Plains. This paper continues our examination of the impact of probable climatic change scenarios on crop evapotranspiration and irrigation requirements. This study of grain corn yields showed the highest yield for the first (or primary) harvest under full irrigation occurring under a sunny and cold scenario in Austin, TX, sunny and cool in Kansas City, KS and sunny and warm in Bismarck, ND. Lowest irrigated yield was found with cloudy and hot and very dry climate change scenarios. Under rainfed-only conditions, minima were obtained under the sunny-hot and -warm scenarios and very dry conditions.

- 20 McKay, Gordon. 1983. Climatic Hazards and Canadian Wheat Trade. In Interpretations of Calamity, ed. K. Hewitt, 219-228. Boston: Allen & Unwin.

KEYWORDS Agriculture, crop yields, economic impacts.

Wheat on the Canadian Prairie is grown near the northern limit of economic agriculture and thus yields are closely tied to variability in climate. This paper examines the national and international trade implications of variability in wheat yields resulting from climatic variability.

- 21 Neild, R.E. 1978. The Complexity of Measuring the Impact of Possible Climatic Change on Agriculture. Transactions of the Nebraska Academy of Sciences 6: 135-139.

KEYWORDS Agriculture, climate analysis, climate forecast, historical analysis, scenarios.

Focus on complexities (i.e. weather variability, technological change, variation and brevity of data sources, marginality of land) related to climate and agriculture relationships in Nebraska. Considers several simulation studies (temperature response models, synthesized climate using historical daily weather record data base). Offers two contrasting future climate scenarios for Great Plains region.

- 22 Newman, James E. and Robert C. Pickett. 1974. World Climates and Food Supply Variations. Science 186: 877-81.

KEYWORDS Agriculture, food, climate analysis, response.

This article reviews world climates and agricultural production, examines how variations in climate might affect agriculture and world food supplies, and offers some suggestions on how to alleviate food shortages resulting from climatic variability.

- 23 Nix, Henry A. 1985. Agriculture. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 105-130. New York: John Wiley and Sons.

KEYWORDS Agriculture, crop yields.

An excellent review of climate impacts on crop production, focussing on methods for assessing impacts and prospects for a broader agroclimatic synthesis based on agro-ecological zonation.

- 24 Oram, P.A. 1985. Sensitivity of Agricultural Production to Climatic Change. Climatic Change 7: 129-152.

KEYWORDS Agriculture, ecological impacts.

Although the range of cultivated species is relatively restricted, domestic plants and animals exhibit considerable resilience to stochastic shocks, and the study of their ecological adaptability and critical physiological and phenological requirements is a valuable first step in determining their possible response to climatic change. Methods of assessing agroclimatic suitability and their limitations are discussed, and suggestions are made for simulating the probable impact of shifts in the main climatic parameters on the productivity and spatial distribution of key crops and livestock. Some regions and crops are climatically more vulnerable than others. As well as attempts to forecast long-term climatic trends and their effects on agriculture, combating climatic variability merits high priority. The paper indicates a number of potentially desirable areas of action and suggests that several of these would be beneficial both as a buffer against short-term effects of variability and as a means of combating climatic change.

- 25 Palmer, Wayne C. 1968. Keeping Track of Crop Moisture Conditions, Nationwide: The New Crop Moisture Index. Weatherwise (August): 156-161.

KEYWORDS Agriculture, crop yields, meteorological services.

The Crop Moisture Index (CMI) is an example of a meteorological approach useful in assessing crop conditions over a large area without having to worry about local variations in soil, crops, root depths, stages of development or precipitation amounts. Based on weekly mean temperature

and total precipitation reports, CMI is the algebraic sum of the evapotranspiration anomaly index and the wetness index.

- 26 Parry, M.L. 1975. Secular Climatic Change and Marginal Agriculture. Transactions-Institute of British Geographers 64: 1-13.

KEYWORDS Climate analysis, agriculture.

An assessment is made of the significance of secular climatic change to marginal cultivation in south-east Scotland. Climatic limits to cultivation in this region occur at levels of about 1050 day-degrees C, 60 mm PWS and 6.2 m/s average windspeed. These limits stood at 320-350 m in the late nineteenth century, yet 700 ha of abandoned medieval cultivation lie above them. Secular changes in temperature and rainfall are resolved into trends in accumulated temperature and PWS. These reveal a substantial deterioration in upland growing conditions after 1250. The climatic limit to cultivation may have fallen 140 m over 300 years. Isopleths of this limit, drawn for selected periods, point to an upland fringe which may have become submarginal to cultivation. A spatial correlation between this submarginal fringe and the distribution of abandoned farmland may suggest an indirect causal relationship.

- 27 Parry, M.L. 1981. Climatic Change and the Agricultural Frontier: A Research Strategy. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 319-336. Cambridge: Cambridge University Press.

KEYWORDS Agriculture, historical analysis.

There has been a tendency to evaluate the historical significance of climatic change by inductive studies of the spatial and temporal coincidence of economic and climatic events in the past. Such studies incorporate the weakness of inductivism: they lack an unbroken logic which establishes the relationships between the various propositions, and they have not sought to test the propositions either empirically or theoretically. There is therefore, little evidence that the economic event is contingent to the climatic event. One way of establishing more precisely the contingent relationships between climate and economy in the past is to adopt a 'retrodictive' strategy. This needs to be based on an understanding of the processes linking climate, agriculture and settlement derived from analogue models of contemporary crop-climate links, from studies of the interaction between weather and farming decisions, and from the analysis of the different effects on agriculture of long- and short-term climatic change.

- 28 Parry, M.L. 1985. The Impact of Climatic Variations on Agricultural Margins. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 351-367. John Wiley and Sons.

KEYWORDS Social impact analysis, agriculture, historical analysis.

A brief statement of Parry's well-known approach to climate impact assessment focussed on agricultural margins. Applies his "risk threshold" view of climate sensitivities. See additional Parry entries.

- 29 Parry, M.L. and T.R. Carter. 1983. Assessing Impacts of Climatic Change in Marginal Areas: The Search For an Appropriate Methodology. Working Paper, International Institute for Applied Systems Analysis, Laxenburg, Austria. 24 pp.

KEYWORDS Crop yields, agriculture, risk analysis, systems analysis.

This paper was written as a starting point for a two-year investigation of short-term climate variations and possible long-term, CO₂ induced climate change and their impacts on agriculture in marginal areas. The concept of climate related marginality is reviewed. The authors propose that impacts of climate fluctuations on marginal areas can be measured as changes in the risk of harvest failure or as "spatial shifts of crop pay-off boundaries." Case studies in the U.S., Canada, and Northern Europe are presented. The final section describes in brief the crop/climate simulation model used to evaluate impacts to Northern England cereal crops; further refinement of this methodology would be pursued during the two-year project conducted by the International Institute for Applied Systems Analysis.

- 30 Parry, M.L. and T.R. Carter. 1985. The Effect of Climatic Variations on Agricultural Risk. Climatic Change 7: 95-110.

KEYWORDS Agriculture, risk analysis.

The thesis of this paper is that impacts from climatic change can be evaluated effectively as changes in the frequency of short-term, anomalous climatic events. These can then be expressed as changes in the level of risk of impact from climatic extremes. To evaluate this approach, the risk of crop failure resulting from low levels of accumulated temperature is assessed for oats farming in southern Scotland. The conclusion is that relatively recent and apparently minor climatic variations in the United Kingdom have in fact induced substantial spatial changes in levels of agricultural risk. An advantage of expressing climatic change as a change in agricultural risk is that support programs for agriculture can be retuned to accommodate acceptable frequencies of impact by adjusting support levels to match new risk levels.

- 31 Pendleton, Dennis F., George M. Van Dyne, and Marilyn T. Whitehouse. 1979. Interim Progress Report: Prediction of Grazingland Productivity Under Climatic Variations. Department of Range Science, Colorado State University, Fort Collins, Colorado.

KEYWORDS Range land, food, response.

The ultimate goal of this study is to provide for decision-makers at national and international levels (1) scientifically-defensible

information on the contribution of grazinglands to food production and (2) a means for determining the variability of yield due to climatic fluctuations. Specific tasks toward the accomplishment of this goal have been defined for each projected year of the study.

- 32 Rosenberg, Norman J. 1981. The Increasing CO₂ Concentration in the Atmosphere and Its Implication on Agricultural Productivity. Climatic Change 3: 265-279.

KEYWORDS Greenhouse effect, agriculture.

The increasing concentration of CO₂ in the atmosphere should result in a general increase in the net primary productivity of most cultivated species and forest species, assuming no counterproductive climatic changes occur. The photosynthetic rate of C₃ plants is most responsive to increasing concentration of CO₂ in the ambient air. C₄ plants demonstrate a stomatal closure that causes reduced transpiration. In the case of both types of plants, the water use efficiency (photosynthesis/transpiration) is likely to be improved.

- 33 Rosenberg, Norman J. 1982. The Increasing CO₂ Concentration in the Atmosphere and Its Implication on Agricultural Productivity: Effects Through CO₂-Induced Climatic Change. Climatic Change 4: 239-254.

KEYWORDS Greenhouse effect, agriculture, crop yields.

In a prior paper (Part 1), the point was made that, assuming an unchanged climate, water use efficiency in agricultural crop production will likely be favored by the increase in CO₂ concentration projected to occur within the next half century. Since climatic change is likely to result from CO₂ concentration increase, its possible impacts on agricultural productivity must also be considered. An attempt to do so, using the Great Plains region of North America as a case study, is reported in this paper (Part 2).

- 34 Sakamoto, C., S. Leduc, N. Strommen, and L. Steyaert. 1980. Climate and Global Grain Yield Variability. Climatic Change 2: 349-361.

KEYWORDS Agriculture, crop yields.

Historical grain yields from several countries were analyzed to determine the variability of grain yield. This was accomplished by assuming a linear technology trend and analyzing the deviations from this trend. The deviation was assumed to be primarily an effect of weather. Using 10 percent deviation from trend as a threshold, it was determined that for each of seven countries the probability of a poor yield year ranged from 17 in India and the United States to 33 percent in Canada and the U.S.S.R. The probability of two consecutive poor wheat yield years was highest in Canada (17 percent) and lowest in Argentina (6 percent). The probability of a poor year occurring in the same year in both the United States and the U.S.S.R. was about 7-8 percent. The highest variability in yield has

occurred in Canada, but variability in India has increased substantially since the 1960s.

- 35 Santer, Benjamin. 1985. The Use of General Circulation Models in Climate Impact Analysis--A Preliminary Study of the Impacts of a CO₂-Induced Climatic Change on West European Agriculture. Climatic Change 7: 71-93.

KEYWORDS Crop yields, greenhouse effect, global circulation models.

An investigation is made of the possible impacts of a climatic change (induced by a doubling of atmospheric carbon dioxide concentration) on the European agriculture sector. Two general circulation models have been used to develop climatic change scenarios for the European study area. From the scenarios, information was obtained concerning the possible behavior of temperature, precipitation, solar radiation, and relative humidity in the altered climatic state. This meteorological information was then employed in two separate crop-weather models--an empirical/statistical model (for winter wheat) and a simple simulation model (for biomass potential). This type of approach represents a considerable departure from that employed by previous large-scale climate impact studies. The results of this investigation demonstrate that a simple crop-weather simulation model may be more suitable for the purposes of agricultural impact analysis than the linear regression models frequently used in such studies.

- 36 Sonka, Steven T., Peter J. Lamb, Stanley A. Changnon, Jr., and Aree Wiboonpongse. 1982. Can Climate Forecasts for the Growing Season be Valuable to Crop Producers: Some General Considerations and an Illinois Pilot Study. Journal of Applied Meteorology 21: 471-476.

KEYWORDS Climate forecasts, crop yields, economic impacts.

A three-step process is proposed to be most efficient for generating skillful climate forecasts which could reduce the adverse socioeconomic effects of climatic variability. These steps involve identifying weather-sensitive economic sectors, documenting the flexibility of these sectors with respect to likely forecast information, and the development of accordingly focused forecast capabilities. An illustration of the types of information needed to identify sector flexibility is provided for Midwest crop production. Finally, a pilot study using actual farmer data for east central Illinois suggests that increased corn yields could have resulted if producers had been forewarned of the benign weather conditions experienced during the 1979 growing season. This implies that skillful, properly structured climate forecasts may be useful to Midwest crop producers.

- 37 Starr, Thomas B. 1977. The Role of Climate in American Agriculture: Past, Present and Future. The Ecologist (Aug./Sept.): 262-269.

KEYWORDS Agriculture, climate analysis, historical analysis, perception, societal vulnerability.

Focus on sensitivity of agricultural production to climate variability with emphasis on issues of vulnerability and uncertainty of prediction, adjustment and response measures. Concludes that US agriculture is finely tuned to the favorable and stable (relatively) recent climate. Such conditions are historically the exception rather than the norm of North American climate. United States agriculture would be wise to prepare itself for less hospitable climate conditions in the future.

- 38 Swaminathan, M.J. 1979. Global Aspects of Food Production. In Proceedings of the World Climate Conference, World Meteorological Organization no. 537, pp. 367-405. Geneva, Switzerland.

KEYWORDS Agriculture, demographic analysis, policy analysis, technology assessment, drought, famine.

Calls for the development and maintenance of defensible and effective national and international food security systems based on "known knowledge and technology." Somewhat out of date. Examines current world agricultural condition, population demands and growth predictions, aquatic production, food chain flexibility, distribution problems (equality), risk and uncertainty factors in food production, and future challenges and opportunities for global food production. Many tables and graphs.

- 39 Swaminathan, M.J. 1984. Climate and Agriculture. In A.K. Biswas, ed., Climate and Development, Vol. 13 of the Natural Resources and the Environment Series. Dublin: Tycooly International Publishing Limited.

KEYWORDS Agriculture, famine, mitigation, drought, flood.

Offers a detailed study of the relationships between climate and agriculture in order to develop methods of sustainable agricultural growth. Considers the vulnerability of world food production systems; natural hazard risks in agriculture; drought impacts and drought management practices; floods; the creation of a national food security system; a plant breeding scenario; CO₂ and other issues. Concludes that climate-induced production variations in agriculture are beyond the control of man. Suggests ways to reduce impacts.

- 40 Terjung, W.H., D.M. Liverman, J.T. Hayes, et. al. 1984. Climatic Change and Water Requirements for Grain Corn in the North American Great Plains. Climatic Change 6: 193-220.

KEYWORDS Crop yields, hydrologic modeling, water resources, scenarios.

A parametric crop water use and yield model was applied to a transect spanning the North American Great Plains to investigate the evapotranspiration demand on grain corn and the associated irrigation water applications needed for optimal crop production. The transect consisted of four sample stations, covering 25 degrees of latitude. 124 climate change scenarios for each of the transect stations, were created by systematically changing air temperature, precipitation, and incident

solar radiation in terms of positive and negative departures from the normal, long-term record. This paper reports how grain corn evapotranspiration and irrigation water amounts would respond to climatic changes inherent in the scenarios if there were no changes in agricultural technology.

- 41 Treidl, R.A., W.D. Wyllie, and F.D. Thompson. 1977. The Impact of the Weather on the Niagara Fruit Crops in 1976. Agrometeorological Report No. 4, Fisheries and Environment Canada, Atmospheric Environment, Downsview, Ontario.

KEYWORDS Agriculture, climate analysis, crop yields.

Overall soft fruit crop yields down in 1976 due to pronounced climatic fluctuations--cold wave in January, instability in March, rain in June--yet the unique soil and climate characteristics and conditions found in the Niagara fruit belt protected these crops from the yield losses suffered elsewhere. Raises the question of land use priorities in the face of continued climate variability.

- 42 U.S. Department of Energy. 1983. Response of the North American Corn Belt to Climate Warming. U.S. Department of Energy, Office of Energy Research, Office of Basic Energy Sciences, Carbon Dioxide Research Division (DOE/NBB-0040).

KEYWORDS Agriculture, climate forecasts, greenhouse effect, scenarios.

Study uses simulation methods concerning CO₂ doubling and climate variability to predict the geographic shift of the U.S. corn belt in response to temperature increase. Reviews past simulation research, urges further research to reduce uncertainties in the prediction process. Concludes increased CO₂ results in longer growing seasons which allow earlier planting dates which allow crops to grow in wetter months of early summer.

- 43 Waggoner, P.E. 1983. Agriculture and a Climate Changed by More Carbon Dioxide. In Changing Climate: Report of the Carbon Dioxide Assessment Committee. pp. 383-418. Washington, D.C.: National Academy Press.

KEYWORDS Agriculture, greenhouse effect, crop yields, ecological impacts, historical analysis, theoretical analysis.

Waggoner's chapter deals with American crop production and how a change to a CO₂-enhanced warmer, drier climate might affect it. There are sections on the effects of CO₂ on photosynthesis and plant growth; changes in yield that might occur in a warmer, drier climate; effects on pathogens and insect pests; effects on irrigation; and some possible adaptation strategies. The author concludes that some of the impacts predicted given his assumptions might work in opposite directions, thus reducing the total impact on yields. Thus, this limited analysis produces a rather

optimistic outlook, based on an assumption that climatic change will occur very gradually.

- 44 Walton, Kenneth. 1952. Climate and Famines in North East Scotland. Scottish Geographical Magazine 68: 13-21.

KEYWORDS Developing countries, famine, historical analysis, response, self-provisioning societies.

Focuses on 18th Century relationships between low levels cultural aid technological achievement, subsistence economies, climate variability and food shortages. Argues for the study of climate variability on the local, historical level as a tool for investigating problems of famine and food supply distribution in areas where climate and food shortage are closely linked.

- 45 Warrick, R.A. 1982. The Possible Impacts on Wheat Production of a Recurrence of the 1930s Drought in the U.S. Great Plains. Climatic Change 6: 5-26.

KEYWORDS Crop yields, drought.

What would be the impacts on wheat production if the U.S. Great Plains were to suffer another severe, prolonged drought? The 1930s drought is chosen as a worst-case scenario, and two sets of crop-yield regression models are employed to simulate yields using actual 1932-40 weather values and assuming constant 1975 technology. The results are first compared to normal or expected yields in each of 53 crop reporting districts in order to determine the range and spatial variation in yield departures over the nine year period. The cumulative deficit over this period is that a return of a 1930s-type drought would still inflict widespread, heavy damage on wheat production in the Great Plains.

- 46 Warrick, R.A., R.M. Gifford, and M. Parry. 1986. Climatic Change and Agriculture. In B. Bolin et al., eds., The Greenhouse Effect, Climatic Change, and Ecosystems, 393-473. New York: John Wiley and Sons.

KEYWORDS Agriculture, crop yields, research review, greenhouse effect, food.

Valuable survey of the direct CO₂ impacts on food crops and potential for climate change impacts. Evidence suggests that a doubling of CO₂ concentration in the atmosphere would lead to a 0-10% increased yield of C₄ crops (e.g., maize and sugarcane) and a 10-50% increase in C₃ crops (e.g., wheat, soybean, rice). The authors suggest that warmer temperatures due to the greenhouse effect may well reduce grain yields in many mid-latitude growing areas, but caution that the uncertain nature of future climate change makes any impact projection unreliable. They also stress the need for impact assessments on agriculture in the low latitudes.

- 47 Wilken, Gene C. 1972. Microclimate Management by Traditional Farmers. Geographical Review 62: 544-560.

KEYWORDS Agriculture, crop yields, climate modification, mitigation, self-provisioning societies.

Small-scale farmers modify the microclimate of the "crop zone" (groundlevel to 2 meters) through manipulation of long/shortwave radiation, shade, albedo, surface geometry, heat, moisture, tillage, mulches, dew, wind, rain and hail impacts. Non-comprehensive review of methods/practices gathered from field reports. Not applicable to large scale, machine agriculture.

- 48 Williams, G.D.V. 1972. Geographical Variation in Yield-Weather Relationships Over a Large Wheat Growing Region. Agricultural Meteorology 9: 265-283.

KEYWORDS Crop yields.

Within a large wheat growing region, the Canadian Prairies, large differences were found in the relationship of wheat yield fluctuations to weather variations. Regression analyses were performed independently on eight non-overlapping groups of districts, using data from the 1952-1966 period and considering each distinct-year in a group as a separate case. The weather variables included May, June and July precipitation and potential evapotranspiration, pre-season conserved precipitation, and some second-degree variables formed from these. Correlations of yields with weather variables were greatest in the driest areas, where only one weather variable was needed to explain 40% of the yield variance. In the most humid parts of the region at least three such variables were needed, and it appeared that there was often too much moisture for maximum yields. Potential applications and possible improvements in the weather-based yield estimation procedures are suggested. The method could be adapted for other crops and for other regions of the world, and could help in long range planning of land use and short range planning to move grain from areas of surpluses to areas of shortages.

- 49 Wittwer, Sylvan H. 1982. Carbon Dioxide and Crop Productivity. New Scientist (July 1982): 233-234.

KEYWORDS Agriculture, crop yields, food, greenhouse effect.

Wittwer argues that an increase in CO₂ in the atmosphere might be beneficial to agriculture, not harmful. An increase in CO₂ results in an increase in crop productivity (more, larger plants) through more efficient water use, photosynthesis and nitrogen fixation by the plant. CO₂ increase also may increase crop growing seasons and the amount of cultivatable acreage.

50 World Meteorological Organization. 1975. Drought and Agriculture. World Meteorological Organization, WMO no. 392, Technical Note no. 138. Geneva.

KEYWORDS Drought, agriculture, response, environmental impacts.

This report presents an overview of agricultural drought--both meteorological aspects and methods for ameliorating its effects.

Chapters: 1. Introduction. 2. Definition of drought. 3. Meteorological indices of agricultural drought. 4. Methods of analysis. 5. The plant, agricultural practices and drought. 6. Pastures and livestock under drought conditions. 7. Drought and water requirements. 8. Diseases and pests in drought. 9. Local environmental control and drought. Appendix 1. Summary of drought definitions. Appendix 2. Drought and the need for a world climatic watch.

51 World Meteorological Organization. 1983. Guidelines on Crop-Weather Models. WCP 50. Geneva: WMO/WCAP.

KEYWORDS Agriculture, climate information, developing countries, crop yields.

This report provides a general overview of types and applications of crop-weather models currently in use around the world. It does not intend to give exhaustive coverage but examples of each major type are provided. Data and computational requirements are given in each case. There is also a large section on the data needs of agroclimatic models, its availability, and problems associated with such data. One of the primary goals of this report was to call to the attention of developing countries the existence of many very simple models which might enhance their food production.

WATER RESOURCES

- 52 Cohen, Stewart J. 1986. Impacts of CO₂-Induced Climatic Change on Water Resources in the Great Lakes Basin. Climatic Change 8: 135-153.

KEYWORDS Greenhouse effect, water resources, global circulation models, scenarios.

Scenarios of CO₂-induced climatic change, based on models produced by the Goddard Institute for Space Studies (GISS) and the Geophysical Fluid Dynamics Lab (GFDL), were used to estimate future changes in water supply in the Great Lakes Basin. The major components of annual Net Basin Supply, surface runoff and lake evaporation, were estimated using the Thornwaite water balance model and the mass transfer approach, respectively. Two scenarios were derived from each climatic change model, one based on present normal winds, the other assuming reduced wind speeds. A third scenario was derived from GFDL, using wind speeds generated by the GFDL model. Results varied from a decrease in Net Basin Supply of 28.9% for GISS-normal winds, to a decrease of 11.7% for GFDL-reduced wind speeds. All five scenarios projected decreases. These differences in projection will have to be considered when performing climate impact studies, since economic activities affected by lake levels would probably experience different impacts under these scenarios.

- 53 Cohen, Stewart J. 1986. Climatic Change, Population Growth, and their Effects on Great Lakes Water Supplies. Professional Geographer 3: 317-323.

KEYWORDS Water resources, response, greenhouse effect, global circulation models.

Two scenarios of CO₂-induced climatic change and projections of population and consumptive use of water to the year 2035 are utilized in a climate impact assessment of future water resources in the Great Lakes basin. When expressed as a streamflow/population index, results indicate a sharp decline of this index. Future index values are projected to be similar to those presently recorded for the Colorado River Basin.

- 54 Dracup, J.A. 1977. Impact on the Colorado River Basin and Southwest Water Supply. In Climate, Climatic Change and Water Supply, 121-132. Washington, D.C.: National Academy Press.

KEYWORDS Water resources, drought, energy, historical analysis, perception.

The Colorado River Basin has more water exported from it than any other U.S. river basin, and dominates the water resources of the Southwest. Dracup describes the legal framework governing allocation of its waters among its many users. Since several of the legislative acts which established this framework were passed, the estimates of the river's mean

annual flow upon which they were based have proven too high, since the available period of flow records was exceptionally wet. This fact and increasing demands for Colorado River water make the possibility of climatic change ominous. Possible future demands, several possibilities for augmenting the river's flow, and potential impacts of a future drought in the basin are briefly discussed.

- 56 Glantz, Michael H. 1982. Consequences and Responsibilities in Drought Forecasting: The Case of Yakima, 1977. Water Resources Research 18: 3-13.

KEYWORDS Drought, climate forecasts, water resources, agriculture.

This study is concerned with the impact of an actual forecast of total water supply available (TWSA) made by the Bureau of Reclamation for irrigators in the Yakima Valley (Washington). Estimates of TWSA (legally calculated by combining natural flow estimates, water storage, and other sources, i.e., return flow) were issued in February 1977, suggesting that less than half of the long-term average water supply would be available for the coming irrigation season. The Bureau allocated the estimated TWSA as follows: those with nonproratable (senior) water rights were to get 98% of their normal water allocation, while those with prompted irrigation districts, as well as individual farmers and federal, state, and local government agencies, to take a variety of measures they might not otherwise have taken. This study raises questions about societal responses to seasonal water supply estimates and about the benefits to society of good forecasts as well as the costs of erroneous ones. It also raises the issue of who, if anyone, should bear the responsibility for the societal implications of such forecasts.

- 57 Glantz, Michael H. and Jesse H. Ausubel. 1984. The Ogallala Aquifer and Carbon Dioxide: Comparison and Convergence. Environmental Conservation 11: 123-131.

KEYWORDS Greenhouse effect, water resources, decision making, response, scenarios, environmental impacts.

Two environmental problems which have major implications for water resources availability in the western Great Plains: the mining of water from the Ogallala aquifer and potential global "greenhouse" warming, are examined. Both problems are slowly developing and could have serious long-term impacts. The authors suggest that the two issues are broadly analogous and that assessments of the implications of aquifer depletion could provide insight into how society might respond to future global warming and its impacts in the Great Plains. Speaking more generally, they also urge scientists to apply analogy and comparison to the study of environmental problems which share one or more common aspects.

- 58 Gleick, Peter H. 1986. Methods for Evaluating the Regional Hydrologic Impacts of Global Climatic Changes. Journal of Hydrology 88: 97-116.

KEYWORDS Hydrologic modeling, water resources, greenhouse effect.

This paper reviews approaches for evaluating the regional hydrologic impacts of global climatic changes and presents a series of criteria for choosing among the different methods. One approach--the use of modified water-balance models--appears to offer significant advantages over other methods in accuracy, flexibility, and ease of use. Water-balance models are especially useful for identifying the regional hydrologic consequences of changes in temperature, precipitation, and other climatic variables. The ability of water-balance models to incorporate month-to-month or seasonal variations in climate, snowfall and snowmelt algorithms, groundwater fluctuations, soil moisture characteristics, and natural climatic variability makes them especially attractive for water-resource studies of climatic changes. Furthermore, such methods can be combined with state-of-the-art information from general circulation models of the climate and with plausible hypothetical climate-change scenarios to generate information on the water-resource implications of future climatic changes.

- 59 Howe, Charles W. and Allan H. Murphy. 1981. The Utilization and Impacts of Climate Information on the Development and Operations of the Colorado River System. In Managing Climatic Resources and Risks, 36-44. Washington, D.C.: National Academy Press.

KEYWORDS Water resources, climate information, decision making, policy analysis.

Important decisions about the development of the Colorado River were made between 1922-1956. This was a period when climate information was poor. This paper reviews the reasons for and consequences of these decisions, the existing procedures for making operating decisions and using climate information, and means for improving the use of climate information.

- 60 Julian, Paul R., Robert W. Kates, and W.R. Derrick Sewell. 1969. Estimating Probabilities of Research Success in the Atmospheric Sciences: Results of a Pilot Investigation. Water Resources Research 5: 215-227.

KEYWORDS Water resources, climate modification, technology assessment.

In this paper we have two main objectives. The first of these is to outline a research and payoff (R & P) model that suggests a procedure for evaluating competing or concurrent research projects. The atmospheric sciences provide a good example for an initial application of the model. Weather modification, particularly artificial stimulation of precipitation, has been touted as an answer to many water resource problems. Alternatives to this technology have received little attention. We suggest that the R & P model could profitably be applied in this instance. The second objective of the paper is incorporated in a pilot study of the first step in such an application: namely, the determination

of the estimated probabilities of success of various technologies in the atmospheric sciences. For this step, response to a questionnaire sent to professional atmospheric scientists were examined to determine whether (1) scientists are willing to provide probability estimates of success of various technologies and whether these estimates are consistent with other estimates of success; (2) personal involvement in a field influences such estimates; (3) the probability estimates are consistent with the respondents' assignment of shares of a research budget; and (4) the estimates are generally in agreement with the reports of 'blue-ribbon' panels of experts.

- 61 Klemes, V. 1985. Sensitivity of Water Resource Systems to Climate Variations. Geneva: World Meteorological Organization. WCP-98.

KEYWORDS Water resources, hydrological modeling, theoretical analysis, systems analysis.

This report reviews past work on the World Climate Applications Programme project to study water-resource systems' sensitivity to climate variations. Klemes suggests methods for better testing of existing and future hydrological models and discusses what types of performance criteria should be used in evaluating such models. The report also includes as annexes a previously published paper (Nemec and Schaake, 1982) and four related working papers by Klemes.

- 62 Lamb, H.H. 1971. Climate-Engineering Schemes to Meet a Climatic Emergency. Earth-Science Reviews 7: 87-95.

KEYWORDS Water resources, response.

An alarming situation exists in the arid regions of central Asia and elsewhere, where increase of population and industry has resulted in overuse of the natural water supply. Ambitious measures proposed in the Soviet Union for solving this problem by diverting water from the rivers which flow into the Arctic Ocean are outlined from published information and are seen to raise novel questions, arising from possible unintended and undesirable side effects on the distribution of climates over many parts of the Northern Hemisphere. The importance of informed scientific study and discussion of the meteorological problem, using a variety of techniques and taking account of the history of natural climatic fluctuations, as well as the margins of error likely in any attempted predictions, is stressed.

- 63 Matalas, N.C. and M.B. Fiering. 1977. Water-Resource Systems Planning. In Climate, Climatic Change and Water Supply, 99-111. Washington, D.C.: National Academy Press.

KEYWORDS Economic modeling, water resources, theoretical analysis, decision making, cost-benefit analysis, hydrologic modeling.

The business of planning and designing water resource systems is subject to uncertainties imposed by the stochastic nature of climate and

streamflow. In this paper, concepts of robustness, regret, and resilience are introduced as indicators of a system's ability to perform adequately in the event of climatic change. The authors also discuss some of the engineering, economic, and political considerations which contribute to the design selection process. Paretian analysis is presented as a potentially useful method for resolving conflicts of interest among groups with differing values in regard to project goals, and different risk aversion characteristics. Matalas and Fiering emphasize that nontechnological factors, including political, institutional, military, social and other issues, can be pivotal in determining the course of the design process.

- 64 Meier, W.L., Jr. 1977. Identification of Economic and Societal Impacts of Water Shortages. In Climate, Climatic Change and Water Supply, 85-96. Washington, D.C.: National Academy Press.

KEYWORDS Water resources, economic impacts, social impact analysis, drought, response, social adjustment.

Meier's discussion of water shortages and their impacts deals primarily with metropolitan water utilities and how they experience and respond to shortages. No mention is made of agriculture. It is also assumed that water availability would decrease gradually as climate changes; the impact of climatic change on drought frequency and severity is not explicitly discussed. The author lists possible causes of water shortages and the kinds of actions that may be taken, distinguishing between short and long-term response options. Brief summaries of the impacts of past shortages in Dallas, TX; York, PA; Trenton, N.J. and the Delaware River Basin are presented as case studies. Seven questions for future research are suggested in conclusion.

- 65 National Academy of Sciences. 1977. Climate, Climatic Change and Water Supply. Washington, D.C.: National Academy Press.

KEYWORDS Water resources, drought, climate analysis, economic modeling, theoretical analysis, response, policy analysis, climate information.

This landmark collection opens with the statement that the earth's climate is in fact changing, and focuses on evaluating the fields of hydrology, water resources, climate and climatic change to identify interactions among them and suggest areas in which further research could be profitable. The introductory "overview and recommendations" summarize the overall conclusions of the panel of contributing authors. Remaining chapters are individually authored papers in three sections: climatology, socio-economic considerations, and water-resource design and practice. The final two papers include case studies of possible future water shortage impacts in the northeastern U.S. and the Colorado River Basin.

- 66 Nemec, J. and J. Schaake. 1982. Sensitivity of Water Resource Systems to Climate Variation. Hydrological Sciences Journal 27, 327-343.

KEYWORDS Water resources, hydrologic modeling.

The problem of the response of water resource systems to climate variations is stated. The importance of the sensitivity of the systems to such variations is demonstrated with respect to the stationarity of the mean and the extremes. A definition of moderate climate variation is adopted. Results of deterministic modelling of the influence of such a variation on streamflow are reported, in extreme conditions of arid and humid basins. The results are used in modelling the influence of climate variations on reservoir storage systems. The model indicates a considerable amplification of the effect of climate change on runoff and storage and emphasizes the importance of studies of sensitivity of water resource systems to climate variation.

- 67 Novaky, Bela, Csaba Pacher, Karoly Szesztay and David Miller. 1985. Water Resources. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 187-214. New York: John Wiley and Sons.

KEYWORDS Water resources.

Broad survey of climate impacts on water resources, with emphasis on management implication of climate change, and methods for assessing impacts.

- 68 Revelle, R.R. and P.E. Waggoner. 1983. Effects of a Carbon Dioxide-Induced Climatic Change on Water Supplies in the Western United States. In Changing Climate: Report of the Carbon Dioxide Assessment Committee, pp. 419-432. Washington, D.C.: National Academy Press.

KEYWORDS Water resources, greenhouse effect, hydrologic modeling, theoretical analysis.

Empirically-derived relationships among mean annual precipitation, temperature, and runoff are used to predict the impacts of a CO₂-induced climate change on water supplies in seven western U.S. water regions. The assumed change is a 2 degree C increase in mean annual temperature and a 10% decrease in precipitation. Impacts on the Colorado River drainage are treated in greater detail than those that other regions might experience, due to its importance for the entire Southwest. The authors point out that the 30 year or longer planning and construction horizon for major water projects normally proceeds under an assumption of climatic stationarity which is being called into question by a growing body of scientific evidence, and that the possibility of carbon dioxide-induced climatic change should be somehow allowed for in the planning process.

- 69 Rhodes, Steven L., Daniel Ely, and John A. Dracup. 1984. Climate and the Colorado River: The Limits of Management. Bulletin of the American Meteorological Society 65: 682-691.

KEYWORDS Water resources.

The flooding in the Lower Basin of the Colorado River during the spring and summer of 1983 led to disagreements as to whether the U.S. Bureau of

Reclamation adequately managed the heavy spring runoff from the Upper Basin. This analysis stresses that the reasons for the flooding go beyond the climatic events of the year and the Bureau's response to them. It is the result of the convergence of three factors: (1) the 17-year period of filling Lake Powell behind Glen Canyon Dam is now over and the system of water storage reservoirs on the river is now considered to be full; (2) during the filling period, physical encroachment into the Lower Basin flood plain accelerated; and (3) the Colorado River Basin experiences significant climatic variability.

- 70 Schaake, J.C., Jr. and Z. Kaczmarek. 1979. Climate Variability and the Design and Operation of Water Resource Systems. In Proceedings of World Climate Conference, World Meteorological Organization, no. 537. pp. 290-312. Geneva, Switzerland.

KEYWORDS Climate system, hydrologic modeling, policy analysis, systems analysis.

Examines the importance of climate variability in considering the design and operation of water resource systems. Stresses reliability factors in system operations, the use of climate information in water resource management, impacts on society, streamflow variability, the relationships between storage, demand for water, and the risk of failing to meet water demands from a given reservoir. Also reviews the importance of water resources variability for regions with different hydrologic and economic conditions and the use of statistical, analytical and numerical approaches to improve climatic transfer functions for relating climatic variables and water resource variables.

- 71 Schwartz, H.E. 1977. Climatic Change and Water Supply: How Sensitive is the Northeast? In Climate, Climatic Change and Water Supply, 111-120. Washington, D.D.: National Academy Press.

KEYWORDS Water resources, theoretical analysis, hydrologic modeling, societal vulnerability, scenarios, drought.

As defined for this paper, the U.S. Northeast comprises 5% of the nation's total land area, contains about 25% of its population, and produces about 30% of its wealth. The author evaluates the region's water supply systems and their sensitivity to climatic change in three ways: by reviewing response to past climate anomalies in each of the three major metro areas; by speculating on the effects of various climatic change parameters on selected water system attributes, and by conducting safe yield sensitivity analysis by varying parameters in synthetic streamflow time series. His "speculative impact matrix of climatic change" includes nine system attributes and five climatic change parameters: decrease in mean streamflow, higher variance, higher skewness, increased streamflow persistence, and the rate of change in the above variables. Schwartz concludes that climatic change is to uncertain an issue to directly influence public policy at this stage, and encourages a policy of maximum planning flexibility and the use of scenarios.

- 72 Timmerman, Peter and A.P. Grima. 1985. Climate Impact Assessment in the Great Lakes Basin: Overview and Research Recommendations. Environmental Monograph #7. Institute for Environmental Studies, University of Toronto.

KEYWORDS Greenhouse effect, response, environmental impacts, policy analysis, water resources.

This small volume includes an overview paper and set of research recommendations from a Canadian Climate Program workshop on the potential physical and socioeconomic impacts of a CO₂-induced climate warming on the Great Lakes Basin. The workshop was held February 8-9, 1985 at Seneca College, Ontario.

- 73 Trelease, F.J. 1977. Climatic Change and Water Law. In Climate, Climatic Change and Water Supply, 70-84. Washington, D.C.: National Academy Press.

KEYWORDS Water resources, drought, environmental impacts, theoretical analysis, perception, social adjustment.

In considering the potential ability of water law systems and institutions to effectively respond to climatic change, Trelease assumes first that water shortages will be the chief problem, rather than surpluses, and secondly that flexibility in legal systems allows adjustment to change to proceed most easily and efficiently. He examines the relative merits of the eastern doctrine of riparian rights, western "prior appropriation" water law; and several kinds of groundwater law systems. Other topics include water organizations; governmental, public, and environmental rights; and the nature and direction of desirable legal changes directed at preparing for and adapting to possible future climatic change.

ENVIRONMENTAL IMPACTS

- 74 Barth, Michael C. and James G. Titus, eds. 1984. Greenhouse Effect and Sea Level Rise: A Challenge for This Generation. New York: Van Nostrand.

KEYWORDS Sea level rise, greenhouse effect, response, environmental impacts.

This anthology consists of 10 chapters dealing with topics such as the implications of sea level rise for hazardous waste sites in coastal floodplains, estimates of future sea level rise, and an economic analysis of the effects of a rising ocean level. Other subjects explored include the coastal geomorphic responses to sea level rise in Galveston Bay, Texas, and Charleston, South Carolina; contingency planning for increased sea levels both before and after a coastal disaster; and the control of erosion, inundation, and salinity intrusion caused by higher sea levels. There are overview chapters on the "greenhouse effect" and the causes and effects of sea level rise, together with a set of independent reviews of the contributed papers. The chapter on postdisaster planning suggests that long-term beach nourishment projects need to consider whether sufficient sand will be available in the future, and that policies prohibiting bayside filling should be modified to permit landward migration of developed barrier islands in step with oceanside erosion and the migration of undeveloped barriers.

- 75 Caviades, Cesar N. 1975. El Nino 1972: Its Climatic, Ecological, Human, and Economic Implications. Geographical Review 65: 493-509.

KEYWORDS El Nino, climate analysis, ecological impacts, economic impacts, fisheries.

This paper presents a description and analysis of the 1972 El Nino. The climatic and oceanic dynamics of El Nino are discussed along with ecological and economic impacts. Impacts on the Peruvian fishing industry are particularly emphasized.

- 76 Caviades, Cesar N. 1981. The Impact of El Nino on the Development of the Chilean Fisheries. In Resource Management and Environmental Uncertainty: Lessons from Coastal Upwelling Fisheries, eds. M.H. Glantz and J.D. Thompson, 351-368. New York: John Wiley and Sons.

KEYWORDS El Nino, fisheries, response.

Since their inception in the late 1950s the industrial fisheries of northern Chile have developed in a highly speculative fashion. Without regulations, the catching and conservation of the fish were left to the discretion of entrepreneurs, so that the catches depended more on the demands of the international market than on the size of the fish

population. Under these circumstances, any ecological disruption led to serious reductions in a fishing stock that had been exploited almost to the limits of its capacity. Viewed in this perspective, the oceanic and ecological anomalies of El Nino 1972-1973, although less dramatic than in Peruvian waters, have led to deep and long-lasting consequences for the marine resources and the coastal communities of northern Chile.

- 77 Caviades, Cesar N. 1984. Geography and the Lessons from El Nino. Professional Geographer 36: 428-436.

KEYWORDS El Nino.

Recognized for years as a major environmental disruption, El Nino generated intense public interest in 1982-83. During its last occurrence, this phenomenon, which develops in the tropical Pacific and usually affects rimlands of the Pacific basin, exceeded its boundaries and its effects were transmitted to continental North America, Europe, Africa and East Asia. Notwithstanding its vast areal extent, the interest of geographers in El Nino events, past and recent, has been comparatively less than that demonstrated by natural scientists and ecologists: little has been accomplished to place these climatic-ecological crises within global perspective. Lessons from El Nino include the acknowledgement of new concepts of climatic transitivity, ocean dynamics and energy exchanges that must find a place within the conceptual wealth of geography if this science intends to keep up with the rapid progress of other geosciences.

- 78 Changnon, Stanley A., Jr., Floyd A. Huff, Paul T. Schickedanz, and John L. Vogel. 1973. Summary of Metromex, Volume 1: Weather Anomalies and Impacts. Illinois State Water Survey Bulletin 62: 198-257. Urbana.

KEYWORDS Climate analysis, environmental impacts.

This is the first of two volumes presenting the major findings from the 1971-1975 METROMEX field operations at St. Louis. It focuses on final interpretations and conclusions obtained primarily through climatological-statistical analyses of spatial and temporal distributions of surface precipitation and severe storms. It addresses also the impacts related to the urban-produced precipitation anomalies. Volume 2 concerns the causes of the anomalies. Key climatic effects are increased cloudiness (+10%), increased total summer rainfall (+30%), and increased severe storm activity (+100%). These increases occur over the city and 10 to 25 miles beyond (east) the urban-industrial areas. The urban-induced anomalies occur most often with squall lines and cold fronts; they maximize in the afternoon and again at night (2100-2400); they appear to be as active in dry periods as in wet periods. Impacts include more runoff, but also more local flooding, soil erosion, silting, and water pollution. The effect of altered weather leads to a 3 to 4% average increase in local crop yields. The urban-induced anomalies are generally disbeneficial in the floodplain area, and have mixed impacts in the rural uplands.

- 79 Cushing, D.H. 1979. Climatic Variation and Marine Fisheries. In Proceedings of the World Climate Conference, World Meteorological Organization, no. 537, 608-626.

KEYWORDS Climate analysis, climate forecasts, fisheries.

Studies the links between events in fisheries in recent decades and climatic factors that might have spurred or modified such events. Examines the effective climate link during the life history of fishes; the recent warm period (1940s); longer term periods; and, shorter term periods. Suggests that: 1) general changes in biological production in the sea might be related to climatic factors; 2) attempt should be made to forecast fishery population recruitments by relating climatic factors to the spring outburst in temperate waters; and, 3) because fish populations "appear to rectify" very low amplitudes of climatic periods, their variability might be of use to climatologists.

- 80 Emanuel, William R., Herman H. Shugart, and Mary P. Stevenson. 1985. Climatic Change and the Broad-Scale Distribution of Terrestrial Ecosystem Complexes. Climatic Change 7: 29-43.

KEYWORDS Ecological impacts, forestry, greenhouse effect.

The broad-scale distribution of terrestrial ecosystem complexes is determined in large part by climate and can be altered by climatic change due to natural causes or due to human activities such as those leading to increasing atmospheric CO₂ concentration. Classifications that recognize the dependence of natural vegetation on climate provide one means of constructing maps to display the impact of climatic change on the geography of major vegetation zones. A world map of the Holdridge Life-Zone Classification, developed from approximately 8,000 meteorological records, is compared with a Holdridge Map with average temperature increments simulated by a model of climate under elevated atmospheric CO₂ concentration. The largest changes are indicated at high latitudes, where the simulated temperature increase is largest and the temperature intervals defining life zones are smallest.

- 81 Etkins, Robert and Edward S. Epstein. 1982. The Rise of Global Mean Sea Level as an Indication of Climate Change. Science 215: 287-289.

KEYWORDS Sea level rise, greenhouse effect.

Rising mean sea level, it is proposed, is a significant indicator of global climate change. The principal factors that could have contributed to the observed increases of global mean sea level in recent decades are thermal expansion of the oceans and the discharge of polar ice sheets. Calculations indicate that thermal expansion cannot be the sole factor responsible for the observed rise in sea level over the last 40 years; significant discharges of polar ice must also be occurring. Global warming, due in some degree presumably to increasing atmospheric carbon dioxide, has been opposed by the extraction of heat necessary to melt the discharge ice. During the past 40 years more than 50,000 cubic kilometers

of ice has been discharged and has melted, reducing the surface warming that might otherwise have occurred by as much as a factor of 2. The transfer of mass from the polar regions to a thin spherical shell covering all the oceans should have increased the earth's moment of inertia and correspondingly reduced the speed of rotation by about 1.5 parts in 1,000,000,000. This accounts for about three quarters of the observed fractional reduction in the earth's angular velocity since 1940. Monitoring of global mean sea level, ocean surface temperatures, and the earth's speed of rotation should be completed by monitoring of the polar ice sheets, as is now possible by satellite altimetry. All parts of the puzzle need to be examined in order that a consistent picture emerge.

- 82 Glantz, Michael H. 1980. El Nino: Lessons for Coastal Fisheries in Africa? Oceanus 23: 9-17.

KEYWORDS El Nino, fisheries, developing countries, climate forecasts, ecological impacts.

Glantz draws upon the impacts of El Nino on the Peruvian anchoveta fishing industry to suggest caution in the development of coastal fishery resources in upwelling zones off the shores of Mauritania and Somalia. He disputes the popular notion that El Nino forecasting with two to six month lead time could have prevented the negative impacts that occurred in 1972-73. Uncertainty as to the exact impacts on biological productivity of a given El Nino event, along with the problem of how such information should be applied, argue against this contention. In closing, Glantz urges that Somalia and Mauritania avoid overcapitalizing their growing fisheries industries in light of uncertainties about the reliability of harvest in the upwelling zones.

- 83 Hoffman, John S., Dale Keyes, and James G. Titus. 1982. Projecting Future Sea Level Rise: Methodology, Estimates to the Year 2100, and Research Needs. U.S. Environmental Protection Agency, Office of Policy and Resource Management, EPA 230-09-007. Washington, D.C.: GPO. 121 pp.

KEYWORDS Greenhouse effect, sea level rise.

Concentrations of atmospheric CO₂ and other greenhouses gases will continue to increase in coming decades. Two National Academy of Sciences panels have concluded that higher levels of these gases will almost certainly produce a large global warming. That warming, by thermally expanding the oceans and by causing the transfer of ice and snow resting on land to the oceans, should raise sea level substantially faster than the rise that has taken place during the past century. Although current knowledge is inadequate to make precise prediction of future sea level rise, it is sufficient to predict the likely range. Many factors were considered in generating the estimates of sea level rise contained in this report: change, and oceanic and glacial response. High and low assumptions for these principal determinants of sea level rise were assumptions allowed the estimation of high and low paths of future sea level rise: Based on this work, the following findings can be stated: (1) Global sea level will almost certainly rise in coming decades. (2)

Estimates of future sea level rise can be used to reduce its adverse impacts. (3) The range of future sea level rise estimates could be narrowed by accelerating research.

- 86 Kauppi, Pekka. 1985. Sensitivity of Boreal Forests to Possible Climatic Warming. Climatic Change 7: 45-54.

KEYWORDS Forestry, ecological impacts, greenhouse effect.

General circulation models indicate substantial CO₂ warming in high latitudes. In these regions, which include the boreal coniferous forests, the activity of ecosystems is largely controlled by temperature. The effective temperature sum (degree-days) is used in this study for describing the regional variability in the productivity of boreal ecosystems. Although the concept is simple, it takes into account two basic factors: the length of the growing season and the day-to-day level of activity of the ecosystem. This study examines which areas in the boreal coniferous forests would be most sensitive to a possible climatic warming. The data used in the study are for Finland.

- 87 Kawasaki, Tsuyoshi. 1985. Fisheries. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 131-153. New York: John Wiley and Sons.

KEYWORDS Fisheries, El Nino.

Detailed survey of theories and empirical indications for effects of climate fluctuations on oceanic fisheries. Discusses fishery production models and various scales of variations in fish stocks. Good survey of little known impacts.

- 88 Namias, J. 1980. Severe Drought and Recent History. Journal of Interdisciplinary History 10: 697-712.

KEYWORDS Climate analysis, drought, extreme events.

Proposes the "teleconnected" or mutually associated nature of atmospheric circulation patterns and how such patterns and other variables can result in drought. Discusses physical factors of drought in temperate and tropical regions; the potential for positive feedback in the synergistic nature of random repetitive drought intervals; statistical and physical aspects of drought on time scales of a month to several years.

- 89 Pittock, A.B. and H.A. Nix. 1986. The Effect of Changing Climate on Australian Biomass Production: A Preliminary Study. Climatic Change 8: 243-255.

KEYWORDS Greenhouse effect, ecological impacts.

Increasing concentrations of carbon dioxide and other infrared absorbing gases are widely proposed as mechanism for a global surface warming over the next several decades. Various methods have been used to anticipate the regional climatic changes which might result. In this paper a climate scenario, roughly corresponding to the climate which might be expected to occur by about the middle of the twenty-first century, has been used as the input into the 'Miami Model' of net primary productivity due to Lieth. Results show that about half of Australia might experience productivity increases in excess of 20%. A small area in the extreme southwest of Australia shows a small decrease in productivity.

- 90 Shugart, H.H., et al. 1986. CO₂, Climatic Change and Forest Ecosystems. In B. Bolin et al., eds., The Greenhouse Effect, Climatic Change and Ecosystems, 475-521. New York: John Wiley and Sons.

KEYWORDS Forestry, greenhouse effect, ecological impacts.

Forest response to the greenhouse effect has received little attention until the mid-1980s when simple life-zone modelling began to indicate substantial shifts in forest extent due to hypothesized climate change. The authors provide a comprehensive discussion of the special problem of forest response, including different time scales, response mechanisms, simulation models, and empirical evidence. They conclude that despite great uncertainty over future climate change and its impacts, the rough indications currently available point to potentially quite substantial forest changes associated with the greenhouse effect.

- 91 Thompson, Kenneth. 1980. Forests and Climate Change in America: Some Early Views. Climatic Change 3: 47-64.

KEYWORDS Forestry, historical analysis.

Supposed connections between forests and climate are long established in Western tradition and were the subject of speculation in the New World even from the time of Christopher Columbus. The luxuriant forest growth and unusual climate of America early invited conjecture on the climatic effects of the forests and the consequences of their removal. Pioneer settlers in America thought that forest clearing was producing a warming trend and affecting the climate in other ways. By the nineteenth century there was wide, but not entirely unanimous, belief that deforestation had caused significant climate changes, especially higher temperatures and lower precipitation. It was also believed that tree planting might increase precipitation in the semi-arid West. Later in the nineteenth century, mainly as a result of increasing availability of climatic data, the possibility of a positive or negative macroscale climatic influence for forests was largely dismissed. Modern scientists now attribute an important microscale climatic influence to forests and are reconsidering the macroscale effects, especially as related to atmospheric carbon dioxide and albedo changes.

- 92 Todorov, A.V. 1985. Sahel: The Changing Rainfall Regime and the "Normals" Used for its Assessment. Journal of Climate and Applied Meteorology, 24: 97-

KEYWORDS Sahelian drought, climate analysis.

Rainfall amounts in the Sahel region of Africa began a decline around 1968 that has continued to the present. The drought of 1982-83 was more severe and devastating than the well-known drought of 1972-73. Most years between 1972 and 1983 experienced below to well-below normal rainfall. These 16 or so dry years make obsolete mean (or normal) rainfall data calculated for periods before the decline began. Despite this, the old normal values are still widely used for various national and international agricultural projects. Discrepancies between the old and new mean values for the amounts of rainfall, and differences in the duration of the rainy season, suggest that mean or normal rainfall data should be calculated for the last 30 and/or 16 years. The rapidly changing climate in the Sahel requires more frequent updating of the climatological normals.

- 93 U.S. Environmental Protection Agency. 1986. Our Fragile Atmosphere: The Greenhouse Effect and Ozone Depletion. EPA Journal 12 (December): 2-30.

KEYWORDS Greenhouse effect, ozone depletion, response, policy analysis, environmental impacts.

Thirteen short articles discuss the causes, effects, and public policy ramifications of two human-caused atmospheric conditions. Three articles describe the depletion of the ozone layer and its consequences, and an additional three pieces explore what is known about the greenhouse effect and its relationship to global warming and sea level rise. The remaining articles address causes, effects, and solutions to global environmental problems. Topics discussed in these papers include the status of American environmental policy, the United Nation's efforts to set up an international framework for controlling chlorofluorocarbon emissions, and the costs of environmental control.

- 94 Wallen, C.C. 1984. Present Century Climate Fluctuations in the Northern Hemisphere and Examples of their Impact. WCP-87. Geneva: World Meteorological Organization.

KEYWORDS Climate analysis, agriculture, fisheries, forestry, sea level rise, environmental impacts, research review.

Wallen summarizes evidence for temperature fluctuations in the Northern Hemisphere with emphasis on the widespread warming trend evident during the period 1880-1950. Changes in the general circulation that may be related to the noted fluctuations are discussed. The second half of the report reviews biogeophysical impacts of these fluctuations on a selected regional basis, with some discussion of associated impacts on agriculture, forestry, and fisheries.

- 95 Welcomme, R.L. 1979. The Effects of Climate Change on Inland Fisheries. In Proceedings of the World Climate Conference, World Meteorological Organization, no. 537, 628-632.

KEYWORDS Climate analysis, climate forecasts, fisheries.

Assumes the impacts of recent changes in climate on inland fish production and water resource availability. Notes that increasing demands on water resources for a variety of purposes recedes system flexibility and equilibrium in the face of even minor changes in any one of a number of climate parameters. Studies the effects of climate factors on fish using several case histories (Sahel, East Africa). Concludes that fluctuations in fish catches in inland waters are associated with climatic changes, and that such changes actually serve as a major fish population regulator. Climate impacts are increased if the fish population is under other forms of stress.

- 96 Williams, G. Dan V. 1985. Estimated Bioresource Sensitivity to Climatic Change in Alberta, Canada. Climatic Change 7: 55-69.

KEYWORDS Ecological impacts, greenhouse effect.

An index of dry-matter productivity is used to assess the sensitivity of bioresources in Alberta, western Canada, to changes in the thermal and precipitation regimes, particularly to climatic warming. Results suggest that warming would improve productivity in northern Alberta, but reduce it, because of the associated increased moisture stress, in the relatively warm, dry southeastern part of the province. Estimated productivity generally increased with precipitation regardless of location or temperature. Climate impact assessment in Canada is made especially challenging by the shortness of the period of instrumental record, the relatively high degree of sensitivity to climatic change, and the sparseness of the station network, particularly in the most sensitive areas.

ENERGY

- 97 Diaz, Henry F. and Ronald L. Hohle. 1984. The Relative Effects of U.S. Population Shifts (1930-80) on Potential Heating, Cooling and Water Demand. Journal of Climate and Applied Meteorology 23: 445-448.

KEYWORDS Migration, energy, water resources.

The effects on potential heating, cooling and water demand induced by the shift and growth of population from cooler and wetter regions of the country to warmer and drier areas were examined. Heating and cooling degree day totals for each of the 48 contiguous states were weighted by population to obtain national totals using U.S. Census figures starting with the 1930 Census. We also developed categorical measures of population in relation to mean annual precipitation and precipitation variability. The water year October to September was used instead of the calendar year to take into account seasonal factors. The shift in population from the Northeast and Midwest to the South and Southwest United States has resulted in relatively lower heating but greater cooling demand on a national basis in the 1980's as compared with the results obtained using the 1930 Census. The increase in population in the arid West has increased the region's sensitivity to precipitation, and hence streamflow fluctuations.

- 98 Flohn, H. 1977. Climate and Energy. Climatic Change 1: 5-20.

KEYWORDS Greenhouse effect, energy.

The energy contribution of anthropogenic climatic fluctuations has been estimated to a gain of 15-20 TW, in comparison with a gain or deficit of 100-300 TW from natural processes responsible for the observed climatic fluctuations of the last 200 years. A dominant role of an increase of CO₂ by a factor 2-5 in the next century, accompanied by side effects acting in the same direction, seems to be most likely. Under the assumption of constant natural factors anthropogenic warming and its effects on the Arctic sea-ice may successively lead to climatic states as in 1931-60, in the early Middle Age (900-1200) and in the climatic optimum period ca. 5000 BP. Finally it may result in a complete destruction of the Arctic sea-ice with a drastic shift of all climatic belts towards north, extending even to the interior Tropics.

- 99 Jager, J. 1983. Climate and Energy Systems: A Review of Their Interactions. New York: John Wiley and Sons.

KEYWORDS Energy, fossil fuels, electrical power, hydropower, greenhouse effect.

Discusses both energy impacts on climate (e.g., waste heat and carbon dioxide) and the effect of climate on energy supply and demand. The latter is a particularly valuable review of energy impact assessment approaches, ranging in scale from individual buildings to hydropower regions. Includes a speculative chapter on the potential influences of solar energy systems on climate.

- 101 Krenz, Jerrold H. 1978. Minimizing the Environmental Impact by More Effective Energy Utilization. Climatic Change 1: 307-318.

KEYWORDS Energy.

Significant climatic variations could result if the global rate of energy consumption continues to increase. However, most of the currently accepted projections of the demand for energy in the United States are based on simplistic extrapolations of the trends of the last few decades. Owing to increased prices and scarcities of energy resources, these projections are not likely to materialize. Investments to utilize energy more effectively are now economically viable. For many energy requirements, it is now more economical to invest in using energy more effectively than to invest in the energy-producing facilities that might otherwise be needed.

- 102 Laurmann, J.A. 1979. Market Penetration Characteristics for Energy Production and Atmospheric Carbon Dioxide Growth. Science 205, 896-898.

KEYWORDS Energy, greenhouse effect, policy analysis.

Estimates are given for the maximum rate at which fossil fuel consumption can be reduced by the introduction of non-carbon-based energy sources, according to the market penetration time concept. These estimates indicate an immediate need to implement a revised energy policy if major climatic changes induced by increased amounts of carbon dioxide are to be avoided in the next century. However, application of market penetration ideas to energy consumption is new and may not be valid for the prediction of future trends.

- 103 Laurmann, J.A. 1979. Climate Change from Fossil Fuel Generated CO₂ and Energy Policy. Environment International 2: 461-473.

KEYWORDS Energy, fossil fuels, greenhouse effect, policy analysis.

Projections of the magnitude of global climatic change from combustion generated CO₂ are both uncertain and controversial, due in large measure to ignorance of the physical mechanisms involved. Analysis indicates that the uncertainties can be considerably narrowed by considering only the most immediate time frame of possible climatic impact, thereby leading to the possibility of rationally assessing the scope of the threat and the need for remedial action.

- 104 Laurmann, J.A. 1983. Strategic Issues and the CO2 Environmental Problem. In W. Bach et al., eds., Carbon Dioxide: Current Views and Developments in Energy/Climate Research, pp. 415-460. Dordrecht, Holland: D. Reidel Publishing.

KEYWORDS Greenhouse effect, cost-benefit analysis, decision making, economic modeling, energy, fossil fuels, policy analysis, response.

Very high levels of uncertainty regarding the magnitude, distribution and timing of future CO2 induced climatic change and its potential impacts lead to widespread disagreements over the best strategic policies for dealing with the issue. The authors note six major lines which "CO2 strategy" might proceed: cessation of research, further research, increasing public awareness, discouraging of fossil fuel burning, eliminating the climatic effect of CO2 in various ways, and preparing for the impacts of future climatic change. They discuss several potentially fruitful methods for quantitatively assessing the merits of each strategic alternative. The appropriate method for discounting the future is a major topic. Feasible methods of reducing consumption of fossil fuels are also suggested.

- 105 Peramunetilleke, T.B. 1982. Climate Defeats Energy Planners in Sri Lanka. Energy 7: 253.

KEYWORDS Energy, hydropower.

Changes in climatic conditions and vagaries of rainfall have seriously affected Sri Lanka's hydro-electric power supplies. The country's planners, who thought that the 1980 installed capacity of 421 MMW would be sufficient to meet present needs, have been compelled to resort to power cuts. Attempts to seed rain clouds with Thai expertise have also failed. The bulk of the country's power supply comes from hydro-plants while thermal plants are used as a back-up source, the yield from this source is 20 MMW.

- 106 Revelle, Roger R. and Donald C. Shapero. 1978. Energy and Climate. Environmental Conservation 5: 81-91.

KEYWORDS Greenhouse effect, environmental impacts, ecological impacts, climate system, energy, food, fossil fuels, mitigation, agriculture, fisheries.

This paper gives the conclusion of Energy and Climate, a report by a panel of the Geophysics Study Committee of the U.S. National Academy of Sciences on the potential consequences of global greenhouse warming. The broad outlines of a world-wide, comprehensive research program on the issue are suggested. The authors review some of the possible environmental and ecological impacts of future climatic change, e.g.: rising mean sea level, destruction of polar ice caps, poleward shifts of fisheries and agroclimatic zones, and impacts on semi-arid and arid regions. The feasibility of various methods for preventing or reducing climatic changes and for mitigating the impacts of climate change is evaluated.

- 107 Weiss, Edith Brown. 1982. The Value of Seasonal Climate Forecasts in Managing Energy Resources. Journal of Applied Meteorology 21, 510-517.

KEYWORDS Energy, decision making, climate forecasts.

Research and interviews with officials of the United States energy industry and a systems analysis of decision making in a natural gas utility lead to the conclusion that seasonal climate forecasts would only have limited value in fine tuning the management of energy supply, even if the forecasts were more reliable and detailed than at present. On the other hand, reliable forecasts could be useful to state and local governments both as a signal to adopt long-term measures to increase the efficiency of energy use and to initiate short-term measures to reduce energy demand in anticipation of a weather-induced energy crisis. To be useful for these purposes, state governments would need better data on energy demand patterns and available energy supplies, staff competent to interpret climate forecasts, and greater incentive to conserve. The use of seasonal climate forecasts is not likely to be constrained by fear of legal action by those claiming to be injured by a possible incorrect forecast.

- 108 Williams, Jill. 1979. Climatic Impact of Alternative Energy Sources. Energy 4: 933-939.

KEYWORDS Energy.

Detailed evaluations have suggested that the order of magnitude of energy demand 50 yr from the present will be 25-40 TW compared with about 8 TW at the present day. Three energy supply sources could be developed on a large enough scale to satisfy a demand of this magnitude: solar and nuclear energy fossil fuels. The potential climate impact of the large-scale deployment of solar energy conversion systems has not been evaluated in detail. Solar thermal electric conversion systems could impact climate through large-scale changes in the energy balance at the earth's surface, in the surface roughness and in the surface wetness. Photovoltaic conversions could impact climate by acting as a local heat source. Ocean thermal electric conversion systems would have their main impact through changes in ocean surface temperature, but could also interfere with major ocean currents and have an impact through release of CO₂ into the atmosphere or albedo changes, for example. The cultivation of plants for biomass conversion systems could influence climate through causing large-scale changes in the surface characteristics. The biomass conversion could also impact climate through releases of gases and particulate matter into the atmosphere. Through the use of climate models and observational studies, these impacts should be studied in more detail. In the meantime, the policies should be kept flexible at the present time until some of the uncertainties about the climate system have been resolved.

COMMERCIAL, INDUSTRIAL, AND MULTIPLE
ECONOMIC IMPACTS

- 109 Center for Environmental Assessment Service. 1980. Impact Assessment: U.S. Social and Economic Effects of the Great 1980 Heat Wave and Drought. NOAA, Center for Environmental Assessment Service. Washington, D.C. 25 pp.

KEYWORDS Economic impacts, extreme events, drought, climate analysis, agriculture, energy, transportation, water resources.

This brief report summarizes direct economic impacts of the June-August 1980 heat wave and drought that affected most of the contiguous U.S. The climatic events characterizing the period are described and depicted on maps. Heat related deaths totaled over 1200 through September 7. Severe impacts to energy consumption, crops, livestock, concrete and asphalt roads, and water resources also occurred. Total losses for the nation and by state are estimated.

- 110 Changnon, Stanley A., Jr. 1985. Climate Fluctuations and Impacts: The Illinois Case. Bulletin of the American Meteorological Society 66: 142.

KEYWORDS Climate analysis, agriculture, water resources, transportation.

Climate fluctuations and their impacts exist on all scales, from the local to the global, but often both are most easily measured and understood on the state scale. Illinois, located in a humid continental climate and with a north-south extent of 640 km, experienced a diversity of climate fluctuations in the period from 1901 to 1980. Illinois records for a variety of climate conditions reveal recent fluctuations that have had major impacts on energy, agriculture, water resources, transportation, and government sectors. Analyses indicate recent changes to wetter and cooler conditions (1961-80 compared with 1901-60). In the last 20 years, there has been more rain and snow and fewer droughts; decreases in temperatures, especially in summer; and increases in storminess. These trends are more marked in the extreme seasons of summer and winter than in the transition seasons. The recent conditions have been generally beneficial to agricultural activities and water resources but detrimental to transportation, energy consumers, and local and state government.

- 111 Dunbar, M.J. 1976. Climate Change and Northern Development. Arctic 29: 183-193.

KEYWORDS Ecological impacts, climate analysis, fisheries, fossil fuels, greenhouse effect, historical analysis, natural resources.

Dunbar, an oceanographer, discusses the potential impact of climate change on marine resources and hazards in the sub-arctic. First, he reviews

evidence for climate change, and concurrent floral and faunal changes, which have occurred during the present interglacial period. Potential impacts to shipping, oil and gas extraction, coastal mining, and fisheries due to climate change are discussed. Skeptical of the significance of greenhouse warming in the future, Dunbar strongly urges continuing research on the role of ocean currents in the climate of subarctic coasts, and the establishment of a much denser network of hydrographic data collection stations in the region.

- 112 Glantz, Michael H. 1984. Floods, Fires, and Famine: Is El Nino to Blame? Oceanus 27: 14-19.

KEYWORDS El Nino, economic impacts, environmental impacts, response, climate forecasts.

A review of El Nino and resulting societal impacts with an emphasis on the 1982-83 El Nino. Glantz reviews the El Nino events of 1957-58, 1972-73, and 1982-83 in terms of their economic, societal, and environmental impacts. Both negative and positive global economic and environmental impacts for the 1982-83 El Nino are discussed. Also discussed are the difficulties involved in making El Nino forecasts.

- 113 Haltiner, G.J., W.E. Bleick, and F.D. Faulkner. 1967. A Proposed Method for Ship Routing Using Long Range Weather Forecasts. Monthly Weather Review 96: 319-322.

KEYWORDS Climate forecasts, transportation.

Two advances in the calculus of variations method for minimal time ship routing are described. The first is a scheme for constructing ocean wave field forecasts which may be expected to have considerable skill for perhaps a week. The second is an improved technique for varying time external ship tracks toward admissibility. Both ideas are illustrated by calculating the optimum track ship route of a VC2AP3 vessel on a transpacific voyage. Possible future developments are discussed.

- 114 Karl, Thomas R. and Robert G. Quayle. 1981. The 1980 Summer Heat Wave and Drought in Historical Perspective. Monthly Weather Review 109: 2055-2073.

KEYWORDS Drought, response, energy.

Economic losses during the hot, dry summer of 1980 were estimated at \$16 billion. Despite these substantial economic losses, analyses of historical (1895-1980) monthly temperature and precipitation data across the 48 contiguous United States indicate that conditions could easily have been worse. Much more hostile conditions have existed in the past, particularly during the 1930s and the 1950s. However, the summer of 1980 does stand out from the past two decades as an extreme anomaly across the southern and southeastern United States. Analyses of Palmer's (1965) drought severity index, Palmer's soil moisture abnormality index, and

values of precipitation minus potential evapotranspiration are used in the assessment of the drought. Monthly mean temperature and population-weighted cooling degree days as related to electrical energy consumption are used to assess the summer heat wave of 1980.

- 115 Kristjansson, Leo. 1969. The Ice Drifts Back to Iceland. New Scientist 41: 508-509.

KEYWORDS Societal vulnerability, economic impacts, climate analysis, fisheries, transportation, social impact analysis, agriculture.

This article reviews major areas of discussion at a 1969 conference of Icelandic historians, geoscientists, and applied scientists concerning the recent increase in winter sea ice on the north coast of the island. From 1920-1964 the ice limit had never approached within sight of Iceland's coast. Possible causes of the two recent heavy-ice years were suggested. Concern over an apparently cooling climate is great because of the potentially devastating impacts on fishing, agriculture, and transportation. Possible psychological implications of extended cold, overcast periods of weather are also mentioned.

- 117 Maunder, W.J. 1979. New Zealand's Real "Economic Climate"--Evaluation and Prospects. New Zealand Meteorological Service, Symposium on the Value of Meteorology in Economic Planning (Oct): 203-245.

KEYWORDS Economic impacts, decision making.

The phrase "economic climate" has in recent times become very fashionable amongst politicians, economists, company managers and the news media. But, what is New Zealand's true "economic climate"? Webster's dictionary gives as a third definition of climate : "the prevailing temper or environmental conditions characterizing a group of period." Using this broad definition, an "econoclimatic" analysis of New Zealand is discussed, primarily with the aim of giving decision-makers in both government and the private sector, an indication of what are the key econoclimatic indicators, and why they must be used if planning is to proceed on anything other than a haphazard basis. Examples of national econoclimatic indicators for key agricultural and energy sectors, on a daily, weekly, monthly, and seasonal basis are given.

- 118 McGuirk, James P. 1982. A Century of Precipitation Variability Along the Pacific Coast of North America and Its Impact. Climatic Change 4: 41-56.

KEYWORDS Climate analysis, societal vulnerability, social adjustment, hydropower.

Precipitation data at seven stations along the west coast of North America, dating back to 1851 at some stations, are synthesized by means of empirical orthogonal function analysis. Characteristics of runs of generally wet and generally dry conditions are quantified. A significant change in precipitation regime, lasting 41 years occurred in the middle of

this century and could return in the future. Drought occurrences, similar to midwestern United States episodes, appear in the data, but are not statistically verifiable. A single example of the interaction of precipitation variability and society is given. Man's actions amplify the impact of variability on hydroelectric power generation in two ways: Society adapts itself rapidly to transient beneficial conditions, creating a false sense of well-being; technology expands to consume maximum available resources, decreasing system resilience.

- 119 McKay, G.A., T.R. Allsopp, and J.B. Maxwell. 1981. Lessons From the Past. Canadian Climate Centre, Report No. 81-1, Downsview, Ontario.

KEYWORDS Climate analysis, construction industry, economic impacts, energy, historical analysis, meteorological services, mitigation, scenarios.

McKay et al. strongly endorse the full exploitation of knowledge of past climates from instrumental records and paleoclimate research as a guide to the possible future course of climate. They draw five lessons or "theorems" from climatic history: "climate is variable; climate influences the environment and human activities; climate operates as a system; climatic anomalies can recur; and man is responsible for most of his climatic problems." Sections discussing each of the above are followed by a section on how these lessons might be applied to problems of offshore oil and gas exploration and drilling. Climatic information needed to optimize various related activities are listed. The paper closes with an injunction to climatologists and meteorologists to identify the needs of users of climate/weather information and to tailor products to those needs. Continued extension of climate records through proxy data sources is also encouraged.

- 120 Muller, Robert A. 1977. A Synoptic Climatology for Environmental Baseline Analysis: New Orleans. Journal of Applied Meteorology 16: 20-33.

KEYWORDS Climate analysis, response, environmental impacts, economic impacts.

Standard climatological observations made between 1971 and 1974 at Moisant Airport, New Orleans, have been organized into a calendar of eight synoptic weather types identified from the daily surface weather maps of the United States. The hourly data have been reorganized into tables representing monthly frequencies of weather types, mean properties at 0600 and 1500 CST, and relationships to precipitation. The climatic calendar and associated climatic properties by weather types represent climatic baseline inventories useful for evaluating favorable conditions for activities dependent upon weather such as construction and recreation, local and regional climatic variation by weather type and season, climatic variability through time, and the responses of environmental and biological processes and activities at the earth-atmosphere interface.

- 121 Muller, Robert A. and James E. Willis. 1978. Climatic Variability in the Lower Mississippi River Valley. Geoscience and Man 19: 55-63.

KEYWORDS Climate analysis, economic impacts, environmental impacts.

The climate of the lower Mississippi River Valley is considered from the perspective of the variability of climatic elements that appear to have significant economic or environmental consequences. Temperatures have become colder, beginning about 1957, and there is a strong tendency for warmer and colder than average months to cluster together. Similarly, there is also a tendency for wetter and drier than average months to cluster together, and also for much more extended sequences of years to be wetter or drier.

- 122 NOAA. 1982. Climate Impact Assessment: U.S. Economic Impact of the Severe Winter of 1982. U.S. Dept. of Commerce, NOAA, Center for Environmental Assessment Services. 47 pp.

KEYWORDS Economic impacts, extreme events, energy, agriculture, transportation, manufacturing.

Severe winter weather in January and early February, 1982 caused serious economic impacts over much of the 48 contiguous United States. This short report consists of graphic depictions of the severity of the winter weather and its impacts. Damages and losses in various sectors are reported, including energy, agriculture, transportation, property, and production. The winter of 1982 is also compared to other periods of widespread severe weather impacts in the U.S. The appendices are short statements on weather/climate impacts on railroads and on the economy in general.

- 123 NOAA. 1982. Climate Impact Assessment: U.S. Economic and Social Impacts of the Record 1976-77 Winter Freeze and Drought. U.S. Dept. of Commerce, NOAA, Center for Environmental Assessment Services. 50 pp.

KEYWORDS Economic impacts, extreme events, manufacturing, food, transportation, energy, agriculture.

This report summarizes impacts of the record-breaking severe weather events of the 1976-77 winter. A severe drought in California and extended periods of record low temperatures in much of the rest of the country caused direct economic losses estimated at 26.9 billion 1977 dollars. The report consists mostly of graphs and maps showing direct impacts to particular economic sectors, including: production, foodstuffs, transportation, retail sales, and energy. Various key indicators are used to illustrate losses in each sector.

- 124 Oklahoma Climatological Survey. 1980. The Economic Impact of Climate. Climate-Weather System: Economic Systems-Biosphere 4: 13 pp. Univ. of Oklahoma, Norman.

KEYWORDS Economic modeling, agriculture, energy, water resources, construction industry, crop yields, food.

This ongoing series by the Oklahoma Climatological Survey contains papers discussing ways in which climate interacts with the biosphere and economic systems. It includes 21 volumes through May, 1985. The first two are the proceedings of two workshops on the use of economic models; many subsequent volumes present newly developed models of climate's impact on particular resources and industries. Four volumes are full-color graphic brochures intended for non-scientists, and several others include agricultural policy analysis, econometric forecasting, and climate's impact on water resources, energy, food production, livestock production, the construction industry, urban systems, and yields of various crops.

- 125 Palutikof, Jean. 1983. The Impact of Weather and Climate on Industrial Production in Great Britain. Journal of Climatology 3: 65-79.

KEYWORDS Manufacturing, economic impacts, economic modeling.

The Index of Industrial Production (IIP) was used as a measure of output from industry in Great Britain. A time-series of this Index was derived extending from January 1958 to May 1979. This was compared both with seasonal extremes of climate and with more general departures from 'average' conditions, to determine the influence, if any, of weather and climate on industrial production. With respect to extreme seasons, a pronounced decline in industrial production took place during the drought summers of 1975-6, and the severe winters of 1962-3 and, to a lesser extent, 1978-9. Nonclimatic factors, such as industrial disputes, are unlikely to have contributed substantially to the shortfall. The categories of industry affected were quite different during the two types of extreme weather event: during the 1962-3 winter it was industries linked to work out-of-doors which suffered, in the 1975-6 drought it was high water requirement industries. To determine the impact of general weather conditions, three sets of step-wise multiple regression analyses were performed using a selection of climate and industrial dispute measures as the independent variables. The dependent variables were values of the January and July IIP with the trend expressing economic growth removed, and the size of the labour force in the construction industry in February. The analyses were performed both upon the full time-series with the extreme events removed. The results suggest that normal variations in the weather influence industrial production.

- 126 Pittock, A.B., et al. 1981. Human Impact on the Global Atmosphere: Implications for Australia. Search 8: 260.

KEYWORDS Greenhouse effect, ozone depletion, economic impacts, response.

A review is presented of the potential impact of human activities on the global atmosphere, with particular reference to climate and damaging ultraviolet radiation in the Australian region. Major problems may result from the burning of fossil fuels through the influence of carbon dioxide on climate, the impact on the ozone layer of chemicals released into the

atmosphere, and the production of atmospheric particulates. The possible direct and indirect impacts on the Australian economy, fuel policy, and society generally are considered. The authors discuss the many uncertainties in the present understanding of these problems and set out minimum research goals necessary to formulate adequate policy responses.

- 127 Russo, John A., Jr. 1966. The Economic Impact of Weather on the Construction Industry of the United States. Bulletin American Meteorological Society 47: 967-972.

KEYWORDS Construction industry, meteorological services, economic impacts.

Many construction activities can be negatively affected by adverse weather conditions. This paper reports the findings of a study by the National Weather Bureau on how weather affects the construction industry nationwide. The weather sensitivities of forty-three construction activities were evaluated. Working with construction companies directly, the Bureau investigated the types of weather information needed by the industry, the state of availability of such information, and the potential savings that might be realized with improved quality and dissemination of forecasts.

- 128 Schneider, R., J.D. McQuigg, L.L. Means and N.K. Klyukin. 1974. Applications of Meteorology to Economic and Social Development. World Meteorological Organization, Technical Note No. 132, Geneva, Switzerland. 117 pp.

KEYWORDS Climate modification, construction industry, agriculture, economic impacts, energy, extreme events, floods, meteorological services, manufacturing, mitigation, recreation, social impact analysis, transportation, water resources.

This three-part report was part of an effort by the World Meteorological Organization to promote the establishment of national Meteorological Services around the world. The first section deals with the use of weather and climate information to enhance economic activities and development. The role of weather in influencing activities in various economic sectors is evaluated in general terms. Techniques of weather modification, and their potential economic and social implications, are discussed in part two. Finally, part three offers examples of how meteorology is applied to enhance economic and social development in the U.S.S.R.

CLIMATE AND HISTORY

- 129 Anderson, J.L. 1981. History and Climate: Some Economic Models. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 337-355. Cambridge: Cambridge University Press.

KEYWORDS Economic modeling, social impact analysis, historical analysis.

The trends of certain economic indicators in Europe show broad correspondences with that of annual average temperature over the last millenium. However, examination of models of economic change in the period reveals no general causal relationship. A number of conceptual difficulties are involved in attempts to demonstrate a relationship between climatic and social change. The principal problem is that a given change in climate may have a variety of effects, and a particular historical event may be the product of either climatic amelioration or deterioration. Between a change in the circulation pattern and a change in historical behaviour lie numerous physical, economic, and social factors which influence any process of causation by their nature, and by their variation and interaction independent of climate.

- 130 Bridgman, Howard A. 1983. Could Climate Change Have Had an Influence on the Polynesian Migrations. Palaeogeography, Palaeoclimatology, Palaeoecology 41: 193-206.

KEYWORDS Historical analysis, migration.

A hypothesis is presented that a change in climate after 1250 AD from a period of optimal climate for long-distance voyaging (the Little Climatic Optimum, 750-1250 AD) to a period of less favourable and finally inhospitable climate for long-distance voyaging (the Little Ice Age, 1400-1850 AD) influenced the Polynesian migrations (300-144 AD). The Little Climatic Optimum, with its persistent trade winds, clear skies, limited storminess, and consistent Walker Circulation may have been an ideal setting for migration. The Little Ice Age with its increased storminess, and increased dust from volcanism may have helped prevent migration. Such changes in climate would influence the migration pattern through physical perception and decision making by the Polynesians, rather than having a direct impact.

- 131 Bryson, R.A. and C. Padock. 1980. On the Climates of History. Journal of Interdisciplinary History 10: 583-597.

KEYWORDS Climate analysis, economic impacts, historical analysis.

Focuses on the "climate factor" in history, particularly economic bases of cultures, nations and societies. Points out times of extremely rapid global climate change as background for analysis of historical trends and

developments. Examines documentary evidence and objective/quantitative climatic reconstructions to develop several climate and history case studies.

- 132 Bryson, Reid A. 1975. The Lessons of Climate History. Environmental Conservation 2: 163-170.

KEYWORDS Climate analysis, climate forecasts, historical analysis, response.

The study of climate history can give insight into future climates. Climate history evidence indicates that climate is not fixed, change is rapid, cultural change follows climate change, "normal" climates are misleading, and other observations. Sources of evidence tested, examined and compared include solar radiation, temperature regimes, arctic expansions and contractions through history. Need for societal ability to react successfully to climate change is stressed.

- 133 Bryson, Reid A. 1975. Some Cultural and Economic Consequences of Climate Change. University of Wisconsin-Madison, Center for Climate Research, Institute for Environmental Studies Report 60. Madison, Wisc.

KEYWORDS Climate analysis, historical analysis, social adjustment.

Analysis of the entire array of radiocarbon dated cultural materials shows preferred times of cultural change globally, over the past 10,000 years. Paleoclimatic studies suggest concomitant times of environmental change. The changes about 3600 BP, 2900 BP, 800 BP, and in the last century provide examples of the mechanism of impact of climatic variation on the affairs of man.

- 134 Bryson, Reid A.; H.H. Lamb; and David L. Donley. 1974. Drought and the Decline of Mycenae. University of Wisconsin-Madison, Institute for Environmental Studies Report 20. Madison, Wisc.

KEYWORDS Climate analysis, drought, historical analysis, response.

Historical climatologists test an historian's proposition that 1) a distinct pattern of extended drought could have been responsible for a culture's collapse and 2) that such a climate event actually occurred. Basic circulation modes over Europe, and monthly drought indices for the area, support possibility that event occurred. Not enough non-circumstantial, correlative field evidence or data to determine categorically that the event did occur in 1200 B.C. Climatologists accept probability that event occurred and stress need for more field data and appropriate questions for further research.

- 135 Claxton, Robert H. and Hecht, Alan D. 1978. Climatic and Human History in Europe and Latin America: An Opportunity for Comparative Study. Climate Change 1: 195-203.

KEYWORDS Historical analysis, societal vulnerability, economic impacts.

Motivated by environmental concerns, a few historians have reaffirmed that history is more than relationships among people; it involves human beings interacting with their environment. Some investigators of European history have given consideration to the effects of climate variations on human history. Preliminary examination of historic documents available for Latin America suggest that a time series of climate variations could also be reconstructed for at least the last 400 years. These preliminary data suggest that the general economic and social crises that prevailed in Europe during the Little Ice Age have parallels in Latin America. Such a concurrence of economic and social trends for these regions seems to reflect the influence of the general adverse climate prevailing during this time. Clearly, an opportunity exists for historians and climatologists to reconstruct the past climate of Latin America and compare these records with other parts of the world to establish the timing, length and magnitude of climate fluctuations over periods of human history.

- 136 DeVries, J. 1980. Measuring the Impact of Climate on History: The Search for Appropriate Methodologies. Journal of Interdisciplinary History 10: 599-630.

KEYWORDS Climate analysis, economic impacts, historical analysis, response, theoretical analysis.

Examines the measurement of climate's impact on economic life in preindustrial Europe in theory and practice. Addresses short-term, conjunctional and long-term climate influences in order to assess methods and results. Focuses on: nature of climate data; investigator biases; climate cycles as generators of business/economic cycles; climate change and climate variance in economic shifts and societal response. Concludes that societies adjust/adapt to long-term climate change thereby reducing harmful impacts.

- 137 Dhalin, Bruce H. 1983. Climate and Prehistory on the Yucatan Peninsula. Climatic Change 5: 245-263.

KEYWORDS Historical analysis, migration.

Long held notions that climate has been stable over the Yucatan peninsula and that today's climate is an accurate reflection of past climates here are being challenged today by a number of researchers. Both empirical and circumstantial evidence are offered for a prolonged and severe period of desiccation in the Maya lowlands and its effects on soils, vegetation, lake levels and ancient Maya cultural processes, ca. 50 BC to 500 AD. After centuries of steady and precocious growth and development, Late Preclassic Maya civilization in the drier northern two thirds of the

peninsula abruptly collapsed, probably due to repeated crop failures and decreasing availabilities of potable water due to severe drought conditions.

- 138 Fischer, D.H. 1980. Climate and History: Priorities for Research. Journal of Interdisciplinary History 10: 821-830.

KEYWORDS Climate analysis, historical analysis, theoretical analysis.

Examines methods and empirical findings of "new" field of historical climatology and suggests future research designed to promote synthesis in climatological history--an integration and conceptualization of the fragmented approaches to the field. Focuses on descriptive history of climate; connections between climate and culture; climatological determinism.

- 139 Flohn, H. 1981. Short-term Climatic Fluctuations and Their Economic Role. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 310-318, Cambridge: Cambridge University Press.

KEYWORDS Economic impacts, historical analysis.

This chapter is an introductory study of the socio-economic impact of short-term interannual fluctuations in climate. Minor long-term climatic fluctuations are generally associated with changes in the number of extreme events. Extreme anomalies on the seasonal time scale often occur in clusters (for example, the three severe winters, 1977-79, in the USA, or the Sahel drought years, 1969-73), and such clustering greatly magnifies the impact. Relationships between climatic anomalies and harvest production are summarized, with emphasis given to the importance of long-distance climatic spatial correlations (teleconnections) and their effects on modern agricultural economies.

- 140 Gunn, Joel and Richard E.W. Adams. 1981. Climate Change, Culture, and Civilization in North America. World Archaeology 13: 87-100.

KEYWORDS Historical analysis, societal vulnerability, water resources, agriculture.

Archaeologists Gunn and Adams attempt to demonstrate the coincidence of global temperature fluctuations with the rise and decline of prehistoric cities of Meso-American cultures. They explicitly recognize the importance of internal and external forces other than climate in causing cultural change. However, in cases where climate change and major cultural change appear to occur simultaneously according to their data, climate is assumed to have been the dominant cause. The coarseness of the climatic time series used, and the assumption of a simple relationship between mean global temperature and the positions of essentially latitudinal precipitation belts across southern North America and Central America, give this paper a definite flavor of climatic determinism.

- 141 Gunnarsson, Gisli. 1980. A Study of Causal Relations in Climate and History: With an Emphasis on the Icelandic Experience. Meddelande Fran Ekonomisk-Historiska Institutionen, Lunds Universitet.

KEYWORDS Climate analysis, historical analysis, response, social impact analysis, societal vulnerability.

Vulnerability of society to climate impacts depends on 1) the magnitude of the climate change and 2) the ability of social resources to meet the change. focus on climate history to see how previous societies responded to climate change and to measure societal vulnerability, past and present (Third World applications). Methodology, recitation of Icelandic experience, case studies.

- 142 Ingram, M.J., D.J. Underhill, and G. Farmer. 1981. The Use of Documentary Sources for the Study of Past Climates. In T.M.L. Wigley, M.J. Ingram, and G. Farmer, eds., Climate and History, pp. 180-213. Cambridge: Cambridge Univ. Press.

KEYWORDS Historical analysis.

Documentary evidence is an important source of detailed information on past climates, particularly for the period from about AD 1100 to the beginnings of the era of instrumental meteorology. This chapter is concerned with the study and climatic interpretation of this evidence. It comprises four sections. The first provides a survey of the available sources, offering some insights into the historical milieu which produced them and indicating in very general terms the kinds of information they contain. There are, however, many pitfalls involved in using historical records, and in the second section we discuss the most basic of them, the problems involved in reliability of sources as records of events. The third section deals with the more difficult problems of source interpretation and analysis, some attention being given to the use of content analysis techniques. Finally, we discuss the scientific analysis of early instrumental observations; the construction of meteorological series of more or less homogeneous information; and the analysis of fragmentary and non-homogeneous series using indexation procedures and spatial mapping techniques (the latter making possible the analysis of qualitative material in terms of atmospheric circulation patterns).

- 143 Ingram, M.J., G. Farmer, and T.M.L. Wigley. 1981. Past Climates and Their Impacts on Man: A Review. In T.M.L. Wigley, M.J. Ingram, and G. Farmer, eds., Climate and History, pp. 3-50. Cambridge: Cambridge University Press.

KEYWORDS Historical analysis, social adjustment, societal vulnerability, perception.

The study of the interactions between climate and history embraces a number of distinct aspects: climate reconstruction; the identification and measurement of the impact of climate on past societies; the adaptation of

societies to climatic stress; and human perceptions of climate and climate change. In this review we discuss all of these aspects.

- 144 Irwin-Williams, Cynthia and Vance C. Haynes. 1970. Climate Change and Early Population Dynamics in the Southwestern United States. Quaternary Research 1: 59-71.

KEYWORDS Historical analysis, social adjustment, migration.

It is becoming increasingly apparent that the pattern of early human occupation of the Southwestern United States was strongly influenced by the major paleoclimatic events of the period 9500 B.C. to A.D. 700. The size of human populations and the distribution of human settlement at both the regional-topographic and large-scale areal level, known from archaeological research are directly correlated to climatic change documented by the evidence of geology and palynology. The effect of climatic change is felt through the actions and reactions of the economic subsystem and its linkages with other subsystems. These reactions reflect not only the character of the climatic stimulus but also the existing state of the cultural system. Alternate reactions include direct systemic readaptation to the changed environment (through changed technologies, methods of population control, etc.); or small scale or large scale relocation of populations in different local niches, regions, or areas whose character most closely approximates the conditions to which the cultural system was initially adapted.

- 145 Jacobsen, Thorkid and Robert M. Adams. 1958. Salt and Silt in Ancient Mesopotamian Agriculture. Science 128: 1251-1258.

KEYWORDS Desertification, environmental impacts, historical analysis, natural resources, response.

Progressive changes in soil salinity and sedimentation contributed to the breakup of past civilizations. 6000 year history of previous agricultural practices, success and failures is useful in designing appropriate modern and future development. Shows how the natural environment (Iraq) was modified by long run effects of human activity (ecosystem destruction).

- 146 Kay, Paul and Douglas L. Johnson. 1981. Estimation of Tigris-Euphrates Streamflow From Regional Paleoenvironmental Proxy Data. Climate Change 3: 251-263.

KEYWORDS Climate analysis, historical analysis, water resources.

A six thousand year history of streamflow in Mesopotamia is derived from a synthesis of regional paleoenvironmental proxy data. The proxy data are interpreted with consideration to the climatic signals represented in the records and to the temporal resolution of the records. A consideration of modern synoptic climatology suggests the spatial patterns of streamflow-generating precipitation in relation to atmospheric circulation. These patterns provide a framework for the interpretation of

streamflow from the regional proxies. Given the nature of the data at hand, only a low frequency signal is reconstructed. Assessment of the role of small scale climatic fluctuations as a forcing function of population dynamics must await the availability of finer resolution environmental data.

- 147 Lamb, Hubert H. 1981. An Approach to the Study of the Development of Climate and Its Impact in Human Affairs. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 291-309. Cambridge: Cambridge University Press.

KEYWORDS Response, historical analysis.

This chapter first reviews the reasons why climatic change came to be conventionally ignored for many years, until quite recently, in planning for the future just as much as in the analysis of human history and archaeology. The prevailing attitude seems now to have changed, although much confusion remains: more knowledge of the behavior of climate is greatly needed. The next section introduces the great variety of types of data and analysis which can now be used to reconstruct a very long past record of climate and the possibilities of corroboration and assessment of margins of uncertainty. The possibilities of reconstruction, particularly in Europe, North America and the Far East, are quite detailed for recent centuries; but outline far beyond the dawn of history. Next, the results of study of the course of climatic development over about the last thousand years, chiefly in Europe, through the impacts on human history and the environment are mentioned. The transition between these extreme climatic periods produced many severe events. A final section mentions some probable outstanding cases of climatic change which affected human history in other times, including our own.

- 148 Lambert, L. Don. 1971. The Role of Climate in the Economic Development of Nations. Land Economics 47: 339-344.

KEYWORDS Historical analysis, health effects.

Lambert's thesis that climate, by controlling the natural ranges of human parasitic diseases, has caused the stagnation of tropical and semi-tropical civilizations and allowed temperate cultures to develop, is a prime example of modern climatic determinism. He claims that early Mesopotamian and other civilizations declined as their people became debilitated by the effects of malaria, hookworms, and other parasites. Sedentary lifestyles and high population densities, it is asserted, promoted the spread of such parasites. "Barbarians" such as those which plagued Rome and ancient China, remained healthier because they were nomadic, had lower population densities, and often came from colder (Northern European) or arid (Central Asian) climates. Lambert only slightly varies the traditional determinist's answer to the question of why modern industrial economies developed primarily in temperate regions.

- 149 MacKay, Angus. 1981. Climate and Popular Unrest in Late Medieval Castile. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 356-376, Cambridge: Cambridge University Press.

KEYWORDS Historical analysis.

This chapter describes and uses some of the documentary and printed sources both quantitative and descriptive in nature which provide data for the reconstruction of climatic fluctuations in the late medieval kingdom of Castile. Aspects of weather factors in the two regions of Old Castile and Murcia are then explained in order to highlight the differences between the dry-farming lands (secano) and the huertas of the Levantine coast. The chapter also considers some aspects of the possible connections between weather fluctuations and late medieval episodes of popular unrest which, although frequently directed against Jews and converses, also expressed grievances of a more general nature. It is argued that 'stimulus-response' interpretations are inadequate and that satisfactory explanations of popular unrest must take into account the kinds of evidence that are often discarded as being 'irrational.'

- 150 McGovern, Thomas H. 1981. The Economics of Extinction in Norse Greenland. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 404-433, Cambridge: Cambridge University Press.

KEYWORDS Historical analysis, migration.

The extinction of the Norse Settlements in Greenland (c. AD 985-1500) has often been cited as a demonstration of the impact of climatic deterioration on a human society. Archaeological data, especially that collected by the 1976-77 Inuit Norse Project, has allowed a working reconstruction of the Norse economy. Combined with existing paleoenvironmental data, this paleoeconomic model indicates that the Norse would have been particularly vulnerable to fluctuations in important marine and terrestrial resources during the fourteenth and fifteenth centuries. However, archaeological and ecological data also indicate that the Norse never made use of alternative resources and ignored efficient Inuit technology. The Norse extinction thus may be seen as a failure of human managers to select effective response to climatic stresses. A speculative organizational model is presented to account for this failure of decision-making.

- 151 Mooley, D.A. and G.B. Pant. 1981. Droughts in India Over the Last 200 Years, Their Socio-Economic Impacts and Remedial Measures for Them. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 465-478, Cambridge: Cambridge University Press.

KEYWORDS Historical analysis, drought, food, economic impacts, famine.

Data on the principal droughts which affected India during the period 1771-1977 have been collected from historical and other sources. The meteorological, political and economic background which has an important bearing on the suffering of the people during droughts has been reviewed.

Application of the Mann-Kendall rank statistic test and Swed and Eisenhart's runs test to the interval between years of successive drought shows that droughts occur randomly in time. These droughts had serious effects on the people and economy of India. Food prices rose beyond the purchasing power of the rural population and led to reduced food-intake, resulting in low vitality and a large number of deaths from epidemics. Shortage of food resulted in exploitation by anti-social elements and in riots. Each drought pushed the farmer deeper in debt. The heavy cost of famine relief prevented the government from attending to such important large-scale problems as the illiteracy of the masses and the need for agricultural improvement. Strengthening of agriculture and the rural economy together with special attention to the programmes for drought-prone areas, food reserves and planning of funds to meet drought situations would afford more protection against drought events.

- 152 Parry, M.L. 1976. The Significance of the Variability of Summer Warmth in Upland Britain. Weather 31: 212-217.

KEYWORDS Climate analysis, historical analysis, agriculture, risk analysis.

The author analyzes historical climate data for southeast maritime Scotland to reveal relationships between elevation and the probability of crop failure. Parry concludes that while accumulated summer temperature decreases roughly linearly with increasing elevation, the probability of occurrence of a critically low summer warmth value increases quasi-exponentially. Thus, very small increases of elevation greatly increase the probability of crop failure. Probability of two consecutive failures--which would exhaust seed reserves and encourage abandonment--increases even more quickly with elevation.

- 153 Pfister, Christan. 1978. Climate and Economy in Eighteenth-Century Switzerland. Journal of Interdisciplinary History 9: 223-243.

KEYWORDS Agriculture, climate analysis, historical analysis, response, societal vulnerability.

Meteorological data in the form of measurements and weather diaries is abundant, detailed, reliable and available. By focusing on agricultural and related sectors of Switzerland's economy, the article discusses trends in climate, crop yields, grain prices, demographic shifts and the growing immunity of western societies to limited meteorological and economic stress.

- 154 Pfister, Christan. 1980. The Little Ice Age: Thermal and Wetness Indices for Central Europe. Journal of Interdisciplinary History 10: 665-696.

KEYWORDS Climate analysis, historical analysis.

Cross-dating instrumental data, field data, documentary proxy data and descriptive data (both of the latter are written sources) yields a refined

picture of the thermal and wetness patterns for spring and summer seasons in Switzerland and Central Europe, 1525-1825. A data base, CLIMHIST, contains 27,000 records (70,000 daily observations) for Switzerland that have been converted and coded for data bank access and use. Trends in cold-cool-wet seasons, little ice ages, sub-periods and minor climate fluctuations are identified throughout the period.

- 155 Pfister, Christian. 1981. An Analysis of the Little Ice Age Climate in Switzerland and its Consequences for Agricultural Production. In T.M.L. Wigley, M.J. Ingram, and G. Farmer, eds., Climate and History, pp. 214-248. Cambridge: Cambridge Univ. Press.

KEYWORDS Agriculture, historical analysis

A careful search across a number of Swiss archives has yielded an unexpected wealth of documentary information on climate. Based on these data the main spells of heat and cold, wetness and drought can be traced back to early sixteenth century at the level of individual months. In the category of 'documentary data' a variety of indicators has been found which permits the estimation of seasonal or monthly temperature patterns. As well as direct weather observations the data include phenological and parafenological records, such as vine harvest dates, and vine yield data and parameteorological records such as snow phenomena and freezing lakes. Before using any such documentary data the sources need to be carefully verified. Dating must be corrected and standardized. Every type of documentary proxy record needs to be carefully calibrated with temperature measurements....In order to assess the impact of the Little Ice Age (1525-1825) climate upon agricultural production the fluctuations of the major staple foods (grain, wine, dairy products) are considered and compared with documentary climate evidence. It appears that the very poor crops were always the result of extreme meteorological conditions, sometimes far beyond the maxima of the present century.

- 156 Post, J.D. 1974. A Study in Meteorological and Trade Cycle History: The Economic Crisis Following the Napoleonic Wars. The Journal of Economic History 34: 315-349.

KEYWORDS Climate analysis, economic impacts, food, historical analysis, response.

Use of meteorology in its theoretical and historical dimensions to examine economic development. Review of research in climate and history, volcanic dust, temperature distributions and weather patterns as these factors impact economic activity, trade cycles, grain yields and prices and livestock markets. Focus on hemispheric relationships between climate and economic events, not just isolated weather processes.

- 157 Post, J.D. 1980. The Impact of Climate on Political, Social and Economic Change: A Comment. Journal of Interdisciplinary History 10: 719-723.

KEYWORDS Demographic analysis, historical analysis, theoretical analysis.

Suggests that neither "secular" climate change nor climate variability may be the key interval for studying the impact of climate on mortality rates or economic activity. Since preindustrial societies in Europe, and societies in general, seem capable of resiliency and/or short-term flexibility in the face of climate change, studies may need to focus on decadal or longer-term studies of climate impact on human societies. Such impact may not be observable even so.

- 158 Rabb, T.K. 1980. The Historian and the Climatologist. Journal of Interdisciplinary History 10: 831-837.

KEYWORDS Historical analysis, theoretical analysis.

Contrasts the methodological approaches of climatologists and historians and suggests how the two fields can relate to each other and serve each other's goals. Also stresses the differences and limitations on the two fields. Calls for a clear establishment of the context, method and goal of all such interdisciplinary efforts in order to more clearly understand the degree of influence, without resorting to generalization, that climate has in human history.

- 159 Rabb, T.K. 1983. Climate and Society in History: A Research Agenda. In R.S. Chen, E. Boulding, and S.H. Schneider, eds., Social Science Research and Climate Change, pp. 62-114. Dordrecht, Holland: D. Reidel Publishing.

KEYWORDS Historical analysis, research review, social adjustment, societal vulnerability.

Presented is a review of research priorities concerning the historical analysis of past societal adjustments to climatic change and their implications for adjusting to future climatic change. Emphasized are (1) the ways that climatic changes have effected societies, (2) the types of adaptation that have protected or strengthened those societies, and (3) the lessons that can be drawn by policy makers from the experiences of recent centuries. This article includes an extensive bibliography.

- 160 Shao-Wu, Wang and Zhao Zong-Ci. 1981. Droughts and Floods in China, 1470-1979. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 271-288. Cambridge: Cambridge University Press.

KEYWORDS Drought, floods, historical analysis.

Documentary historical data from yearbooks, diaries and gazettes have been used to construct drought and flood charts for China for the period AD 1470-1979. The characteristics of spatial and temporal variations of drought and flood have been examined by means of empirical orthogonal function analysis and power spectrum analysis. The eigenvectors based on historical data are similar to those obtained from an analysis of instrumental records for the period 1951-1974. This provides strong support for the reliability of the historical data and for the methods of interpretation of these data. Six distinct types of drought and flood

distribution can be distinguished, and a chronology of types from 1470 to 1979 is given. The relationship between the variations of drought and flood and fluctuations of the atmospheric circulation is also discussed.

- 161 Shaw, Brent D. 1981. Climate, Environment, and History: The Case of Roman North Africa. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 379-403. Cambridge: Cambridge University Press.

KEYWORDS Historical analysis, agriculture.

North Africa has long been renowned not only in academic literature, but also in popular imagination as the 'Granary of Rome'. This myth has been the principal basis upon which theories of a climatic change that afflicted the Maghrib since the period of Roman rule have been founded. These arguments, developed on the basis of false assumptions about the past, dubious literary evidence, and misunderstood archaeological data, took on an impetus of their own and continue to affect many investigations into climatic change in the ancient Mediterranean event to the present day. To prevent further abuse of the historical data, this chapter investigates the historiographical origins of the question of climatic change in this central region of the Roman Empire. It attempts to demonstrate that the question has been determined by factors quite extraneous to a proper scientific study (e.g. colonial biases, historical misconceptions about the Roman Empire, mistaken ideas about past agricultural productivity etc.) Most of the literary and archaeological arguments that have been deployed hitherto are largely mythical and should be discarded from any serious discussion in the future. The question must be formulated afresh, free from its historical roots.

- 162 Smith C.G. 1979. The Cold Winters of 1767-68, 1776 and 1814, as Observed at Oxford. Weather 34: 346-358.

KEYWORDS Climate analysis, extreme events, historical analysis.

Recent extremes of seasonal weather in Britain are not particularly abnormal or inexplicable given the 300 year meteorological record of the area. Compares January weather records from several sources for 1767, 1768, and 1814 with similar records for January 1947 and 1963.

- 163 Smith, David C., Harold W. Borns, W.R. Baron and Anne E. Bridges. 1981. Climatic Stress and Maine Agriculture, 1785-1885. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, Chapter 19, Cambridge: Cambridge University Press.

KEYWORDS Historical analysis, agriculture, migration.

The purpose of this study is to document the relationship between climatic stress and Maine agriculture during the period 178-1885. The research focuses on Maine's prime agricultural area of the early and middle nineteenth century: present-day Kennebec County. To locate evidence of possible climatic stress a climate record for the region was

reconstructed. Instrumental records for Maine locales during the nineteenth century were kept by amateur meteorologists and by various agents of federal and local government. The earliest records begin in the 1810s. For the period prior to 1820 there exist a number of qualitative weather diaries. These have been analysed by means of a content analysis technique to develop a quantitative record which is generally comparable to the later instrumental climate records. The possible importance of climate as a factor which helps to explain out-migration has not previously been considered by historians. The preliminary results of our analysis suggest that variations in climate and contemporary perceptions of them did, in fact, play a significant role.

- 164 Solomou, Solomos. 1986. The Impact of Climatic Variations on British Economic Growth, 1856-1913. Climatic Change 8: 53-87.

KEYWORDS Economic impacts, agriculture, historical analysis.

The impact of climatic change on the output and productivity long swings of the agricultural sector and the aggregate economy is considered for the period 1850-1913. Various economic explanations for the observed swings are examined and are found to be inadequate. The agro-climatic relationship is found to be of critical importance in accounting for the swings of the agricultural sector and some of the aggregate variations. This relationship is not found to remain constant over time. There is evidence of reduced climatic impact and the non-weather sensitive sectors filtered out much of the impact of climatic change on the aggregate economy during 1890-1913.

- 165 Sutherland, Donald. 1981. Weather and the Peasantry of Upper Brittany, 1780-1789. In T.M.L. Wigley, M.J. Ingram and G. Farmer, eds., Climate and History, pp. 434-449. Cambridge: Cambridge University Press.

KEYWORDS Historical analysis, agriculture, economic impacts, drought, societal vulnerability.

Historians of Old Regime France have long been aware of some of the relationships between meteorological change and peasant communities. The disastrous harvests and famines of the seventeenth century and the effects of the poor harvest of 1788 on the insurrections of the following year have all been thoroughly studied. From these a model of weather conditions and rural societies has developed. Thus a poor harvest is generally held to produce greater death rates, migration, indebtedness, unemployment, sales of peasant property and falling wage rates. Yet the model may only hold good for the effects of spectacular weather conditions. Thus in the region around the town of Vitre in Brittany in the 1780s peasants were able to withstand the droughts of 1782, 1785-86 and the poor harvest of 1788 surprisingly well. The major victims were infants and children who could be replaced easily, while the poor may have held their own because secondary sources of income were only partially dependent upon the grain harvest. Thus for all the mesmerizing poverty, and despite the greater suffering of the poor and the defenceless, many

peasant communities were not as vulnerable to the weather as we generally think.

- 166 Thompson, Kenneth. 1981. The Question of Climatic Stability in America Before 1900. Climatic Change 3: 227-241.

KEYWORDS Climate analysis, historical analysis.

Belief that regional climates had significantly changed in historic times, possibly as a result of human activities, is firmly established in the Western tradition. Europe itself was believed to have undergone such changes, especially a warming trend, since ancient times. It was also widely believed that the European colonization of North America would duplicate many of the changes that had occurred in Europe, including the climatic changes that were supposed to have taken place. In the New World, it was at first believed that climatic change was occurring, as a result of human settlement and land use changes, but these views gave way to the idea of climatic stability. The first extensive compilations of reliable North American precipitation and temperature data in the latter part of the nineteenth century seemed to support the notion of stable climates. Ideas relating to macroclimatic change and stability that were entertained in America before 1900, mainly between 1770 and 1870, are examined.

- 167 Utterstorm, Gustaf. 1955. Climatic Fluctuations and Population Problems in Early Modern History. Scandinavian Economic History Review 3: 3-47.

KEYWORDS Climate analysis, demographic analysis, developing countries, economic impacts, historical analysis, response, social adjustment.

Dispells historians notion that population is active agent, nature the passive agent in food production and supply issues. Links climate variability (particularly mild epochs), ice sheet retreat and sea levels to population growth trends, migration, social and economic development, health and agricultural success. Reviews historians and climatologists work on historical climatology and human history. Links past climate/society interactions to present ones. Much detail, sources discussion.

- 168 Vries, Jan De. 1985. Analysis of Historical Climate-Society Interaction. In R.W. Kates, J.H Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 273-291. New York: John Wiley and Sons.

KEYWORDS Historical analysis, economic impacts.

Excellent survey of methods for assessing impacts of climate change in historical times. Unique in the historical literature for emphasis on statistical analysis.

- 169 Weiss, Barry. 1982. The Decline of Late Bronze Age Civilization as a Possible Response to Climatic Change. Climatic Change 4: 173-198.

KEYWORDS Historical analysis, drought, migration, crop yields, response.

The disintegration of Eastern Mediterranean civilization at the end of the late Bronze Age has traditionally been attributed to the irruption of new peoples into this area. However, the nearly contemporaneous decline of highly organized and powerful states in Greece, Anatolia, Egypt, and Mesopotamia warrants consideration of possible environmental causes likely to operate over sizable areas, especially since archaeological research has not succeeded in establishing the presence of newcomers at the onset of the Bronze Age disturbances. It has been suggested that past climatic patterns recur in the present epoch but with a possibly different frequency. To establish that a spatial drought analogue to the above hypothesized migration can occur, temperature and precipitation records from 35 Greek, Turkish, Cypriot, and Syrian weather stations for the period 1951-1976 were examined. The Palmer drought index, an empirical method of measuring drought severity, was computed for each of these stations for the period of record. Since wheat yields tend to be highly correlated with winter precipitation for the area in question, the drought indices for the winter months were subjected to an empirical eigenvector analysis. The potential of eigenvector analysis in investigating problems of this type are discussed.

- 170 Wigley, T.M.L., N.J. Huckstep, A.E. Ogilvie, G. Farmer, R. Mortimer, and M.J. Ingram. 1985. Historical Climate Impact Assessments. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 529-563. New York: John Wiley and Sons.

KEYWORDS Historical analysis.

Excellent and detailed survey of research on historical climate impacts. Provides a framework for assessing the findings of historical studies. Includes a detailed table of 24 studies giving detailed information on time scales, methods, quality, etc. The table alone is worth it.

POLICY, DECISION MAKING, AND PERCEPTION

- 171 Changnon, Stanley A., Jr. 1983. Society's Involvement in Planned Weather Modification. Agricultural Water Management 7: 15-21.

KEYWORDS Climate modification, environmental impacts, response, policy analysis.

Study of the societal and environmental aspects of planned weather modification have helped point to the issues and concerns that weather modification practitioners, state and federal officials, and supporters of weather modification programs must consider if the utilization of the precipitation modification technologies is to proceed in a meaningful way within our society. The understanding of these issues and how to address them is of particular importance in implementing and operating a state program. Social, economic, and legal impacts call for state involvement in project development, project funding, regulation and monitoring, research, and in public relations. The degree of state involvement varies according to the length of a project and the degree of certainty of the capability to enhance precipitation.

- 172 Chen, Robert S. 1983. Interdisciplinary Research and Integration: The Case of CO₂ and Climate. In R.S. Chen, E. Boulding, and S.H. Schneider, eds., Social Science Research and Climate Change, pp. 229-248. Dordrecht, Holland: D. Reidel Publishing.

KEYWORDS Greenhouse effect, decision making, research review.

The possibility that increasing atmospheric carbon dioxide concentrations may lead to significant climate changes poses a problem of unusual breadth and complexity to society. Research on this problem, and on ways society can respond to it, needs to be carefully organized and managed in an interdisciplinary and flexible manner. New means of integrating research results and ensuring their usefulness for policy decisions must be explored. Research on the CO₂ problem should also be closely 'tied-in' with research on other social and environmental issues.

- 173 Fischhoff, Baruch and Lita Furby. 1983. Psychological Dimensions of Climate Change. In R.S. Chen, E. Boulding, S.H. Schneider, eds., Social Science Research and Climate Change, pp. 180-203. Dordrecht, Holland: D. Reidel Publishing.

KEYWORDS Perception, decision making, policy analysis, response, greenhouse effect, research review.

This paper outlines aspects of perception and decision making which are relevant to societal response to a greenhouse warming. This paper presents a research agenda based on understanding how facts about the

greenhouse problem are perceived by both experts and lay decision makers and how this influences the assessment and choice of adjustment strategies.

- 174 Fischhoff, Baruch. 1981. Hot Air: The Psychology of CO₂-Induced Climatic Change. In Cognition, Social Behavior, and the Environment, ed. J.H. Harvey, 163-184, Hillsdale, N.J.: Lawrence Erlbaum Associates.

KEYWORDS Perception, decision making, response, social adjustment, greenhouse effect.

A review of the psychological and perceptual factors which influence decision making and choice of adjustment strategies for problems of a CO₂-induced climatic change. The author reviews the extensive literature on risk perception and decision making under uncertainty identifying the difficulties that decision makers confront in perceiving and understanding low-probability events. Problems in assessing and comprehending the complexity and variety of information about the possible causes and effects of a CO₂-induced climatic change are also discussed.

- 175 Freebairn, J.W. 1983. Drought Assistance Policy. The Australian Journal of Agricultural Economics 27: 185-199.

KEYWORDS Drought, agriculture, response, policy analysis.

Droughts are an inevitable and recurrent hazard of the Australian agricultural scene. While most farmers and stockmen generally balance good harvest years against bad years, some farmers do not make adequate provision for the stock, income, and cash flow losses caused by drought. Assistance provided for the 1982-83 drought illustrates ways in which subsidies are provided. Under complementary federal and state legislation, the Natural Disaster Relief Arrangements (NDRA) support a broad framework of core measures of assistance and for sharing of the subsidy costs. The core measures include concessional loans to farmers unable to obtain funds from commercial sources, freight subsidies and subsidies for livestock slaughter. In practice, the package of subsidies available varies from one drought to another and often between states for any one drought. Fodder subsidy and interest rate subsidy schemes use in 1982-83 are discussed, alternative policy initiatives advanced by economists to assist private decisionmaking are examined, and an efficient and equitable alternative drought policy is proposed. Findings and suggestions from the study include: 1) in terms of dollars spent, the most important forms of drought aid provided were the subsidies for purchased fodder and debt interest; 2) concessional carry-on finance was available only to a sub-set of affected farmers and the subsidy was discriminatory in several ways; and 3) government can assist private decisionmaking by providing information about seasonal conditions and decision options.

- 176 Glantz, Michael H. 1979. A Political View of CO₂. Nature 280: 189-190.

KEYWORDS Decision making, policy analysis, greenhouse effect.

An excellent assessment of the response of political institutions and policy makers to the problems of a CO₂-induced climatic change. Glantz argues that there are two types of decision-making processes: crisis management and muddling through. Muddling through is the approach most often followed in dealing with environmental problems. However, as the problem worsens and a crisis is perceived, crisis management becomes the mode of decision making. Glantz argues that neither approach is appropriate for dealing low-level cumulative environmental problems such as those associated with climatic change. He argues that what is needed is a combination of "crisis awareness" and cautious decision making.

- 177 Glantz, Michael H. and Richard W. Katz. 1977. When is a Drought a Drought? Nature 267: 192-193.

KEYWORDS Sahelian drought, desertification, perception, climate analysis, drought, range land, livestock, ecological impacts.

Recurrent drought is a normal feature of arid and semiarid regions, including the West African Sahel. The authors assert that changing perceptions of what is "normal" rainfall in the Sahel have made climate the scapegoat for problems with at least equally important socioeconomic causes. They stress that no single number--such as mean precipitation--can adequately convey both the central tendency and high variability of arid or semiarid climates. Mean precipitation, in fact, is an especially poor indicator because it is positively skewed. Decision makers need to have a more sophisticated understanding of high climatic variability and its implications in order to effectively manage the resources of areas like the Sahel.

- 178 Glantz, Michael H., Jennifer Robinson, and Maria E. Krenz. 1985. Recent Assessments. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 565-598. New York: John Wiley and Sons.

KEYWORDS Policy analysis, technology assessment.

An interesting analysis of several recent climate impact studies: the MIT Sudan-Sahel project; the National Defense University study Climate Change to 2000; the IFIAS Drought and Man 1972 case study, the National Academy of Science ozone depletion analysis, and the Dept. of Transportation's SST impact study. Focuses on organization and institutional aspects of the studies to identify common weaknesses and strengths in such multi-disciplinary, multi-faceted projects.

- 179 Hare, F. Kenneth and W.R. Derrick Sewell. 1986. Awareness of Climate. In Geography, Resources, and Environment. Vol. II, Themes from the Work of Gilbert F. White, ed. R.W. Kates and I. Burton, 207-239, Chicago: University of Chicago Press.

KEYWORDS Response, perception, policy analysis, climate modification, research review.

This paper examines the growing awareness of the importance of climate among atmospheric scientists, climatologists, social scientists, and policy makers over the past 20 years. The authors attribute this increasing awareness to breakthroughs in computer modelling and a series of worldwide climate shocks in the 1970s. Particular emphasis is placed on the socioeconomic implications of climate, climatic change, and climate modification. The authors see the need for a new field of social science, research directed toward the study of climate and society interaction.

- 180 Hare, F. Kenneth. 1984. Changing Climate and Human Response: The Impact of Recent Events on Climatology. Geoforum 3: 383-394.

KEYWORDS Ozone depletion, greenhouse effect, economic impacts, food, response.

Over the last decade climate has become an increasingly significant factor in world affairs because of its effect on food supplies, energy consumption and environmental quality. At the same time the scientific community has had to re-appraise the nature and scope of climatology, increasing political relevance, leading to a growth in interdisciplinary activity involving both natural and social scientists. The 1980s promise to continue this broadening of scope as the two-way interaction of human societies and the atmospheric system are further explored and evaluated. This paper examines these trends, paying particular reference to the main climate-based environmental concerns currently being debated; the effect of halocarbons on the ozone shield, climate and food production, desertification, the CO₂ 'greenhouse' effect, acid rain and the significance of teleconnections.

- 181 Katz, Richard W., Allan H. Murphy, and Robert L. Winkler. 1982. Assessing the Value of Frost Forecasts to Orchardists: A Dynamic Decision-Making Approach. Journal of Applied Meteorology 21: 518-531.

KEYWORDS Decision making, agriculture, extreme events.

The methodology of decision analysis is used to investigate the economic value of frost (i.e., minimum temperature) forecasts to orchardists. First, the fruit-frost situation and previous studies of the value of minimum temperature forecasts in this context are described. Then, after a brief overview of decision analysis, a decision-making model of the fruit-frost problem is presented. The model involves identifying the relevant actions and events, specifying the effect of taking protective action, and describing the relationships among temperature, bud loss, and yield loss. A bivariate normal distribution is used to model the

relationship between forecast and observed temperatures. A computational technique called dynamic programming is used in conjunction with these models to determine the optimal actions and to estimate the value of meteorological information. Some results concerning the value of frost forecasts to orchardists in the Yakima Valley of central Washington are presented for the cases of red delicious apples, bartlett pears, and elberta peaches. Several possible extensions of this study of the value of frost forecasts to orchardists are briefly described. Finally, the application of the dynamic model formulated in this paper to other decision-making problems involving the use of meteorological information is mentioned.

- 182 Mann, Dean E. 1983. Research on Political Institutions and Their Response to the Problem of Increasing CO₂ in the Atmosphere. In R.S. Chen, E. Boulding, and S.H. Schneider, eds., Social Science Research and Climate Change, pp. 116-145. Dordrecht, Holland: D. Reidel Publishing.

KEYWORDS Policy analysis, decision making, response, social adjustment, research review, greenhouse effect.

Presented in this article is a set of priorities for formulating a research agenda in political science for addressing the problem of CO₂-induced climatic change. The emphasis is on political institutions and decision making and their influence on private individuals and organizations. Included is a good discussion of adjustment and implementation strategies and the decision making process.

- 183 Mather, John R., Richard T. Field, Laurence S. Kalkstein, Cort J. Willmott, and W.J. Maunder. 1981. Climatology: The Impact of the Seventies and the Challenge for the Eighties. Weather and Climate 1: 69-76.

KEYWORDS Social adjustment, climate information, decision making.

A succession of climatic vicissitudes during the 1970s have focussed attention on some of the major problems that will confront humanity during the 1980s and the 1990s, and how man--using information about the climatic resource--can make better decisions. Fundamental to these better decisions is the need to focus attention on the exchanges of heat, water, and momentum that occur at or near the earth's surface. Since the decisions to be made involve, among other things, food production, energy consumption, and environmental pollution, they will have wide-ranging political, social, and economic implications. This paper focuses on the important role of the "geographical climatologist" in meeting these challenges.

- 184 Maunder, W.J. 1970. The Value of the Weather. London: Methuen.

KEYWORDS Research review, meteorological services, economic impacts.

A bench-mark survey of the social and economic impacts of weather and climate. Quite eclectic and inclusive; valuable reference on impacts ranging across physiological, business, utilities, recreation, agriculture, etc. References through 1969. Best if used in conjunction with Maunder (1986).

- 185 Maunder, W.J. 1986. The Uncertainty Business: Risks and Opportunities in Weather and Climate. London: Methuen.

KEYWORDS Response, decision making, climate information, economic impacts.

This recent book is an extensive review of the economic, social, political, planning, and legal aspects of weather and climate. It is primarily concerned with the use of climate and weather information in decision making and with how decisions concerning the atmosphere are made. It examines climate as an "elite resource" which is often taken for granted and argues for the need to accept climate as an integral part of resource management.

- 186 McQuigg, J.D. and R.G. Thompson. 1966. Economic Value of Improved Methods of Translating Weather Information Into Operational Terms. Monthly Weather Review 94: 83-87.

KEYWORDS Climate information, decision making.

A number of investigators have advanced the thesis that weather information has (or accrues) economic value because it makes possible "better" management decisions in a weather-sensitive process. A simulation model approach is used to modify this thesis, and to illustrate the necessity for the decision-maker to have a sufficiently precise method for translating weather information into operational terms.

- 187 Meyer-Abich, Klaus M. 1980. Socioeconomic Impacts of CO₂-Induced Climatic Changes and the Comparative Chances of Alternative Political Responses: Prevention, Compensation, and Adaptation. Climatic Change 2: 373-385.

KEYWORDS Social adjustment, economic impacts, policy analysis, greenhouse effect.

Prevention of climatic change by changing human economic behaviour or compensation for climatically detrimental effects by technological fixes is not necessarily better than adaptation. In fact, there are good reasons to conclude that adaptation is the most rational political option, at the same time requiring least marginal action. The problems arising from CO₂ all appear at present to be marginal ones which arise, and should be taken care of, for other reasons as well. With respect to CO₂-induced changes we could not do better than do what should be done in any event for reasons of development policy.

- 188 Myer-Aich, K.M. 1980. Chalk on the White Wall? On the Transformation of Climatological Facts into Political Facts. In J. Ausubel and A.K. Biswas, eds., Climatic Constraints and Human Activities, 61-73. Oxford: Pergamon Press.

KEYWORDS Greenhouse effect, policy analysis.

A political analysis of the growing scientific consensus over the potentials for climate change due to the greenhouse effect. Myer-Aich discusses the three generally recognized, broad potential societal responses to climate change: prevention, compensation and adaptation. He concludes that adaptation is the least costly and disruptive. It appears that he means individual, unregulated adaptation as opposed to a coordinated, programmatic--presumably government sponsored--adaptive effort.

- 189 National Academy of Sciences. 1981. Managing Climatic Resources and Risks. Washington, D.C.: National Academy Press.

KEYWORDS Decision making, risk analysis, policy analysis, climate information.

This volume is from the Panel on the Effective Use of Climate Information in Decision Making of the Climate Board, National Research Council and is a review of the effectiveness of the use of climate data and services in public and private decision making processes. The volume includes overview chapters, a set of recommendations, and individually authored papers in the appendix.

- 190 Pittock, A. Barrie. 1980. Monitoring, Causality, and Uncertainty in a Stratospheric Context. PAGEOPH 1/2: 643-661.

KEYWORDS Climate system, decision making.

Our increasingly complex understanding of stratospheric chemistry and transport processes leaves us with various theoretical possibilities of appreciable and perhaps serious environmental impact due to human activities. These possibilities raise policy questions in which the economic and other costs of regulating human activities must be weighed against the possible consequences of no such regulation. The natural variability of the atmosphere, the physical and other limitations on our global sampling and monitoring abilities, and the difficulties in establishing causal connections leave us in a state of uncertainty as to the reality and magnitude of at least some of these theoretical environmental impacts. Policy-makers must make decisions in the face of these uncertainties.

- 191 Quinn, M.L. 1982. Federal Drought Planning in the Great Plains--A First Look. Climatic Change 4: 273-296.

KEYWORDS Drought, historical analysis, policy analysis.

Drought--the climatic nemesis of the Great Plains--has long been a topic of concern. With this situation in mind, one might wonder if the United States government ever engaged in efforts geared toward strengthening the region's resistance to this recurring phenomenon. That inquiry is explored here. In so doing, the paper presents an historical sampling of the federal role in drought planning--by the way of legislative and other means--for the period, late 1870's to 1940. Included in the sampling are the J.W. Powell report, dry-land farming, irrigation, shelterbelts, and crop insurance--to name but a few. When these drought planning measures are examined as a unit, it provided a basis for some interpretative observations--summarized in the conclusions. The postscript is a commentary on the concept of a national drought planning policy. Categorized as the precursor to an impact assessment study, this work can serve as a reference point for additional interdisciplinary research not only on the subject of drought planning but also on the manner in which segments of society interact with climate and (as in this case) its varying components. The climatically intense Great Plains, its diversity hidden beneath a cape of perceived sameness, offers an ideal research focus but is but one example. Thus, the way seems clear for geographers, historians, sociologists, political scientists, economists, and others to continue to become increasingly involved in, and make significant contributions to, such climate-related investigations.

- 192 Schelling, Thomas C. 1984. Anticipating Climate Change: Implications for Welfare and Policy. Environment 26: 6-9.

KEYWORDS Response, policy analysis, perception, greenhouse effect.

Good review of the policy implications of a CO₂-induced climatic change. Schelling argues that emphasis must be placed on dealing with the wider issue of climatic change and not just those problems associated with increasing CO₂. In addition, background factors such as changes in technology and population or natural changes in climate cannot be ignored in assessing long-term changes resulting from increasing CO₂. Also presented is a comprehensive framework for analyzing policy response based on (1) reducing CO₂ production, (2) removing CO₂ from effluents or atmosphere, (3) countervailing modifications in climate, and (4) adapting to increasing CO₂ and changing climate.

- 193 Stewart, Thomas R. and Michael H. Glantz. 1985. Expert Judgment and Climate Forecasting: A Methodological Critique of "Climate Change to the Year 2000". Climatic Change 7: 159-183.

KEYWORDS Perception.

The National Defense University's study of climate change to the year 2000 was based largely on the judgments of the members of two expert panels. Although the study has been widely distributed and apparently read by policy makers in the U.S. and abroad, the method of eliciting and analyzing expert judgment has not been critically reviewed. This paper uses the literature on judgment and subjective probability to evaluate the expert judgment methods used in the study.

- 194 Weiss, Edith Brown. 1983. International Legal and Institutional Implications of an Increase in Carbon Dioxide: A Proposed Research Strategy. In R.S. Chen, E. Boulding, and S.H. Schneider, eds., Social Science Research and Climate Change, pp. 148-175. Dordrecht, Holland: D. Reidel Publishing.

KEYWORDS Response, policy analysis, decision making, greenhouse effect.

The greenhouse problem is international in scope and thus requires an international solution. In this paper existing legal institutions and procedures that are relevant to addressing the greenhouse problem and global climate change on an international level are discussed. Presented is a research agenda designed to promote an understanding of the legal and institutional structures which must underlie any international effort at dealing with the problem of climatic change.

- 195 Whyte, Anne V.T. 1985. Perception. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 403-436. John Wiley and Sons.

KEYWORDS Perception, risk analysis, social impact analysis.

An important discussion of a little-researched but critical area in climate impacts: people's perception of climate and its change. Incorporates theories on perception of probability and uncertainty, risk analysis, different types of perceivers, the role of the media, and provides citation to the relatively thin literature on this topic.

- 196 Wilhite, Donald A., Norman J. Rosenberg, and Michael H. Glantz. 1984. Government Response to Drought in the United States: Lessons from the mid-1970s. University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, Center for Agricultural Meteorology and Climatology, CAMAC Progress Report 84/1-5. Lincoln, Nebraska.

KEYWORDS Drought, response, decision making, policy analysis, historical analysis.

This report is published in five parts. Part 1 is the "Executive Summary." Part 2 is entitled "The History of Drought Response in the Great Plains, 1850-1950." Part 3--"Federal Response to the Mid-1970s Drought." Part 4--"A Case Study of Federal and State Response in Nebraska, South Dakota and Texas." and Part 5--"Drought Response in the United States and Australia: A Comparative Analysis." The study contends that both the U.S. and state governments respond to drought conditions through crisis management operations. Furthermore, the reaction to crisis often results in the implementation of hastily prepared assessment and response procedures that many times lead to ineffective, poorly coordinated, and untimely results. Four requirements for more effective response were identified: 1) reliable and timely information products and dissemination plans; 2) improved impact assessment techniques, particularly in the agricultural sector; 3) a common designation procedure administered by a

single interagency committee; and 4) standby assistance programs that address the specific problems associated with drought.

- 197 Wilhite, Donald A., Norman J. Rosenberg, and Michael H. Glantz. 1986. Improving Federal Response to Drought. Journal of Climate and Applied Meteorology 25, 332-342.

KEYWORDS Drought, response, policy analysis.

Severe and widespread drought occurred over a large portion of the United States between 1974 and 1977. Impacts on agriculture and other industries, as well as local water supplies, were substantial. The federal government responded with forty assistance programs administered by sixteen federal agencies. Federal response to the mid-1970s drought was largely untimely, ineffective and poorly coordinated. Four recommendations are offered that, if implemented, would improve future drought assessment and response efforts: 1) reliable and timely informational products and dissemination plans; 2) improved impact assessment techniques, especially in the agricultural sector, for use by government to identify periods of enhanced risk and to trigger assistance measures; 3) administratively centralized drought declaration procedures that are well publicized and consistently applied; and 4) standby assistance measures that encourage appropriate levels of risk management by producers and that are equitable, consistent and predictable. The development of a national drought plan that incorporates these four items is recommended. Atmospheric scientists have an important role to play in the collection and interpretation of near-real time weather data for use by government decision makers.

THEORY, RESEARCH ASSESSMENTS, AND TECHNIQUES

- 198 Ausubel, J.H. 1983. Can We Assess the Impacts of Climatic Changes? Climatic Change 5: 7-14.

KEYWORDS Greenhouse effect, ecological impacts, economic impacts, scenarios.

Assessing the impact of a given human-induced climatic change, like a global warming brought about by carbon dioxide, involves balanced examination of the implications of the specific environmental change and the other implications of the assumptions which generate the CO₂ in the first place. There will be many, simultaneous impacts on ecosystems; these are illustrated by looking at effects on photosynthesis and on marine biota. For several reasons economics is quite limited in the evaluation it can provide of such effects. Nevertheless, useful 'scenarios' can be constructed by combining description of possible CO₂-induced impacts with the other implied change, for example, the increases in world mining, trading, and burning of coal. Several, often divergent pictures are likely to persist because of inherent uncertainties and cultural bias.

- 199 Ausubel, J.H. and A.K. Biswas, eds. 1980. Climatic Constraints and Human Activities. Oxford: Pergamon Press.

KEYWORDS Research review, theoretical analysis, greenhouse effect, drought, agriculture.

A collection of papers from the Task Force meeting on Climate and Society Research, February, 1980 at the International Institute for Applied Systems Analysis. Chapters include an essay on the economics of climate, crop-climate models, and drought. Of special interest are chapters on drought and self-provisioning societies--research conducted under the UN Environment Program that has not been published in accessible form elsewhere, and a case study of the U.S. Great Plains.

- 200 Biswas, A.K., ed. 1984. Climate and Development. Volume 13 of the National Resources and the Environment Series. Dublin: Tycooly International Publishing Limited.

KEYWORDS Agriculture, climate analysis, developing countries, policy analysis.

Focuses on the "dimensions of interrelatedness" between climate and development. Suggests development strategies that serve to enhance the use of climate as a resource by developing countries. Emphasizes the impact of climate on terrestrial biota, agricultural development, water resources planning and management and human health. Also focuses on the

study of climate risk and climate risk assessment through the use of input-output models.

- 201 Bolin, B., B.R. Doos, J. Jager, and R.A. Warrick, eds. 1986. The Greenhouse Effect, Climatic Change and Ecosystems. New York: John Wiley and Sons.

KEYWORDS Research review, greenhouse effect, theoretical analysis.

An excellent set of papers prepared for the 1985 Villach Conference on the greenhouse effect. Included are state-of-the-art reviews of CO₂ emission and residence scenarios, other greenhouse gases, and impacts on climate, sea level, terrestrial ecosystems, forests, and agriculture. Includes especially useful chapters on "How will climate change?", climate scenarios, and impacts on agricultural systems.

- 202 Bowden, Martyn J.; Robert W. Kates; Paul A. Kay; William E. Riebasame; Richard A. Warrick; Douglas L. Johnson, Harvey A. Gould; and Daniel Weiner. 1981. The Effect of Climate Fluctuations on Human Populations: Two Hypotheses. In Wigley, T.M.L., M.J. Ingram, and G. Farmer, eds, Climate in History, pp. 479-512. Cambridge: Cambridge University Press.

KEYWORDS Societal vulnerability, historical analysis, migration.

The relationship between climatic fluctuations, population dynamics and social vulnerability are examined in the Tigris-Euphrates Valley 6000 BP to the present; the Sahel AD 1910-74; and the US Great Plains AD 1880-1979. Two major hypotheses are tested. The lessening hypothesis states that societies are able to lessen the impact of minor climatic stress (events with a return period of the order of less than 100 years) upon the resident population and indirectly on the entire society. The catastrophe hypothesis states that the increasingly elaborated technology and social organization that insulated a livelihood system from recurrent minor climatic stress do little to reduce and may increase the system's vulnerability to major climatic stress (defined as events with a return period of the order of more than 100 years).

- 203 Brooks, Reuben. 1971. Human Response to Recurrent Drought in Northeastern Brazil. Professional Geographer 23: 40-44.

KEYWORDS Drought, response, societal vulnerability, developing countries.

Discusses the social consequences of drought in Northeastern Brazil with particular reference to the 1877 drought in which an estimated 2,000,000 died. The social impact of drought is discussed as a sequence of consequences: economic, physiological, sociological, and political.

- 204 Butzer, Karl W. 1980. Adaptation to Global Environmental Change. Professional Geographer 32: 269-278.

KEYWORDS Greenhouse effect, societal adjustment, response.

Atmospheric carbon dioxide is expected to double by A.D. 2050, raising global temperatures 2 to 3 degrees Celsius. A model for climatic deviations is presented, based upon paleoclimatic experience 5,000 to 8,000 years ago, when midlatitude temperatures were 1.5 to 2.5 degrees C higher. The economic prognosis includes a U.S. barely able to meet its own agricultural needs and a substantial overall reduction of world food supplies. The revolutionary implications for contemporary sociopolitical alignments suggest an urgent need for long-range planning and more, historically oriented research.

- 205 Butzer, Karl W. 1983. Human Response to Environmental Change in the Perspective of Future, Global Climate. Quaternary Research 19: 279-292.

KEYWORDS Response, theoretical analysis.

Human response to severe environmental stress is conceived and implemented by individuals, but must be approved by the group. These decisions are made with respect to perceived circumstances. Societies are enmeshed with adaptive systems that provide a matrix of opportunities and constraints for a wide range of potential behavioral variability. Such systems repeatedly readjust to short-term crises, e.g., droughts, but persistent and severe environmental stress may require substantial revision of adaptive strategies. The Sahel drought of 1968-1973 is an example of a brief but severe crisis, recurring along the Saharan margins perhaps once every 30 years. Closer inspection shows links between intensified intertribal warfare and ecological stress in the lower Omo Valley. The decline of the Egyptian New Kingdom during the 12th century B.C., in response to economic stagnation, sociopolitical instability, dynastic weakness, foreign pressures, and poor Nile floods over 50-70 years, represents a more complex and fundamental modification, with systemic simplification lasting 450 years. Such insights can be applied to future, global climatic change for the North American and Soviet breadbaskets, to threaten world food supplies at a time of maximum demographic pressures and declining resources. Public perception and remedial planning should receive the attention of Quaternary scientists, in order to preempt an involuntary, global systemic simplification.

- 206 Calef, Wesley. 1950. The Winter of 1948-49 in the Great Plains. Annals of the Association of American Geographers 40.

KEYWORDS Economic impacts, extreme events, historical analysis, response, social impact analysis.

Severe winter conditions (extreme events) may not be as isolated or anomalous as they appear in human memory, they may be a normal part of the broader, overall climate of a region. Focus on "kind" of individual storms making up a severe winter and their "effect" as a study in

"geographic climatology." Focus on individual storm impacts and the subsequent societal response. Use of local interviews, newspapers, official reports for five state region.

- 207 Changnon, Stanley A., Jr. 1982. Examples of Climate Information Provided by a State Climate Center. Journal of Applied Meteorology 21: 551-559.

KEYWORDS Climate information.

An understanding of applied climatology and its information-gathering research requires recognition of the total cause-and-effect spectrum including the issue detection, the research effort pursued, the type of product, the users, and their applications of findings. Twenty climatic information studies done at the Illinois Climate Center in 1977-1979 are reviewed to illustrate why they were done, often as a result of general inquiries or specific requests, and a few of their key results. The studies each required from weeks to months to complete. Most users of the results fell in two general classes, government or business-industry. The studies revealed applications in three areas: the design of facilities, the planning and/or operations of facilities and activities, and the climatic assessment of weather extremes.

- 208 Changnon, Stanley A., Jr., Howard J. Critchfield, Robert W. Durrenberger, Charles L. Hosler, and Thomas B. McKee. 1981. Examples of Applications of Climatic Data and Information Provided by State Climate Groups. Bulletin American Meteorological Society 61: 1567-1569.

KEYWORDS Climate information.

The value of climate data and the information derived from the data still seems to be an unknown to many. Five persons engaged in providing climate services in different U.S. climatic zones have assembled a few widely different examples of recent uses of climate data and information. These help demonstrate the diversity of applications, and the value of the data and of those who can interpret them.

- 209 Chen, Robert S., Elise Boulding, and Stephen H. Schneider. 1983. Social Science Research and Climatic Change. Dordrecht, Holland: D. Riedel Publishing.

KEYWORDS Response, social adjustment, research review, greenhouse effect.

This book is a valuable collection of review essays by social scientists on societal response to a CO₂-induced climatic change. Through this set of essays the book outlines an interdisciplinary, social science approach to the problem of climatic change. The goal of these review essays is to identify research priorities within the various social science disciplines--geography, history, political science, psychology, anthropology, and law. Each review essay is preceded by a short introduction by one of the editors. The final essay address the need for an interdisciplinary approach to the problem.

- 210 Clark, William C. 1982. Carbon Dioxide Review: 1982. New York: Oxford University Press.

KEYWORDS Greenhouse effect, research review.

A review of the carbon dioxide problem and its effects on climate, society, and the environment. This book presents a comprehensive interdisciplinary assessment by leading researchers in the fields of climate, energy, and agriculture.

- 211 Clark, William C. 1985. Scales of Climate Impacts. Climatic Change 7: 5-27.

KEYWORDS Theoretical analysis, systems analysis, ecological impacts, societal vulnerability.

Climates, ecosystems, and societies interact over a tremendous range of temporal and spatial scales. Scholarly work on climate impacts has tended to emphasize different questions, variables, and modes of explanation depending on the primary scale of interest. Much of the current debate on cause and effect, vulnerability, marginality, and the like stems from uncritical or unconscious efforts to transfer the experience, conclusions, and insights across scales. This paper sketches a perspective from which the relative temporal and spatial dimensions of climatic, ecological, and social processes can be more clearly perceived, and their potential interactions more critically evaluated. Quantitative estimates of a variety of characteristic scales are derived and compared, leading to specific recommendations for the design of climate impact studies.

- 212 Committee for the Global Atmospheric Research Program. 1975. Understanding Climatic Change: A Program for Action. National Academy of Sciences, Washington, D.C.

KEYWORDS Climate analysis, climate system.

When published this became a definitive statement on climatic change and the physical science needed to understand and predict it. Now dated, but useful for its attempt to define the terms climatic change and climatic variability.

- 213 Copans, Jean. 1983. The Sahelian Drought: Social Sciences and the Political Economy of Underdevelopment. In Interpretations of Calamity, ed. K. Hewitt, 83-97. Boston: Allen and Unwin.

KEYWORDS Drought, response, theoretical analysis.

Presented is a radical socialist perspective on the Sahel drought and related impacts. Aspects of external and internal social and natural exploitation, and the concept of neo-colonialism are discussed. Copans argues that the study of the use of the natural environment must be first

a study of the social exploitation of those who use it. The Sahel drought is used to support this argument.

- 214 Czelnai, R. 1980. Climate and Society: The Great Plain of the Danube Basin. In J. Ausubel and A.K. Biswas, eds., Climatic Constraints and Human Activity, 149-180. Oxford: Pergamon Press.

KEYWORDS Social impact analysis, theoretical analysis.

Mostly a theoretical piece linking characteristics of climate events (duration, magnitude, extent, and nature) to the absorptive capacity of social systems. Attempts to sort out factors such as sensitivity, resiliency, vulnerability and adjustment; but these ideas are not very well linked to the empirical study of the Danube Plain.

- 215 d'Arge, R.C. 1979. Climate and Economic Activity. In Proceedings of the World Climate Conference, World Meteorological Organization, no. 537, 652-681.

KEYWORDS Climate analysis, economic impacts.

Reviews and summarizes the evidence on the impact of climatic changes on various economic sectors of several countries. Further, it attempts to examine qualitatively some of the more obvious international repercussions of climate variation. Focuses on economic impacts and benefit-cost analyses concerning such areas as the effects of climate change, the use of stratospheric aircraft, fluorocarbon and nitrogen fertilizers pollution and CO₂.

- 216 d'Arge, R.C., William D. Schulze, and David S. Brookshire. 1982. Carbon Dioxide and Intergenerational Choice. American Economic Association Papers and Proceedings 72: 251-256.

KEYWORDS Cost-benefit analysis, economic modeling, greenhouse effect.

If traditional methods of cost-benefit analysis are applied to the issue of global warming, the usual process of discounting the future leads to a result that even catastrophic losses in the distant future are almost worthless to the present generation. This and the uncertainties of predicting future social, political and technological change lead the authors to suggest that some other future discounting rate may be more appropriate, depending upon the ethical basis of the analysis. Four different ethical systems are defined in terms of the discount rate they imply in two cases: where actual investment in future generation is possible, and where it is not. The authors conclude that global consensus on the proper ethical criterion is unlikely, and that the best strategy for the present is probably to restrict CO₂ emission as much as possible.

- 217 Dickinson, R.E. 1986. How Will Climate Change? In B. Bolin et al., eds., The Greenhouse Effect, Climatic Change and Ecosystems, 206-270. New York: John Wiley and Sons.

KEYWORDS Climate analysis, global circulation models, greenhouse effect, climate information.

Very useful review of theory and modelling of climate change with emphasis on the greenhouse effect and global circulation models written by an experienced atmospheric modeller. Especially useful discussions of the types, strengths and weaknesses of atmospheric models. Surveys deficiencies, reliability and usefulness of models, cautioning that continental and regional level climate change projections are not yet modelled with "any degree of confidence."

- 218 Farhar-Pilgrim, Barbara. 1985. Social Analysis. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 323-350. New York: John Wiley and Sons.

KEYWORDS Social impact analysis, social adjustment, technology assessment.

A broad review of "social impact assessment" as applied mostly by sociologists and others assessing the influence of development projects on communities. Some good reviews of work on hail suppression, urban climate change, etc. good guidelines on what to look for in community social impacts.

- 219 Garcia, R.V. 1981. Drought and Man: The 1972 Case History. Vol. I, Nature Pleads Not Guilty. Oxford: Pergamon Press.

KEYWORDS Sahelian drought, societal vulnerability, developing countries, drought, disaster relief, climate analysis, technology assessment.

This overview of the 1972 Sahelian famine crisis attempts to access, at national and global scales, the climatic and social causes of the tragedy. Critical appraisals of "standard" development practices and international aid systems are included. The volume leans heavily towards socioeconomic explanations although the final two chapters examine the "climatic dimensions of drought." Garcia's intent is to raise a strong voice of dissent from the prevailing view that the Sahelian disaster was primarily climatic in origin, and to raise questions about how the excessive vulnerability of developing countries to such disasters has come about and might be remedied.

- 220 Garcia, R.V. and J.C. Escudero. 1982. Drought and Man: The 1972 Case History. Vol. II, The Constant Catastrophe: Malnutrition, Famines and Drought. Oxford: Pergamon Press.

KEYWORDS Developing countries, societal vulnerability, theoretical analysis, technology assessment, health effects, drought, social impact assessment.

The sequel to Garcia's analysis of the 1972 famine crisis in the Sahel broadens to a general study of malnutrition as a medical and social phenomenon. Seven mostly theoretical chapters include discussions of how drought impacts on nutrition and how the impacts of climate anomalies can be analyzed with a social structural context. Chapters 8-11 present case studies of malnutrition and its relationship to drought in several countries. The authors' overriding conclusion is that malnutrition is essentially a political phenomenon, with the corollary that "underdevelopment" and malnutrition do not necessarily go together; development can in fact aggravate malnutrition and societal vulnerability to natural disasters.

- 221 Glantz, Michael H. 1977. Nine Fallacies of Natural Disaster: The Case of the Sahel. Climate Change 1: 69-84.

KEYWORDS Sahelian drought, societal vulnerability.

This article presents nine statements which are generally "accepted" as true. However, when they are applied to a particular situation, in this case the recent prolonged drought in the Sahelian zone in West Africa, they are as often untrue as they are true. For example, such generalizations as "people learn from their mistakes" or "when the rains come, everything will return to normal" or "technology is the answer", when applied uncritically to a specific situation often prove to become part of the problem as well as a hindrance to the attainment of a solution to that problem. It is strongly suggested that these nine generalizations, here called "fallacies", be carefully assessed when applied, thereby removing one more obstacle in dealing with environmental problems in general and natural hazards in particular.

- 222 Glantz, Michael H. 1977. Desertification: Environmental Degradation in and Around Arid Lands. Boulder, Colo.: Westview Press.

KEYWORDS Desertification, famine, climate analysis, developing countries, policy analysis.

A benchmark collection of papers on the desertification issue, including climate and physical causes, ecological impacts, pastoral systems and human response. Good chapter on the basic statistical properties of rainfall and how statistics are used and misused in analyzing rainfall trends.

- 223 Glantz, Michael H. 1981. Considerations of the Societal Value of an El Nino Forecast and the 1972-1973 El Nino. In Resource Management and Environmental Uncertainty: Lessons from Coastal Upwelling Fisheries, ed. M.H. Glantz and J.D. Thompson, 449-476. New York: John Wiley and Sons.

KEYWORDS El Nino, climate forecasts, fisheries, response.

There has been a great deal of research on the scientific aspects of the El Nino phenomenon in an attempt to reduce the uncertainties surrounding its environmental and biological impacts. However, little research effort to date (with a few notable exceptions) has been directed toward the societal value of an El Nino forecast. This chapter is an attempt to address that gap. More than 60 experts in various fields were asked what they might have done in 1972-1973 if a hypothetically perfect El Nino forecast had been available 2-4 months in advance of its onset. The purpose of this approach (what might be called a case scenario) was to determine how much flexibility decisionmakers in Peru and elsewhere might have, given the hypothetical availability of an extremely reliable El Nino forecast. The study's findings suggest that while in theory many good uses can be attributed to the development of a reliable El Nino forecast, in practice it appears that its value may be quite limited.

- 224 Glantz, Michael H. and Nicolai Orlovsky. 1983. Desertification: A Review of the Concept. Desertification Bulletin 9: 15-22.

KEYWORDS Desertification, research review, drought, ecological impacts, agriculture, range land.

Glantz and Orlovsky review a broad range of definitions and explanations of desertification. Some researchers have viewed desertification as a process of change; others as the end result of a process (desertification-as-event). Climatic factors include changes in climatic (e.g. precipitation) variability, long-term climatic changes, and periodic droughts. The contributions of improper cultivation practices, overgrazing, excessive wood gathering, and inappropriate technology are discussed in turn. The authors encourage a broadening of the concept of desertification, particularly on the issue of where it can occur; they refer to the work of French author Aubreville, who was concerned with the destruction of Africa's tropical forests.

- 225 Glantz, Michael H., ed. 1986. Drought and Hunger in Africa: Denying Famine a Future. Cambridge University Press.

KEYWORDS Drought, famine, food, social impact analysis, social adjustment, policy analysis, research review, theoretical analysis.

An important and valuable collection of papers focused on Africa but relevant to climate and society research elsewhere. Especially useful for presenting new theoretical perspectives and case studies (e.g., Nigeria, Botswana, Ethiopia and Kenya). Divided into four sections: physical and social setting; internal vs. external perspectives; case studies; and lessons for the future. The internal-external factors section casts new light on the durable debate over causes of famine in Africa and theoretical perspectives on development, resiliency, impacts, and policy.

- 226 Glantz, Michael H., Richard Katz, and Maria Krenz, eds. 1987. The Societal Impacts Associated with the 1982-83 Worldwide Climate Anomalies. National Center for Atmospheric Research, Boulder, Co.

KEYWORDS El Nino, economic impacts, environmental impacts, drought, social impact assessment, response, extreme events, floods.

This important and useful volume is composed of 13 individually authored chapters which outline the worldwide societal impacts resulting from climate anomalies which have demonstrated strong teleconnections with the 1982-83 El Nino/Southern Oscillation. These papers are from a meeting held in Lugano, Switzerland in November 1985 and jointly sponsored by UNEP and NCAR. Included in the volume is a general overview essay on the El Nino/Southern Oscillation phenomenon; essays on drought impacts in Indonesia, Australia, West Africa, and India; impacts on crop yields in China; socioeconomic impacts in Japan, USSR, and Western Europe; and an assessment of impacts in the United States. The emphasis of each paper is on environmental, societal, and economic impacts and on response. The volume also includes an interesting and useful appendix of climate impact maps which illustrate the worldwide occurrence and location of droughts, floods, and severe storms during the El Nino years of 1957-58, 1972-73, and 1982-83.

- 227 Glantz, Michael. 1977. The Value of a Long-Range Weather Forecast for the West African Sahel. Bulletin of the American Meteorological Society 58: 150-158.

KEYWORDS Climate forecasts, climate information, response.

This paper is a study of the political, economic, social, and environmental implications for the West African Sahel of a long-range weather forecast. People representing several disciplines and fields of endeavor were asked what they would have done in October 1972 had they had an accurate forecast in terms of monthly averages of rainfall and temperature for the rainy season in 1973. The paper contains their responses and discusses their recommendations in light of the existing social, political, economic, and environmental constraints existing not only in the Sahelian countries but also in the international community.

- 228 Hare, F. Kenneth. 1977. Climate and Desertification. In Desertification: Its Causes and Consequences, pp. 63-167. Oxford: Pergamon Press.

KEYWORDS Climate analysis, desertification, climate modification, response, Sahelian drought.

Hare's contribution to the U.N. desertification conference is an overview of dry climates, their causes as then understood, attempts to model dry climates and the inherent difficulties of this effort, and potentially fruitful approaches to responding to dry climates and desertification. His emphasis is exclusively on climatology and biogeophysical processes. Avenues for future research are suggested. The three appendices include

separately authored papers on dry climate modelling and a chronology of dry-region climatic variations.

- 229 Hare, F. Kenneth. 1981. Climate: The Neglected Factor? International Journal 36: 371-387.

KEYWORDS Research review.

An excellent but dated review of the initiatives taken in the 1970s to create an international awareness of climate as an economic and political factor. Hare chronicles the efforts of atmospheric scientists to develop an international consensus on the need for climate impact assessment work. Efforts by the UN, other international organizations, and national governments are reviewed. The need for interdisciplinary work (particularly among physical and social scientist) is stressed.

- 230 Hare, F. Kenneth. 1985. Climatic Variability and Change. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 37-68. New York: John Wiley and Sons.

KEYWORDS Climate analysis, climate system.

Provides an excellent overview of the types and causes of climate fluctuations that can affect biophysical and social systems. Special attention to the Greenhouse Effect, urban influences, and public and scientific perception of climate changes.

- 231 Hare, F. Kenneth. 1985. Future Environments: Can They be Predicted? Institute of British Geographers Transactions New Series 10: 131-137.

KEYWORDS Scenarios, environmental impacts, response.

In environmental questions the public demand is for predictions--of how matters will evolve with or without remedial action. Attempts to model environmental systems in numerical terms rarely yield convincing predictions, because of the systems' great complexities. Ecosystem approaches, in particular, are rarely useful in predictions aimed at management. Ordinary human synthesis still underlies most successful action. The new field of environmental studies deals in practices with such synthesis, which aims at sketching possible and desirable futures.

- 232 Heathcote, R.L. 1985. Extreme Events Analysis. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 369-401. New York: John Wiley and Sons.

KEYWORDS Extreme events, social impact analysis, disaster relief.

A useful and innovative survey of approaches to climate impacts focussing on the natural hazard view of climate. Special attention is paid to what to measure and how to gather information in cases of climate extremes.

- 233 Hewitt, Kenneth, ed. 1983. Interpretations of Calamity. Boston: Allen & Unwin.

KEYWORDS Response, developing countries, drought, extreme events, agriculture, famine, theoretical analysis.

This collection of essays is an important critique of the dominant or traditional approach to natural hazards research. Alternative theoretical perspectives for hazards research are discussed. Most of the examples and case studies are concerned with problems of climatic hazards such as drought and floods or with problems of climatic stress and variability. The emphasis in many of these essays is on the role that social, political, and economic institutions play in increasing or prolonging the social and economic consequences of natural hazards.

- 234 Idso, Sherwood B. 1980. The Climatological Significance of a Doubling of Earth's Atmospheric Carbon Dioxide Concentration. Science 207: 1462-1463.

KEYWORDS Greenhouse effect, climate analysis.

The mean global increase in thermal radiation received at the surface of the earth as a consequence of a doubling of the atmospheric carbon dioxide content is calculated to be 2.28 watts per square meter. Multiplying this forcing function by the atmosphere's surface air temperature response function, which has recently been determined by three independent experimental analyses to have a mean global value of 0.113 K per watt per square meter, yields a value of ≤ 0.26 K for the resultant change in the mean global surface air temperature. This result is about one order of magnitude less than those obtained from most theoretical numerical models, but it is virtually identical to the result of a fourth experimental approach to the problem described by Newell and Dopplick. There appears to be a major discrepancy between current theory and experiment relative to the effects of carbon dioxide on climate. Until this discrepancy is resolved, we should not be too quick to limit our options in the selection of future energy alternatives.

- 235 Jodha, N.S. and A.C. Mascarenhas. 1985. Adjusting in Self-provisioning Societies. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 437-464. New York: John Wiley and Sons.

KEYWORDS Self-provisioning societies, developing countries.

An excellent review of work in climate impacts on peasant populations in the Third World. Very useful references, tables, and surveys of methods in an area often neglected in climate impacts research.

- 236 Johnson, Douglas L. 1977. The Human Dimensions of Desertification. Economic Geography 53: 317-321.

KEYWORDS Desertification, Sahelian drought, societal vulnerability, developing countries.

Johnson's article introduces a special issue of Economic Geography devoted to desertification. He and all of the contributing authors view desertification as a product of the interaction of natural environmental--including climatic--fluctuations and human populations pursuing survival and "livelihood security." Placing the problem in global perspective Johnson notes that a total of about 50 million people (in 1977) were directly affected by productivity losses due to desertification. While this is only a small percentage of the Earth's total population, the problem is highly significant to those concerned, and especially deserving of attention if it is avoidable. Focusing on short-term precipitation deficits as the chief cause has diverted attention from equally important social causes. Johnson emphasizes the importance of site specific field research and notes the highly multidisciplinary nature of the data used and viewpoints adopted by the various authors.

- 237 Karl, Thomas R. and William E. Riebsame. 1984. The Identification of 10- to 20- Year Temperature and Precipitation Fluctuations in the Contiguous United States. Journal of Climate and Applied Meteorology 23: 950-966.

KEYWORDS Climate analysis, response.

A potentially fruitful approach to assessing society's sensitivity to climate change is to study the impacts, perceptions and adjustments of recent climate fluctuations. We set out to determine if the recent (1931-82) United States climate record exhibits fluctuations of sufficient scope and magnitude to be useful in a complement of retrospective, empirical studies of climate impacts. The search for fluctuations was designed specifically to identify areas and periods in which the climate within an epoch was terminated by a rather sharp transition to another epoch with a climate unlike the previous epoch. The largest 10- to 20-year temperature and precipitation climate fluctuations were identified across the contiguous United States, along with various scenarios of simultaneous change of temperature and precipitation for the four seasons and annually. The climate fluctuations were specifically identified for the purpose of studying and modeling climate impacts, but they are also of general interest to researchers investigating the physical behavior of climate across the United States. On a seasonal basis our results indicate that over the past half century the most significant and widespread climate fluctuations for temperature of 10-20 years duration, in terms of standardized departures, have been associated with temperature changes of 2 degrees C or more during the winter and summer seasons.

- 238 Kates, Robert W. 1980. Climate and Society: Lessons From Recent Events. Weather 35: 17-25.

KEYWORDS Extreme events, mitigation, response, perception, Sahelian drought, greenhouse effect, societal vulnerability.

Reviewing natural hazards research, Kates notes the climatic origin of most natural hazards, including the three most important: floods, tropical cyclones, and droughts. In terms of percentage of GNP, developing countries suffer significantly heavier losses from natural hazards than industrialized countries. Three general areas in which our understanding is limited are noted: how to reduce societal vulnerability within a context of widespread inequality; how complex social systems are impacted by perturbation; and how society might perceive and respond to "slow, pervasive climate change." It is crucial both that existing knowledge of how climatic vulnerability can be reduced be acted upon and that the practical and theoretical difficulty of climate impact assessment be recognized and grappled with. Finally, Kates emphasizes that societies would be wise to consider the basis values which will guide them in making decisions about climatic issues, which will always involve a significant level of uncertainty.

- 239 Kates, Robert W. 1981. Competing Views as to What Really Happened in 1910-14 and 1968-74. Mazingira 5: 72-83.

KEYWORDS Sahelian drought, response, societal vulnerability.

Presented is a review of the drought problem in the Sahel in light of two competing views. The first suggests that the Sahelian population has become more vulnerable to the impacts of drought while the second suggests that societal vulnerability has decreased.

- 240 Kates, Robert W. 1985. The Interaction of Climate and Society. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 3-36. New York: John Wiley and Sons.

KEYWORDS Theoretical analysis.

The author provides an informative, theoretical overview of climate and society research, offering conceptual models for organizing research on climate impacts. Good research review.

- 241 Kates, Robert W., Jesse H. Ausubel, and Mimi Berberian. 1985. Climate Impact Assessment: Studies of the Interaction of Climate and Society (Scope 27). New York: John Wiley and Sons.

KEYWORDS Research review.

The most comprehensive survey of climate and society theory, research methods, and recent impact studies available. Covers most of the key

areas where climate fluctuations affect human activities, and offers guidance to researchers contemplating impact studies.

- 242 Kellogg, W.W. 1980. Modeling Future Climate: It is Time to Plan for a Climate Change and a Warmer Earth ... Ambio 9: 216-221.

KEYWORDS Climate forecasts, greenhouse effect, global circulation models, fossil fuels, energy, scenarios, response, economic impacts, social impact analysis.

In this general overview of the greenhouse issue, Kellogg discusses basic concepts of climate and climate models, and how various human activities can alter the earth's heat balance. He concludes that increasing atmospheric levels of CO₂ and perhaps other infrared absorbing trace gases constitute the largest single influence of mankind on the climate. Two extreme scenarios of future CO₂ production are suggested--a high and a low case. The range of projected changes in global temperature and other aspects of climate is reviewed; Kellogg also mentions the possibility that large-scale deglaciation of Antarctica and Greenland could occur. Lastly, Kellogg proposes what he feels are the necessary components of a program to assess the potential impacts of a global CO₂ induced climate change and evaluates the feasibility of preventing the change from occurring.

- 243 Kellogg, W.W. and R. Schware. 1981. Climate Change and Society: Consequences of Increasing Atmospheric Carbon Dioxide. Boulder, Colo.: Westview Press.

KEYWORDS Research review, greenhouse effect, policy analysis.

A semi-popular collaboration of a physical and social scientist that lays out the greenhouse problem potential impacts on societies, and possible social response. Still a useful introduction to non-scientists.

- 244 Lamb, Peter J. 1980. Sahelian Drought. New Zealand Journal of Geography (April): 12-16.

KEYWORDS Climate analysis, climate forecasts, Sahelian drought.

Weather systems responsible for causing precipitation in the West African Sahel region are described. Many authors have claimed that droughts in this region are caused by equatorward shifts of large-scale atmospheric circulation components due to expansion of the Northern Hemisphere circumpolar vortex. The author suggests that equatorward displacements of tropical Atlantic sea surface temperature zones and related atmospheric features may also play an important role. These displacements, which seem to coincide with Sahelian droughts, have not been shown to be forced by changes in the northern circumpolar vortex. Lamb emphasizes that insufficient understanding of the causes of Sahelian drought exists for making confident forecasts of the future trend of precipitation in the region.

- 245 Lamb, Peter J. 1983. Sub-Saharan Rainfall Update for 1982: Continued Drought. Journal of Climatology 3: 419-422.

KEYWORDS Sahelian drought, climate analysis, economic impacts.

The 1982 value of a sub-Saharan rainfall index previously published for 1941-1981 is given. This establishes that the drought which commenced in 1968 and persisted very strongly throughout the 1970s and 1980-1981 continued into 1982, which was the third driest year of the period 1968-1982, and also appears to have received substantially less rainfall than the drought years of the 1940s. Several meteorological and socioeconomic implications of this situation are discussed. The paper also provides a recomputation of the entire 1941-1982 index time series that was permitted by the forward extension of the database since the original calculation for 1941-1974.

- 246 Lave, Lester B. and Dennis Epple. 1985. Scenario Analysis. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 511-528. New York: John Wiley and Sons.

KEYWORDS Scenarios.

Nice discussion of the potential use of scenarios in climate impact studies, with useful suggestions on how to organize a scenario-building exercise, what factors should be included, and alternative ways that scenarios can be applied to real-world problems. Good approaches for incorporating interdisciplinary research on climate and society.

- 247 Leighly, John. 1943. Climatology Since the Year 1800. Transactions, American Geophysical Union 30: 658-672.

KEYWORDS Climate analysis.

Most of the work done in climatology in the past 150 years can be assigned to one of the following classes of investigation or presentation: empirical formulation of climatic data, descriptive climatology, climatological cartography, organization of observational data by synoptic categories, investigation of the physical bases of climate, definition of climatic types and the delineation of climatic regions, and reconstruction of past climates. Although their relative importance has varied, through much of the period under consideration all these fields have been cultivated simultaneously. Especially in the latter part of the Nineteenth and early part of the Twentieth Century, climatology has been too strongly dominated by a descriptive approach. Satisfactory physical interpretations of the phenomena recorded have often been impossible, but even the physical insights available at any given time have not always been applied. It would appear that the rational treatment of climatic data can be attained more readily through synoptic concepts than through a frontal attack with the general formulations provided by physical theory.

- 248 Lovell, C.A. Knox and V. Kerry Smith. 1985. Microeconomic Analysis. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 293-321. New York: John Wiley and Sons.

KEYWORDS Economic impacts, systems analysis.

An attempt to lay out the potential contributions of microeconomics to analyzing and assessing the impacts of climate fluctuations on market economies. Briefly describes input-output analysis, cost-benefit analysis, and econometric and system simulation models. Not very encouraging as to applicability of microeconomics to climate impact assessment.

- 249 Maunder, W.J. and J.H. Ausubel. 1985. Identifying Climate Sensitivity. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 85-101. New York: John Wiley and Sons.

KEYWORDS Social impact analysis, economic impacts, construction, manufacturing, meteorological services, transportation.

Methods for conducting quick assessments of contemporary climate sensitivities are presented, stressing impacts on regional and national economic indices, especially agricultural production, and on international trade.

- 250 National Academy of Sciences. 1983. Changing Climate: Report of the Carbon Dioxide Assessment Committee. Washington, D.C.: National Academy Press.

KEYWORDS Greenhouse effect, environmental impacts, climate forecasts, agriculture, water resources, sea level rise, response, mitigation, research reviews.

This volume attempts to give a comprehensive assessment of increasing atmospheric CO₂, its possible influence on climate, and the associated impacts in areas including agriculture water supplies, sea level, and Arctic and Antarctic regions. Past fluctuations in CO₂ concentrations and estimates of future emissions are reviewed. There are chapters devoted to the difficulty of detecting climate change and to its implications for human welfare and the spectrum of possible response. The first chapter provides a synthesis of the committee's findings and recommendations; more detail on individual topics is given in the subsequent chapters.

- 251 National Science Foundation. 1968. Human Dimensions of the Atmosphere. Washington: U.S. Government Printing Office.

KEYWORDS Research review, social adjustment, policy analysis, climate modification.

A lesser known but valuable early assessment of the impacts of weather and climate on society. Driven not by the potential for natural or

inadvertent climate change, but rather by the then-promising aspect of purposeful weather and climate modification, several researchers who have played subsequent roles in climate and society research present their ideas on human response and adaptation, policy aspects of the atmosphere, and the economic implications of atmospheric modification.

- 252 Oguntoyinbo, J.S. 1986. Drought Prediction. Climatic Change]9: 79-90.

KEYWORDS Drought, Sahelian drought, climate forecasts, global circulation models.

Drought prediction has been an age-old problem, but in more recent times the magnitude of the Sahelian drought has brought into focus the need to improve the techniques for predicting such droughts with some measure of accuracy. From the present state of knowledge, drought prediction is difficult, if not impossible. Two major approaches appear to prominent in the search for appropriate techniques. These include the use of teleconnections and the development of numerical models.

- 253 Oguntoyinbo, J.S. and Odingo, R.S. 1979. Climate Variability and Land Use: An African Perspective. In Proceedings of the World Climate Conference, World Meteorological Organization, no. 537, 552-580.

KEYWORDS Agriculture, historical analysis, response, desertification, social adjustment, social vulnerability.

Archaeological, geomorphological and historical evidence suggests that the Sahara Desert region of Africa has experienced periods of much wetter climates than at present. Paper attempts to highlight some of the events that suggest the effects of climate variability on land use characteristics under varying conditions, and to show the resultant effects of man's impact on the environment. Focuses on areas marginal to the desert. Suggest developing land use strategies to respond to climatic variability.

- 254 Parry, Martin L. 1986. Some Implications of Climatic Change for Human Development. In Sustainable Development of the Biosphere, eds. W.C. Clark and R.E. Munn, 378-407, Cambridge: Cambridge University Press.

KEYWORDS Response, social adjustment, societal vulnerability, economic impacts, agriculture, research review.

Valuable review article focusing on the social process of adaptation and adjustment to variability and change in climate. Models and concepts of climate impact assessment and societal adjustment to environmental change are discussed in light of research on the response of agricultural systems to changes in climate. Characteristics of societal vulnerability to climatic change are discussed along with importance of changes in the frequency of extreme events and their social and economic impacts. The impact of climate change is also discussed in light of changes in economic risk.

- 255 Petterssen, Sverre. 1966. Recent Demographic Trends and Future Meteorological Services. Bulletin American Meteorological Society 47: 950-963.

KEYWORDS Climate forecasts, demographic analysis, global circulation models, meteorological services, natural resources, technology assessment.

Petterssen provides general reviews of the progress of worldwide demographic transformation and the contributing scientific revolution in building his case for an expanded practical role for meteorology in the future. Population pressure and resultant strain on natural resources by the year 2000 will call for more accurate, more sector specific, and longer-range weather reporting and forecasting. Major technological breakthroughs which have spurred the advancement of meteorology are listed chronologically, as are theoretical milestones in meteorology. The author closes by describing the proposed World Weather Watch system and the recent development of general circulation research programs.

- 256 Pittock, A.B. 1980. Towards a Warm Earth Scenario for Australia. In G.I. Pearman, ed., Carbon Dioxide and Climate: Australian Research, pp. 197-209. Canberra: Australian Academy of Sciences.

KEYWORDS Greenhouse effect, scenarios, societal vulnerability.

Measured and projected increases in carbon dioxide content of the atmosphere point towards a significant global warming. The regional effects of such a warming will determine the social and economic consequences for Australia and the world. Four methods of arriving at a tentative regional scenario for Australia are discussed. These methods are: (i) numerical modelling, (ii) extreme warm and cold year ensemble comparisons, (iii) palaeoclimatic reconstructions for past warm epochs, and (iv) dynamical/empirical reasoning. While each method has obvious drawbacks, the results show a surprising degree of convergence on a "warm earth" scenario in which all of Australia north of 25 deg. S would be significantly wetter but the southern parts of Western Australia, Victoria and possibly all of Tasmania would probably have lower precipitation. High priority should be given to further investigations using numerical models which include an interactive dynamic ocean and hydrologic cycle including variable cloudiness.

- 257 Riebsame, William E. 1985. Research in Climate-Society Interaction. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 69-84. New York: John Wiley and Sons.

KEYWORDS Theoretical analysis, research review.

The author offers a structure for climate and society research based on four "views" of climate: climate as setting, climate as determinant, climate as hazard, and climate as natural resource. Research implications of each view are discussed.

- 258 Riebsame, William E. 1985. Climate Hazards: Lessons from Recent Events in the United States. Disasters 9: 295-300.

KEYWORDS Response, extreme events.

Three recent cases of climate extremes are studied to identify human impacts and response strategies and to identify common characteristics that may help illuminate the nature of climate hazards. The 1980 heat wave in the central US, 1981 cold wave in Boston, and recent flooding and lake level rise in northern Utah, illustrate several important aspects of climate hazards that separate them from the more traditional set of catastrophic events (e.g. tornadoes, hurricanes and earthquakes) usually dealt with by hazards research and management. Among those characteristics are an emphasis on health impacts rather than physical damage, accumulative effects rather than short shocks, a tendency for impacts to accrue to certain socio-economic classes, and relatively slow onset. The management and research implications of these hazard characteristics are explored.

- 259 Riebsame, William E., Henry F. Diaz, Todd Moses, and Martin Price. 1986. The Social Burden of Weather and Climate Hazards. Bulletin of the American Meteorological Society 67: 1378-1388.

KEYWORDS Extreme events, societal vulnerability, social adjustment.

Socioeconomic vulnerabilities and impacts associated with weather and climate hazards in the United States are assessed. Trends in deaths and economic losses resulting from tornadoes, tropical storms and hurricanes, and floods (including flash floods) are presented in detail. To the extent possible, death statistics are normalized by the population at risk, and loss data are adjusted for inflation. The results suggest a significant decline in deaths attributed to tornadoes and hurricanes at the same time that property damages have increased. In contrast, both deaths and losses due to floods have increased substantially in the past few decades. Emphasis should be given to the following activities as ways to decrease the overall social burden of atmospheric hazards: 1) improve the use of weather and climate information by emergency managers, 2) develop better impact-assessment methods, and 3) explore new ways to reduce future property losses.

- 260 Robinson, Jennifer. 1985. Global Modeling and Simulations. In R.W. Kates, J.H. Ausubel, and M. Berberian, eds., Climate Impact Assessment, pp. 469-492. New York: John Wiley and Sons.

KEYWORDS Systems analysis, economic modelling.

A sober survey of the potential application of global simulation models (ala Club of Rome and subsequent models) to assessing the impacts of climate change. Offers detailed analysis of strengths and weaknesses of several integrated models. Especially useful for the cautions raised by the author, and for suggestions on how to interpret model results.

- 261 Rosenberg, N.J., ed. 1978. North American Droughts. Boulder, Colo.: Westview Press.

KEYWORDS Drought, economic impacts, policy analysis.

Papers presented at an AAAS symposium on drought. Includes historical, economic, and institutional papers.

- 262 Sah, Raaj. 1979. Priorities of Developing Countries in Weather and Climate. World Development 7: 337-347.

KEYWORDS Developing countries, response.

The LDC performance is crucially dependent on climate, and the application of climate sciences can produce substantial benefits. This paper discusses: (1) the state-of-the-art and the potential of: climatology, weather forecasting, weather modification, and long-term trends in the Earth's climate; (2) economically attractive applications and research; (3) available climate-related capabilities in LDCs; and (4) rough estimates of costs, benefits, lead-times and institutional requirements for investments in weather and climate. Immediate investment in applied climatology and operationally oriented weather prediction is found highly desirable. The benefits would be substantially higher than costs if investments respond to priority needs. International cooperation would reduce cost and lead-time for LDCs.

- 263 Schneider, Stephen H. 1977. Climate Change and the World Predicament: A Case Study for Interdisciplinary Research. Climatic Change 1: 21-43.

KEYWORDS Societal vulnerability, famine, drought, agriculture, decision making.

The relationship between climatic change and issues of population, food, resources, environment and the human condition i.e., the world predicament, are explored. It is concluded that society is dangerously vulnerable to natural climatic variability at times of depleted food reserves (such as now) and that massive use of technologies (especially energy) to improve the human condition could well cause significant climatic change as early as the year 2000. Therefore, these problems cannot be addressed in the sole context of disciplinary research, and the obstacles and opportunities for interdisciplinary research at academic institutions are explored. Criteria for interdisciplinary research quality review are suggested, and contrasted to traditional peer review processes.

- 264 Schneider, Stephen H. and Richard L. Temkin. 1978. Climatic Changes and Human Affairs. In John Gribbin, ed., Climatic Change, pp. 228-246. Cambridge: Cambridge University Press.

KEYWORDS Response, societal vulnerability, risk analysis, food, water resources, energy.

A review of the impacts of climatic change on society and modes human response and adjustment. Reviewed are the implications of climatic variability in specific societal sectors such as food, water, and energy. Issues of societal vulnerability, risk, and response are also discussed.

- 265 Schneider, Stephen H. and Robert S. Chen. 1980. Carbon Dioxide Warming and Coastline Flooding: Physical Factors and Climatic Impact. Annual Review Energy 5: 107-140.

KEYWORDS Climate analysis, climate forecasts, economic impacts, floods, greenhouse effect, policy analysis, research review.

This broad review of greenhouse warming and the possibility of the deglaciation of West Antarctica and resulting global sea level rise is concerned primarily with potential impacts on the continental U.S. The authors first discuss the evidence for CO₂ increase and the physical basis for projected global warming. A review of recent literature reveals substantial disagreement among scientists over the likelihood, potential extent, and timing of a Western Antarctic deglaciation. The possible extent of inundation along U.S. coasts due to a 15-25 foot sea level increase is suggested. Possible social and political impacts, the consequences of discounting the future effects of CO₂, and general policy options in responding to the CO₂ problem are discussed in the final sections.

- 266 Smagorinsky, Joseph. 1983. Climatic Changes Due to CO₂. Ambio 12: 83-85.

KEYWORDS Climate forecasts, global circulation models, greenhouse effect, technology assessment, fossil fuels.

Smagorinsky provides a broad overview of the CO₂/Greenhouse warming issue and some of its many facets. He first reviews the capabilities and limitations of climate models being used to estimate climatic response to increasing CO₂ concentrations. A series of key questions about CO₂ increase, its effects, and human response are then suggested. Methodologies and technologies used for monitoring climate change are outlined. The author closes by identifying major institutions worldwide which are investigating various aspects of the CO₂ problem and by suggesting priorities for research and action in the 1980s.

- 267 Smith, V. Kerry. 1982. Economic Impact Analysis and Climatic Change: A Conceptual Introduction. Climatic Change 4: 5-22.

KEYWORDS Economic impacts, economic modeling, cost-benefit analysis, greenhouse effect.

A review of the issues and problems involved with economic impact analyses of natural and human-induced climatic change. This paper is primarily concerned with methodological issues. It is argued that because of factors which are specific to climatic change, traditional methodologies

such as benefit cost analysis will need substantial amendment or complete replacement.

- 268 Spitz, P. 1980. Drought and Self-Provisioning. In J. Ausubel and A.K. Biswas, eds., Climatic Constraints and Human Activities, 125-147. Oxford: Pergamon Press.

KEYWORDS Social impact analysis, developing countries, self-provisioning societies, drought, agriculture, food.

A lesser known, early study as part of the WCIP, Spitz's work on the impacts of climate variability on self-provisioning or subsistence societies is based on an equilibrium model linking production, rate of self-provisioning, and surplus which yields variations in the number of months of self-provisioning. This useful concept can be helpful to comparative analysis of climate impacts and for tracking cumulative effects.

- 269 Thompson, J.C. 1962. Economic Gains from Scientific Advances and Operational Improvements in Meteorological Prediction. Journal of Applied Meteorology 1: 13-17.

KEYWORDS Climate forecasts, economic modeling.

Long range plans for national and international economic improvements are vitally affected by the influence of weather and climate. It is therefore of interest to examine the magnitude of potential economic gains which may result from meteorological research. In this paper a preliminary study is made of the relative economic gains in weather prediction which may result from meteorological research. In this paper a preliminary study is made of the relative economic gains in weather prediction which may be achieved through further basic scientific studies in meteorology as well as through more operationally-oriented research. Considering the economic model used and sample predictions analyzed, the results suggest that average potential gains are strikingly uniform, ranging from five to ten per cent of the protectable weather losses.

- 270 Timmerman, Peter. 1981. Vulnerability, Resilience and the Collapse of Society: A Review of Models and Possible Climatic Applications. Environmental Monograph No. 1, Institute for Environmental Studies, 42 pp. University of Toronto, Canada.

KEYWORDS Theoretical analysis, response, social adjustment, societal vulnerability, perception.

This paper is a theoretical analysis of climate and society interaction drawing from systems ecology and behavioral science. The author explores the concepts of vulnerability and resilience in social systems that interact with the environment. An interesting discussion of the basic models of human environment interaction is presented. It is argued that often attempts at adjusting to environmental stress actually decreases

resiliency and thus increases vulnerability. Also explored is the problem of dealing with uncertainty.

- 271 Torry, William I. 1983. Anthropological Perspectives on Climate Change. In R.S. Chen, E. Boulding, and S.H. Schneider, eds., Social Science Research and Climate Change, pp. 208-227. Dordrecht, Holland: D. Reidel Publishing.

KEYWORDS Developing countries, self-provisioning societies, response, social adjustment.

This article focuses on how local institutions respond to stress resulting from problems of climatic change. The emphasis is on household organizations in developing countries. The author presents a set of research priorities and argues for a systematic cross-cultural mode of analysis.

- 272 Waddell, Eric. 1975. How the Enga Cope with Frost: Responses to Climatic Perturbations in the Central Highlands of New Guinea. Human Ecology 3: 249-273.

KEYWORDS Extreme events, self-provisioning societies, social adjustment.

The adaptive strategy of a population of New Guinea highland subsistence farmers is considered in the light of events surrounding a series of severe frosts experienced in 1972. Coping with frost is seen to be a critical preoccupation for all Enga, and agricultural mounding a universal response, adequate to deal with the mild frosts of Central Enga country below 2250 m but insufficient above. There, among the Fringe Enga, a sequence of responses at three different levels may be identified. These may be called the local, intraregional, and extraregional levels because of their progressively wider geographical spread in agricultural activity and attendant increased population mobility. A correspondence is indicated between response level and frost intensity. This response, while effective, is being modified through cropping innovations and disrupted by colonial situation. Further, at higher levels, it is incompatible with the prescribed course of political and economic development.

- 273 Waddell, Eric. 1983. Coping with Frosts, Governments and Disaster Experts: Some Reflections Based on a New Guinea Experience and a Perusal of the Relevant Literature. In Interpretations of Calamity, ed. K. Hewitt, 33-43. Boston: Allen and Unwin Inc.

KEYWORDS Developing countries, self-provisioning societies, response, social adjustment, theoretical analysis.

A review of government response to the drought and frost problem in New Guinea in 1972. Waddell argues that the response of the new New Guinea government, Australia, and religious organizations, while successful, served to undermine and discourage traditional coping mechanisms. Waddell

also presents a critique of the traditional or dominant view in natural hazards research in light of his New Guinea research.

- 274 Warrick, Richard A. 1980. Drought in the Great Plains: A Case Study of Research on Climate and Society in the USA. In J. Ausubel and A.K. Biswas eds., Climatic Constraints and Human Activities, pp. 93-123. New York: Pergamon Press.

KEYWORDS Drought, historical analysis, response, societal vulnerability, theoretical analysis.

An effort to stimulate thinking about climate/society interactions. Catalogues available research methods, existing case-studies, current research and suggests new issues for study. Offers two conceptual models of climate/society relationships as illustrated by a case-study of drought in the Great Plains.

- 275 Warrick, Richard A. 1983. Drought in the U.S. Great Plains: Shifting Social Consequences? In Interpretations of Calamity, ed. K. Hewitt, 67-82. Boston: Allen and Unwin Inc.

KEYWORDS Drought, societal vulnerability, social adjustment, response, agriculture.

Major droughts in the US Great Plains are reviewed, and changes in social impacts and adjustment strategies are discussed. Warrick offers two hypotheses concerning changes in drought impacts and adjustments. The first argues that impacts and consequences have not necessarily lessened, rather they have shifted (spatially and socially) to higher system levels. Second, while local impacts have lessened, long-term societal vulnerability to a major drought has increased.

- 276 Warrick, Richard A. and Martyn J. Bowden. 1981. The Changing Impacts of Droughts in the Great Plains. In M.P. Lawson and M.E. Baker eds., The Great Plains: Perspectives and Prospects, pp. 111-137. Lincoln: Univ. of Nebraska Press.

KEYWORDS Climate analysis, disaster relief, historical analysis, response, societal vulnerability.

A progress report on the Great Plains case study of the impact of drought. Focus on two hypotheses concerning climate variability and societal vulnerability with a framework for conceptualizing the notion of drought impacts on society. Drought record of the Great Plains is established and related to wheat yield, migration, farm transfer and federal aid.

- 277 Warrick, Richard A. and William E. Riebsame. 1983. Societal Response to CO₂-Induced Climate Change: Opportunities for Research. In R.S. Chen, E. Boulding, and S.H. Schneider, eds., Social Science Research and Climate Change, pp. 20-60. Dordrecht, Holland: D. Reidel Publishing.

KEYWORDS Response, social adjustment, societal vulnerability, research review.

How might a climate change, induced by increased CO₂ in the atmosphere, affect societies? What is the range of existing and potential mechanisms for societal response? And how might research contribute to a reduction of the adverse impacts (or enhancement of the unique opportunities) of a climate change by providing greater understanding of the processes involved in climate and society interaction? This paper reflects an initial effort to shed light on these questions. It offers first a framework for identifying key issues in climate-society interaction; eight major questions are suggested by the framework. A discussion of each major question is then presented with the purpose of reviewing the current state of knowledge, identifying the gaps. In all, twenty-two research needs are outlined and are summarized at the conclusion of the paper. The perspective is interdisciplinary, but the review draws heavily from the geographic literature, reflecting the disciplinary bias of the authors.

- 278 Wigley, T.M.L., P.D. Jones and P.M. Kelly. 1986. Empirical Climate Studies. In B. Bolin, et al., eds., The Greenhouse Effect, Climatic Change and Ecosystems, 271-322. New York: John Wiley and Sons.

KEYWORDS Climate analysis, scenarios, climate information.

Empirical studies of climate change, both historical and paleoclimatological, are an important complement to modelling studies. The authors group empirical studies useful in greenhouse research into three categories: analysis of past climate change, warm-world scenarios, and detection. Empirical studies provide much richer regional details than do models, but are not necessarily physically linked to the greenhouse effect per se. They do provide relevant insight into natural climate variability, system response, baseline indicators for future detection, and useful guidelines to climate impact analysts.

- 279 Wilhite, Donald A. 1982. Measuring Drought Severity and Assessing Impact. International Symposium on Hydrometeorology, American Water Resources Association, pp. 333-335.

KEYWORDS Drought.

Our sensitivity to variations in climate is increasing in response to world population pressures and diminishing natural resources. The impact of droughts of the mid-1970s and early 1980s is recent evidence of this sensitivity. In the U.S. annual losses due to drought are estimated to be approximately \$1.2 billion. As a result, decision makers at all levels are experiencing an expanding need for accurate, near real-time information about droughts and their effects. The Palmer Drought Severity Index (PDSI) has been widely used as a general measure of water conditions. This index is based on a hydrologic accounting system which produces an index of zero under normal weather conditions for all climatic regimes. However, the PDSI is not infallible. In fact, the reliability

of this index for many applications has become increasingly suspect. This paper will focus on the shortcomings of the PDSI and suggest some alternative approaches to the characterization of drought severity and impact.

- 280 Wilhite, Donald A. and Michael H. Glantz. 1985. Understanding the Drought Phenomenon: The Role of Definitions. Water International 10: 111-120.

KEYWORDS Drought, response, theoretical analysis.

This article reviews the considerable disagreement concerning the concept and definition of drought. The authors argue that most existing definitions of drought are simplistic and thus lead to a lack of understanding about the concept and to inaction by policy makers and managers. The authors suggest that a definition of drought must incorporate both physical and social factors. A more precise and objective definition of drought should lead to a better understanding of impacts and adjustments.

- 281 Williams, R.E.O. 1958. Weather and Health. The New Scientist (Dec. 1958): 1583-1585.

KEYWORDS Health effects.

Dr. Williams reviews hypotheses and evidence concerning how weather conditions may influence the incidence and spread of human diseases. He suggests that weather might alter any of three variables: susceptibility to disease, the survival and transportation of bacteria in the environment, and human behavior related to the spreading of diseases. Several authors have suggested relationships between absolute humidity and epidemic diseases such as cholera, smallpox, and spinal meningitis. Williams points out that humidity is closely related to other aspects of weather which might be equally involved. Increases in respiratory ailments during inversions and resultant high pollution levels are noted. Finally, the author stresses that weather/disease relationships are unlikely to be simple and that convincing evidence of complex relationships has not yet been produced.

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