COLLABORATIVE RESEARCH
ON NATURAL HAZARDS

PROGRESS REPORT

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October 1973
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PREFACE

This report provides a summary of the work accomplished up to October, 1973 in the collaborative research program on natural hazards. The research is supported mainly by grants from the U.S. National Science Foundation to Clark University and the University of Colorado.

Further information about the research program is available from the following:

Ian Burton
Environmental Sciences and Engineering Programme
University of Toronto
Toronto 181, Canada

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U.S.A.

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The collaborative program of natural hazard research aims to understand the ways in which man perceives extreme natural events and adjusts to the hazard; to apply this knowledge towards reducing the social cost of these events; and to extend such understandings to the new complex of largely man-made environmental risks. The program, which began formally in September 1967, with support from the National Science Foundation, followed a decade of geographic research into the human ecology of extreme geophysical events, and was aimed at drawing together findings from a wide variety of studies in late 1972.

The research began in 1956 with studies of floods at the University of Chicago. This led to the formulation of a basic research paradigm. For any natural hazard, the key issues are as follows: 1) assessment of the extent of human occupancy of hazard zones, 2) identification of the full range of possible human adjustments to the hazard, 3) study of how men perceive and estimate the occurrence of hazard, 4) description of the process of adaptation and of adoption of damage-reducing adjustments in their social context, and 5) estimation of the optimal set of adjustments in terms of anticipated social consequences. By the end of the decade the paradigm was being extended to tidal flood areas as well as riverine areas, to regions subject to semi-arid and humid drought conditions, to the urban snow hazard, and to dwellers in areas of seismic risk.

In seeking sustained support from the National Science Foundation the principal investigators, Ian Burton (University of Toronto), Robert W. Kates (Clark University), and Gilbert F. White (University of Colorado) sought to undertake a more comprehensive attack on the problems caused by natural hazard than previously possible. The aims of the proposal were described as follows:

1. To extend the insights and strategies developed in previous work to other hazards and to other cultural settings especially where such studies show promise of high social benefits;

2. To consider the existence of a "Natural Hazard Syndrome" by examining the similarities and differences in human adjustment to extreme geophysical events, biological hazards, quasi-natural environmental hazards, and common man-induced risks of modern society;

3. To probe further into major factors underlying adjustment to natural hazard, including the role played by uncertainty, crisis and technology in the adjustment process;

4. Related to these major research objectives was the need for encouraging new investigators, including those from other disciplines, developing new research instruments and experimental methods, designing comparative cross-cultural studies, and preparing literature and research reviews of new areas of investigation.
The entire program was seen as the work of five years with much of the initial two-year grant devoted to the initiation of new lines of study, the preparation of research instruments, and the undertaking of pilot investigations. Major field studies and their appraisal were to take place in the following three years. Delays in funding and the ceilings on expenditures led to the extension of the initial two-year period by six additional months. The work at the University of Colorado was completed for operating purposes in July, 1973.

Applying the Results of Past Research to New Situations

A current list of hazards contains 19 distinctive geophysical events the occurrence of which pose severe problems for man. In the original formulation of the research program it was recognized that each of these might pose a significant research opportunity, but not necessarily for the principal investigators. It was hoped that other investigators would help broaden the areas of hazard research and that the principal investigators would seek to encourage such undertakings, and to make available whatever new concepts and research instruments might flow from their own activities.

During the early years of the project, a number of investigators were encouraged to extend the research paradigm to other hazards. J. Kenneth Mitchell of Rutgers undertook a study of community adjustment to coastal erosion. Frost and high winds among farmers in Central Florida were studied by Robert Ward of Eastern Michigan University. An examination of the response of New England water supply managers to humid area drought was completed by Arey, Kates and Russell, and has been published by Resources for the Future.

The death-to-damage ratio from tornadoes as compared to other natural hazards in North America is extremely high, and it is particularly high in areas subjected to occasional rather than frequent tornado damage. A preliminary study by Duane Baumann of Southern Illinois University demonstrated a marked disparity between the pattern of deaths from tornadoes predicted on the basis of an index relating tornado patterns and population density, and the actual pattern of tornado deaths. To investigate this phenomenon further, a field study of perception of tornado hazard with emphasis on areas of low and moderate occurrence was initiated and a preliminary report on an analysis of behavior in relation to personality traits revealed by sentence completion tests was presented in April, 1971 by Baumann and John Sims of the Committee on Human Development of the University of Chicago.

In contrast with the high death toll of tornadoes are the complex social costs posed by urban snow hazard. The original proposal suggested the possibility of high gains from the application of the research approach to the design of optimal strategies for municipal response to a widely varying snow hazard. Two groups of investigators began work on this problem. Burton and Archer made a pilot study of community behavior in response to snow in Toronto, and Relph and Goodwillie prepared a bibliography on snow and ice problems. Another group (David Arey, Baumann, Mark Blacksell,
John Rooney and Clifford Russell undertook an extensive field program including observations in six U. S. cities with comparative observations in three Canadian cities, and the final report was edited by Baumann.

Possibly the most significant social consequences of hazard are found in arid and semi-arid lands where drought and subsequent crop failure weigh heavy in the economic growth and prosperity of many nations. A pilot study at University College, Dar es Salaam by Kates and Leonard Berry of the perception of drought and adjustment to drought hazard by peasant farmers in Tanzania provides the investigators with critical experience and insights into the problems and opportunities of cross-cultural research. The study involved interviews with 460 farmers at fifteen different sites. It showed that the perceived frequency of rain failure is clearly related to the average annual and seasonal rainfall an area receives, but not in a simple linear relationship. While Tanzanian farmers found it as difficult to explain drought causation as do their North American counterparts, a supernatural explanation was more common. Drought adjustments were varied, but on-the-farm adjustments were rare, suggesting this as a major area of potential improvement. Few definitive questions were answered, rather the study served as the basis for encouraging further work by natural resource research institutions in East Africa and for the intensive cross-cultural study in 1971.

Differences and Similarities in Natural Hazards

One series of studies has been carried out to improve our knowledge of the range of hazardous situations, and another set to specifically compare attitudes towards different hazards.

In the first set a comprehensive study of the hazardousness of a place, London, Ontario, was completed by Kenneth Hewitt and Burton. This has been published at Toronto. London, Ontario, it turns out, is not really very hazardous, with the recurrence interval for a major natural disaster from any source about thirty years. Interestingly, the probability of occurrence of a disaster of man-made origin is about the same, and the study urges recognition of "the common link between disasters of all kinds of whatever origin." While it might be wise public policy to recognize these linkages, it is not clear whether the people of London do so. A second phase of the study was undertaken in collaboration with a psychologist, Myra Schiff. This measures the perception of the various natural and man-made hazards by the London public, and was presented in preliminary form at the April 1971 meeting of the Association of American Geographers (AAG), and has since been completed but is not yet published.

Along with the London study, extension of the research paradigm to other sources of hazard began. A first cut at a comprehensive classification of environmental hazards including those with geophysical, biological and man-made origin in which the distinctive physical characteristics, particularly those relating to perception and adjustment, was made at Colorado in the Spring of 1971. Detailed
work was completed on such a classification of environmental pollution by Mary Barker, Burton, and John Hewings. The hazards of water-related disease were classified by White, David Bradley and Anne White in a book published by the University of Chicago Press in 1972.

All the foregoing relate to differences in hazard origin. A second basis for difference may be between the rare extreme event and common recurrent hazard. A study of a minor recurrent hazard in the form of the impact of daily weather on a non-trivial recreational activity was by Robert Adams at Clark. The study by Mitchell of perception of slow-moving coastal erosion and by Martyn Bowden at Clark of long-term climatic change also throw some light on significant differences.

To compare the public perception of hazards directly, we have, except for the London study, experimented with several paper and pencil tests. Semantic differential tests of eight hazards and forty descriptive scales given to students at two universities by Baumann and Keith McNiel showed that while students correctly group the eight hazards along a natural-man continuum, they viewed them quite differently along other scales. A second semantic differential study of twelve hazards and twenty-one descriptive scales by Stephen Golant and Burton revealed that while hazards tend to be grouped correctly as to origin (natural, quasi-natural and man-made hazards), a man-made hazard such as riot is regarded as more closely related to tornado, earthquake, and flood, than to a natural hazard such as a snow storm.

In another test (Golant and Burton), 206 respondents rank ordered fifteen hazards by desired avoidance. These included physical hazards (personal injury or discomfort arising from illness or man-made origin), social hazards (injury of a psychic or non-physical kind arising from group interaction) and natural hazards (implying possible physical injury but solely from environmental circumstances). The commonsense expectation that natural hazards are regarded in ways similar to physical hazard and distinctly different from social hazards was upheld but the test did not show a great within-class consistency.

A third approach involved the use of a modified Rosenzweig picture-frustration test of nine social and nine environmental sources of frustration. The test indicated no differences between types of hazard in the direction of aggressive reactions to the situations (outward, inward, or avoided) and in ego defense reaction, but a greater tendency was noted to search for a solution to social frustration situations as opposed to the more apparent dominance of the source of frustration in environmental situations.

From another quarter the review of the risk-taking literature by Kogan and Wallach in Perspectives in Psychology leaves undecided the related question of whether consistency in risk-taking exists across hazardous situations, such consistency at least for natural hazards being a requirement for the existence of a natural hazards syndrome.
Uncertainty, Crisis and Technology

Most decisions related to hazard adjustment involve some degree of uncertainty. During the first two years an effort was made to examine decision-making under uncertainty from several approaches. Simple games based on the "Prisoner's Dilemma" were devised by Burton to simulate uncertainty experimentally. The psychological literature dealing with risk-taking, particularly laboratory experimentation, was scanned and discussions were held with a few leading experimentalists. Focusing on decision-making situations, an annotated bibliography was prepared and a relatively simple framework for describing decision-making situations was developed by Howard Kunreuther, then of the University of Chicago Business School, and White. This was tested very roughly with two groups of commercial farms in central Florida by Ward. The farmers confront the same frost and wind hazards with crops having contrasting time horizons: tomato farmers who plan less than one year ahead and orange growers who plan for a 20-30 year period. These decisions in themselves can be contrasted to the decision-model being developed for use with very short time horizons, the daily weather forecast by Adams.

The critical examination of decision-making models was carried a step forward by Paul Slovic of the Oregon Research Institute who, drawing on the psychological studies of decision processes, drafted with Kunreuther and White a report on "Decision Processes, Rationality, and Adjustment to Natural Hazards: A Review and Some Hypotheses." These studies led to a separate economic analysis of decision making, including lexicographic methods.

All of the foregoing focused on individual decision-making, but in studies of coastal erosion (Mitchell), water pollution (Hewings), and humid area drought (Arey, Roger Kasperson), an attempt was made to model the community decision-making process. The work dealing with humid area drought, suggests that at least for that hazard in the area studied, crisis generated by drought has not had the effect of encouraging excessive reaction to the hazard either of the type reported for floods or suggested in water supply decisions. On the other hand, a suggestion emerged from the drought study and is being further examined in the context of urban snow hazard by Arey, that a modest amount of hazard-induced stress is actually beneficial to municipal decision-makers with hazard-related responsibilities.

The major hypotheses developed to that point, and the model of choice which they imply were brought together by Kates in Working Paper No. 14.

Taken as a total effort, the work reported on herein suggests that an understanding of the role of uncertainty, crisis and technology in hazard adjustment may come from both laboratory and empirical studies: analysis of judgmental processes in controlled situations; careful descriptions of actual decision-making under uncertainty; historical examination of the aftermath of crisis; and comparative studies of adjustment to similar hazards in societies with different coping technologies.
Improved Research Instruments and Increased Outreach

Related to the research objectives reported on above was a strongly felt need for improved methodology. A search was launched for field instruments suitable for personality assessment including cross-cultural applications. At Toronto, a modified Rosenzweig picture-frustration test was tried but abandoned. At Clark, a photo-choice instrument to classify both general environmental experiences and specific hazard experience was devised but has not seemed promising so far. Also at Clark, a combination of telephone and mail surveys was used to test for seasonal shifts in attitudes toward snow hazard: no significant change was found. At Colorado a sentence completion test using a selection of stems devised by Sims was tried.

Still badly needed is an improved method of eliciting from hazard area residents expected frequencies of hazard occurrence. However, instruments suggested in the original proposal, such as a risk-propensity standard and a sensitivity-to-nature test now seem less promising, partly because of the difficulties involved in their development. The available instruments from North American studies were combined and tested at the Merida Social-Psychological Field Station in the Yucatan in December 1969. They were further revised and tested by Bowden, Barning and a group of undergraduates in the Virgin Islands and in Puerto Rico by Baumann, Sims and a group of graduate students in January 1970. The results were sufficiently promising so that with further changes they became the basis for Working Paper No. 16.

Possibly the most important achievement of the first two years was the widening of the base for new investigations. The work reported herein far exceeds that made possible by the financial support of the grant. Some four hundred research workers around the world receive the working papers of the project and the policy has been adopted of charging for copies provided in the U.S. and Canada. The series of Natural Hazard Working Papers now has sufficient standing orders to cover all direct costs and to enable the series to go on without subsidy.

A research conference held at Williamstown, Massachusetts, in March 1969 was attended by 22 participants and 14 papers were discussed. The analytical methods were applied by Argy and others to a special study of drought and hurricane hazards for the National Water Commission during the summer of 1971. The approach was discussed at the National Academy of Engineering Benefit-Risk Colloquium in April 1971. It figured largely in the symposium on perceptions and attitudes in resource management at the University of Victoria in April 1970, and in the United Nations Seminar on flood loss reduction in Tbilisi, October 9, 1969. Public reports on the research program were given at the August 1970 and April 1971 meetings of the Association of American Geographers.

While much of the work reported on in this progress report was supported by the National Science Foundation, financing also came from Resources for the Future, Inc., the U.S. Office of Water
Resource Research, the Canadian Emergency Measures Organization, the Canadian National Advisory Committee for Geographical Research, the Rockefeller Foundation, UNESCO, and various university research and fellowship funds.

Comparative Studies

In the original research proposals we set the following goal:

At the end of the first three years, we want to have completed at least two studies designed to extend existing research in areas with high potential social gain (a pilot study of drought in Tanzania and an analysis of optimal snow adjustment in North America), to have developed and tested cross-culturally a set of improved research instruments (personality assessment measures and methods of describing decision-making), and to have completed the preliminary comparative studies sufficient to choose the sites for the major field studies in the fourth year of the project (literature reviews, measures of physical hazard).

This minimal goal was met, and work began on a series of comparative studies and national studies. The major emphasis in the concluding phase of the research was on an extensive set of cross-cultural comparisons of various hazards and on applying the results of these new studies and previous North American research to the now recognized global problems of natural and man-made environmental hazard.

Comparative studies were completed at two levels of complexity. On the observational level, interested scientists were invited to make use of our simplified perception-adjustment questionnaire and method for describing decision-making situations, and to apply these to a local set of hazard situations particularly significant to their national life. Sponsorship for such comparative observations was provided by the Commission on Man and Environment of the International Geographical Union. The response here was encouraging.

Status of Field Observations*

<table>
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<tr>
<th>Hazard</th>
<th>Area</th>
<th>Investigator and Affiliation</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>Air Pollution</td>
<td>Budapest, HUNGARY</td>
<td>Ferenc Probald Eötvös Loránd Tudományegyetem Foldrajzi Intézet</td>
<td>120 interviews coded, preliminary analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kun Béla tér 2 Budapest, Hungary</td>
<td></td>
</tr>
<tr>
<td>Air Pollution</td>
<td>Edinburgh, SCOTLAND, UNITED KINGDOM</td>
<td>Douglas Billingsley Department of Geography University of Edinburgh</td>
<td>180 interviews coded, preliminary analysis</td>
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<td>Hazard</td>
<td>Area</td>
<td>Investigator and Affiliation</td>
<td>Status</td>
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<td>Air Pollution</td>
<td>Exeter, England, UNITED KINGDOM</td>
<td>Mark Blacksell, Department of Geography, University of Exeter, The Queen's Drive, Exeter, Devon, England</td>
<td>120 interviews coded, preliminary analysis</td>
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<td>Air Pollution</td>
<td>Ljubljana, YUGOSLAVIA</td>
<td>David Kromm, Department of Geography, Kansas State University, Manhattan, Kansas</td>
<td>160 interviews coded and analyzed</td>
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<td>Air Pollution</td>
<td>Sheffield, England, UNITED KINGDOM</td>
<td>Geoffrey Wall, Department of Geography, Sheffield University, Sheffield, England</td>
<td>120 interviews coded, preliminary analysis</td>
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<tr>
<td>Avalanche (Earthquake)</td>
<td>Huaylas Valley, PERU</td>
<td>Carlos Penaherrera de Agiula, University of San Marcos and National Planning Institute, Lima, Peru</td>
<td>86 interviews completed, but data not suitable for analysis</td>
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<td>Coastal Erosion</td>
<td>Bolinas, California, U.S.A.</td>
<td>Rowan Rowntree, Department of Geography, Syracuse University, Syracuse, New York</td>
<td>120 interviews coded and analyzed</td>
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<tr>
<td>Drought</td>
<td>South AUSTRALIA</td>
<td>R. Leslie Heathcote, School of Social Sciences, Flinders University of South Australia, Bedford Park, South Australia</td>
<td>181 interviews coded and analyzed</td>
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<td>Drought</td>
<td>Northeast BRAZIL</td>
<td>Reuben Brooks, Department of Geography, George Peabody College for Teachers, Nashville, Tennessee</td>
<td>467 interviews coded and analyzed</td>
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<td>Drought</td>
<td>Eastern KENYA</td>
<td>Philip Mbithi, Institute of Developmental Studies, University of Nairobi, Nairobi, Kenya</td>
<td>600 interviews coded, preliminary analysis</td>
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<td>Benjamin Wisner, Faculty of Medicine, University of Dar es Salaam, Dar es Salaam, Tanzania</td>
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<tr>
<td>Drought</td>
<td>Northwestern NIGERIA</td>
<td>Wolf Roder Department of Geography University of Cincinnati Cincinnati, Ohio</td>
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<td></td>
<td></td>
<td>Herbert Dupree Department of Geography University of Michigan Ann Arbor, Michigan</td>
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<tr>
<td>Drought</td>
<td>Sukumaland, TANZANIA</td>
<td>Thomas Hankins 64 Nola Drive Holden, Massachusetts 01520</td>
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<td></td>
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<td>Carlos Parra Earth Sciences Department New Mexico State University Las Cruces, New Mexico</td>
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<tr>
<td>Drought</td>
<td>Yucatan, MEXICO</td>
<td>Edgar Jackson Department of Geography University of Toronto Toronto, Ontario</td>
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<td>Tapan Mukerjee Department of Economics University of the Pacific Stockton, California</td>
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<td>Earthquake</td>
<td>Cornwall, Ontario, CANADA</td>
<td>Edgar Jackson Daya Hewapathirane Department of Geography University of Colorado Boulder, Colorado</td>
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<td>Earthquake</td>
<td>San Francisco, California, U.S.A.</td>
<td>R. Ramachandran Department of Human Geography University of Delhi Delhi, India</td>
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<tr>
<td></td>
<td></td>
<td>Takamasa Nakano Tokyo Metropolitan University Tokyo, Japan</td>
<td></td>
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<tr>
<td>Flood</td>
<td>Rural CEYLAN</td>
<td>R. J. &amp; M. E. Cheatle Chancellor College University of Malawi Limbe, Malawi</td>
<td></td>
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<td>Flood</td>
<td>Ganges, INDIA</td>
<td>150 interviews coded and analyzed</td>
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<td>Flood</td>
<td>Kochi, JAPAN</td>
<td>474 interviews coded and analyzed</td>
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<td>Flood</td>
<td>Chiromo, MALAWI</td>
<td>118 interviews coded and analyzed</td>
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<tr>
<td>Flood</td>
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<td>120 interviews coded and analyzed</td>
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<td>66 interviews coded and analyzed</td>
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<td>116 interviews completed, no data received</td>
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<td>Flood</td>
<td>Shrewsbury, Wales, UNITED KINGDOM</td>
<td>Donald Harding, University College of Swansea, Swansea, Glamorgan, Wales</td>
<td>132 interviews coded and analyzed</td>
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<td>Frost</td>
<td>Wasatch, Utah, U.S.A.</td>
<td>Richard Jackson, Brigham Young University, Provo, Utah</td>
<td>completed, no data received</td>
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<td>Hurricane</td>
<td>Coastal BANGLADESH</td>
<td>M. Aminul Islam, Department of Geography, University of Dacca, Dacca, Bangladesh</td>
<td>253 interviews completed, only partial data received</td>
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<td>Hurricane</td>
<td>Galveston, Texas, U.S.A.</td>
<td>Duane Baumann, Department of Geography, Southern Illinois University, Carbondale, Illinois</td>
<td>2 studies - 120 interviews each both coded and analyzed</td>
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<td>Hurricane</td>
<td>Pass Christian, Mississippi, U.S.A.</td>
<td>Duane Baumann, John Sims</td>
<td>120 interviews coded and analyzed</td>
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<td>Hurricane</td>
<td>PUERTO RICO</td>
<td>Duane Baumann, John Sims</td>
<td>147 interviews coded and analyzed</td>
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<td>Hurricane</td>
<td>Tallahassee, Florida, U.S.A.</td>
<td>Duane Baumann, John Sims</td>
<td>120 interviews coded and analyzed</td>
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<td>Hurricane</td>
<td>VIRGIN ISLANDS</td>
<td>Martyn Bowden, Graduate School of Geography, Clark University, Worcester, Massachusetts</td>
<td>93 interviews, coded and analyzed</td>
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<td>Landslide</td>
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<td>Takamasa Nakano Tokyo Metropolitan University Tokyo, Japan</td>
<td>interviews completed, no data received</td>
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<td>Pesticides</td>
<td>San Luis Valley, Colorado, U.S.A.</td>
<td>Daniel Amaral Graduate School of Geography Clark University Worcester, Massachusetts</td>
<td>28 interviews coded, preliminary analysis</td>
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<td>Tornado</td>
<td>Kansas, Oklahoma, Alabama, Illinois, Massachusetts, Connecticut, U.S.A.</td>
<td>Duane Baumann John Sims</td>
<td>420 interviews no data received</td>
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<td>Snow</td>
<td>Marquette, Michigan, U.S.A.</td>
<td>Fillmore Earney Department of Geography Northern Michigan University Marquette, Michigan</td>
<td>120 interviews coded and analyzed</td>
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<tr>
<td>Wind</td>
<td>Boulder, Colorado, U.S.A.</td>
<td>Don Miller 789 9th Street Boulder, Colorado</td>
<td>96 interviews, coded and analyzed</td>
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<tr>
<td>Volcano</td>
<td>COSTA RICA</td>
<td>Gilles Lemieux Department of Geography University of Calgary Calgary, Alberta Canada</td>
<td>170 interviews coded and punched</td>
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<td>Volcano</td>
<td>Kilauea, Hawaii, U.S.A.</td>
<td>Brian Murton Department of Geography University of Hawaii Honolulu, Hawaii</td>
<td>101 interviews coded and analyzed</td>
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</table>

*Excluding observations made as part of national studies.

On the national level, we attempted to organize at least two studies, one in a developing and the other in a developed nation, for each of four hazards: drought, flood, earthquake, and hurricane. Each study was to involve a review of the significance of the hazard in national life, the theoretical and practical range of adjustments, four or more sample field studies in contrasting frequency areas to detail the perception of hazard and the adoption of adjustments, and an analysis of potential reduction in the social cost of the hazard.
These plans were changed by the deletion of several studies and the addition of another.

Preparation for the national studies was advanced by a draft manual put together in 1970 at Toronto, and by detailed planning at Clark for the drought investigations. The latter planning centered on a conference (April 2-5, 1970) for which the list of participants and papers is given in an appendix. A subsequent working session at Sunapee, New Hampshire involved Banning, Kates, Porter, Wisner, R. Howard, and G. Knight of Kansas.

On a third level of detail, we originally proposed in-depth systems analysis of the drought hazard in a developing and developed country. This analysis was combined with two of the national studies.

Through our association with several international government and non-government groups, opportunities were found to extend the research to other areas with only minimal support from the N.S.F. funds. The International Geographical Union (I.G.U.) established in December 1968 a new Commission on Man and Environment which decided to promote 1) case studies of the effects of human manipulation of environment, and 2) comparative studies of adjustments to natural hazards and perception of them. For the latter work, the methods of study were drawn from our research. Burton and White are members of the Commission, the other members being Professor David Amir of Israel, Academician Gerasimov of the USSR, Professor T. Nakano of Japan, Professor E. Neef of the Democratic Peoples Republic, and Dr. R. Ramachandran of India. As reorganized in the summer of 1972, Professor S. Leszczycycki of Poland was added, and Professors Neef and Ramachandran were dropped.

The ad hoc committee on Problems of the Human Environment established by ICSU (International Council of Scientific Unions) was advised of the activities of the I.G.U. Commission, and its first report stresses the need for international collaboration in research on environmental hazards.

The UNESCO Advisory Committee on Natural Resources Research provided general endorsement for the research program described in this report. UNESCO also provided modest support for organization by the I.G.U. Commission on Man and Environment of an international seminar on methodology for comparative studies, held in Gödöllő, Hungary, August 4-9, 1971. Scientists from 12 countries (Belgium, France, German Democratic Republic, Hungary, India, Israel, Japan, New Zealand, United Kingdom, U.S.A., U.S.S.R., and Yugoslavia) took part and indicated their willingness to collaborate on such a program. The International Geographical Congress at Montreal in August 1972 and a meeting of the Commission in Calgary, late July 1972 were set as targets for reports on comparative observations.

As a result of the Gödöllő seminar two other goals were set for the Calgary and Montreal meetings. One was the completion of a series of global summaries of the forms of human response to selected hazards. On the basis of draft materials, compiled by Anne U. White and presented at Gödöllő, it was decided to begin with summaries for drought, earthquake, tropical cyclones, and hail. The other goal
was the stimulation of a series of national reviews of the natural hazard situation. Professor Nakano of Tokyo Metropolitan University and Academician Gerasimov of the USSR Academy of Sciences brought preliminary reports of this character for their respective countries and then revised them.

The major findings from the comparative studies are incorporated in a volume which is to be published by the Oxford University Press in the spring of 1974. Its table of contents is given as an appendix.

The Commission prepared for the Secretariat of the United Nations Conference on the Human Environment, Stockholm, June 1972, a brief statement of the application of the research so far completed to international policy regarding hazards. The resolutions of that Conference contain explicit reference to the need for new policy in coping with natural hazards.

Finally, we have drawn together the results of the five-year research program in a form suitable for publication by the Oxford University Press as a short book by the three principal investigators. This may be expected to provide a culmination to the program by setting forth the state of knowledge achieved by that time on natural hazards, and by developing to some extent the implications of the research for environmental hazards of all kinds. A draft currently is under review and we expect that a final draft will be completed during the Spring of 1974.

Just as natural hazards are a subset of environmental hazards, so man's struggles with his environment are only part of the total stress to which individuals and societies respond. Human life without stress is unimaginable. Where there is no stress there is no life. Our research has just begun to uncover examples of human behavior in relation to natural hazards which appear to be more or less deliberately stress-seeking. At present, we can do no more than speculate about the human need for stress and the role of the natural environment in meeting part of that need.

Comparative Field Observations

Each collaborator making field observations has used Working Paper No. 16 as a guide, changing the procedures outlined there as may be appropriate to the local situation. In most cases the changes involve slight changes in wording, or the addition of questions. The coded results were sent to Colorado for elementary data processing, including frequencies and measures of association for selected variables. All of the sentence completions were classified and coded in Colorado. The individual investigators have been free to use the resulting materials in any way they choose, but the basic materials are available for comparative study.

The project has contributed small sums to cover part of miscellaneous field expenses, and provided the projective test analysis and basic data processing.
National Studies of Selected Hazards

The national studies of drought went forward in good order. Leslie Heathcote of Flinders University carried out the work in Australia with national support. Kates and a number of faculty at the University of Dar es Salaam completed the field work in Tanzania with the support of the Rockefeller Foundation.

The work on tropical cyclones (hurricanes) was initiated in East Pakistan by M. Aminul Islam of the University of Dacca before the disastrous November 1970 cyclone struck. His reconnaissance study of a sector of the coast is an invaluable observation on conditions making for the disaster, and was reported to the ECAFE Seminar on Tropical Cyclones in October. Subsequent field work was greatly impeded by the civil war in Bangladesh. After a long suspension it was renewed, and Islam was drawing together his findings in the autumn of 1973. In the United States, observations were made in three selected communities on the Florida, Alabama, and Texas coasts under the sponsorship of Baumann, Patton, and Cook.

The flood study in Ceylon was a partial casualty of political mutiny. Daya Hewapathirane lost many of the field interviews, but went back into the field with the cooperation of the responsible government ministries, and completed the interviews in 1972. A final draft was in sight in the autumn of 1973. No national studies of floods in Canada were undertaken, but a brief comparison was made of Canadian and United States experience.

Because of difficulties in finding suitable collaborators, earthquake studies were abandoned. In their place air pollution was selected as a hazard involving large human responsibility for its generation but also closely linked to physical conditions. With the support of Resources for the Future, Burton initiated studies of the differential response to air pollution in selected cities in the United Kingdom. Local university faculty cooperated in each case. Observations were made in Exeter (Mark Blacksell), Edinburgh (Douglas Billingsley), and Sheffield (G. Wall). These were reported at Calgary, and a special volume of analysis of the United Kingdom air pollution experience is being prepared for publication at Toronto.

Global Summaries

In addition to the three sample global summaries to be published in the Oxford University Press volume, we have initiated an effort to use this outlook and information in the new United Nations Disaster Relief Office which was established by the United Nations Assembly in the autumn of 1972. In a series of discussions with the staff of that office, it was agreed that the Commission would provide the drafts of papers on human response to hurricanes, floods and tornadoes which would be joined with papers by UNDRO on disaster preparedness and by WMO on the physical features and forecasting of those phenomena. UNDRO then would undertake to arrange for publication of whatever text might finally be approved. The input from this research program thus would be an analysis on means of preventing disasters and would be circulated to admin-
istrators in member nations.

Other Extensions of the Program

Beyond the activities cited above, the research program has led to extension of its concepts and methods in both national and international directions.

In the United States, a number of the participants have joined in projects supported by the NSF program on Research Applied to National Needs. These include: the Assessment of Research on National Hazards, 1972-74 (White is a co-principal investigator, and Burton and Kates are consultants); Post-Disaster Community Policy Issues, 1973-74 (Kates is a senior investigator); and Reducing Losses From Selected Natural Hazards. (Kunreuther is the principal investigator). All of these built upon experience and methods developed in the program.

People associated with the program contributed to the work of the National Water Commission on matters relating to risks in water availability. David G. Arey and Duane D. Baumann co-authored a background study on Alternative Adjustments to Natural Hazards. Tapan Mukerjee also submitted a report to the National Water Commission on drought hazard which was released through the National Technical Information Service.

The UNESCO Man and Biosphere Programme has been organized during 1972 and 1973 to outline a variety of international activities along a few organizing themes. One of these is the problem of environmental perception. In the report suggesting activities dealing with that problem (Expert Panel on Project 13: Perception of Environmental Quality, Final Report, Paris, 26-29 March, 1973) the findings and outlook developed in the Natural Hazards program have a prominent place. It may be expected that further work on these questions will be undertaken by UNESCO national committees as a part of the MAB effort.

In October 1973 SCOPE adopted a new program for assessment of changes in the global environment. This effort will involve almost all the major international scientific unions as well as national committees. One important component will be examination of the conditions affecting societal response to man-made environmental hazards. This draws very heavily upon studies of natural hazards such as pesticides and industrial stack emissions. Burton has been asked to serve as chairman of a SCOPE commission to guide this activity.

The collaborative program thus moves into its final stage with significant output from the program in terms of research findings, with several direct applications of those findings to public policy activities, and with the knowledge that it, has instigated a number of cooperative activities which will continue after its termination.
APPENDICES

List of Publications
   Working Papers
   Journal Articles
   Books and Monographs
   Dissertations and Theses
   Dissertations in Progress

DROUGHT CONFERENCE, 1970
UNESCO SEMINAR ON NATURAL HAZARDS, 1971
IGU MAN AND ENVIRONMENT COMMISSION MEETING, 1972

TABLE OF CONTENTS FOR NATURAL HAZARDS: LOCAL, NATIONAL AND GLOBAL,
IN PRESS
LIST OF PUBLICATIONS

Working Papers


LIST OF PUBLICATIONS (continued)


Journal Articles


LIST OF PUBLICATIONS (continued)


LIST OF PUBLICATIONS (continued)

Books and Monographs


Dissertations and Theses


LIST OF PUBLICATIONS (continued)


Dissertations in Progress

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Clark University, April 2-5, 1970

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<thead>
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<th>Name</th>
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<tr>
<td>Andris Auliciems</td>
<td>Environmental Climatology</td>
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<td>Walker Banning</td>
<td>Drought Models/Australia</td>
<td>Clark</td>
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<tr>
<td>Duane Baumann</td>
<td>Behavioral Hazard Research</td>
<td>Clark</td>
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Gilbert F. White, Notes on Comparative Study of Agricultural Drought in Australia and Tanzania.

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TABLE OF CONTENTS FOR NATURAL HAZARDS: LOCAL, NATIONAL, GLOBAL, In Press

Part I: Natural Hazards Research: Concepts, Methods, and Policy Implications

1. Natural Hazards Research: Concepts, Methods, and Policy Implications, Gilbert F. White

Part II: Individual and Community Response

2. Tropical Cyclones: Coastal Bangladesh, M. Aminul Islam
3. Human Response to the Hurricane, John H. Sims and Duane D. Baumann
4. Attitudes Toward Hurricane Hazard on the Gulf Coast, Earl J. Baker and Donald J. Patton
5. India and the Ganga Floodplains, R. Ramachandran and S. C. Thakur
6. Flood Hazard at Shrewsbury, United Kingdom, Donald M. Harding and Dennis J. Parker
9. Coastal Erosion: The Meaning of a Natural Hazard in the Cultural and Ecological Context, Rowan A. Rowntree
11. Drought in Eastern Kenya: Nutritional Status and Farmer Activity, Benjamin Wisner and Philip M. Mbithi
12. Response to Drought in Sukumaland, Tanzania, Thomas D. Hankins
14. Coping With Drought in a Preindustrial, Preliterate Farming Society, Herb Dupree and Wolf Roder
15. Individual and Community Response to Rainfall Variability in Oaxaca, Mexico, Anne V. Kirkby
16. Drought in South Australia, R. L. Heathcote
17. Decisions by Florida Citrus Growers and Adjustments to Freeze Hazards, Robert N. Ward
18. Frost Hazard to Tree Crops in the Wasatch Front: Perception and Adjustments, Richard H. Jackson
19. Human Adjustment to Volcanic Hazard in Puna District, Hawaii, Brian J. Murton and Shinzo Shimabukuro
20. Human Adjustment to the Earthquake Hazard in San Francisco, California, Edgar L. Jackson and Tapan Mukerjee
22. Avalanche Problems in Norway, Gunnar Ramsli
23. Problems in the Use of a Standardized Questionnaire for Cross-Cultural Research on Perception of Natural Hazards, Thomas F. Saarinen
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