

# XI. Knowledge Gaps and Research Needs

The purpose of this chapter is to identify what information is needed which, if provided, will assist Congress in policy formulation, legislation, budget allocations, and oversight on flood hazards management.

## WHY RESEARCH?

Research and systematic study are increasingly important to the policy process since they are primary tools for understanding complex interrelationships, for effectively gathering empirical information, for defining alternative actions, and for providing a means of evaluating their practicality and effectiveness.

With regard to flood hazards management, there are at least five distinct considerations justifying research:

- The *empirical base* is weak for policy formulation, decisionmaking, and implementation with regard to floods, flood hazards, and flood hazards management. In terms of the dollars at risk, or the total and recurrent Federal commitment, the knowledge base is surprisingly sparse.
- *Reduction of uncertainty* is a primary function of Government, and research is an important tool for providing credible knowledge to those making policy, administrative, and technical decisions.
- *Planning for research and development* by agencies is fragmented, underfunded, and too limited in scope. Much of the flood hazards research has neither a significant policy focus nor a discernible client.
- *Emphasis on physical problems and measures*, the historical pattern of flood research is continuing in the face of new policy direction toward nonstructural approaches.
- *Criteria of effectiveness* can be major contributions of research, especially as they enable realistic and realizable goals to be set.

Flood hazards research should have a multi-agency base. For greatest effectiveness, research units should be located within each agency con-

cerned with flood hazards and the related institutional and economic infrastructure of a flood region. Many agencies, such as the Federal Insurance Administration (FIA) and the Federal Home Loan Bank Board, have, at best, weak internal research units. As a consequence, they cannot adequately define research needs or interpret research results from outside sources that relate flood hazards to their larger mission. The following are the key elements of an adequate policy R&D program.

- Information needs should be determined by the research sponsoring agency for itself while taking the needs of other interested parties into account. These include the executive branch itself, Congress, State, local, and other governmental users, private sector agencies, associations, and individual citizens.
- The plan should be systematic but allow for its own evolution in terms of time, budget, and topical priorities.
- A plan to disseminate timely information effectively and actively to all parties-at-interest must be built into each program and project at its beginning.
- The research plan should consider the utilization of research results, i.e., how to make the information influence public and private decisions.
- Research programs should have their own evaluation plan including explicit criteria, schedules, and mechanisms for correction and feedback.

## WHAT IS CURRENTLY KNOWN WITH RESPECT TO FLOOD HAZARDS MANAGEMENT?

Since research is primarily a mechanism for generating knowledge, before turning to specific research priorities, a brief inventory of what is currently known about flood hazards follows:

- The extent of aggregate (national) and (local) exposure to floods, as reflected in mortality, personal injury, and property loss data.

- There are data on the historical frequency and magnitude of floods in many specific flood hazard areas.
- Demographics, economics, and other social studies are well enough understood to be used to identify trends that impinge on floodplain development, uses, and occupancy.
- Past experience, with its strong reliance on structural engineering controls, has shown that nonstructural controls must be introduced and made to work in concert with the engineering approaches.
- There is a large flood insurance program in place that has almost 16,100 participating communities and 1.3 million policyholders indemnified for \$43.8 billion. This suggests grassroots support for a program with the proper incentives.

## **KNOWLEDGE GAPS IN FLOOD HAZARDS MANAGEMENT**

There are five main areas where additional knowledge is needed:

- the generation of information,
- the transmission of information,
- the utilization of information,
- the effectiveness of already established hazards-related programs, and
- information gaps in the National Flood Insurance Program (NFIP).

Inadequate information about NFIP is specifically noted because this program plays such a prominent part in flood hazards management.

### **Generation of Information**

Federal disaster research needs to be coordinated. There is no systematic plan across agencies, with the private sector, with State and local governments, and with Congress for identifying information needs for policy setting, program planning, land use management, and engineering design utilization.

- The means are inadequate for identifying and transmitting State and local information needs to the Federal agencies.
- There is little R&D being conducted at the Federal level that could help generate integrated information. Case studies would be useful.

- There is no mechanism for determining what needs to be known to improve flood hazards management.
- There are not enough first-rate researchers in the field due to the lack of steady and adequate support and because there is no sense of urgency on the part of the Federal Government.

### **Transmitting Information**

- There are, at present, no criteria that have been established for determining the relative success or failure of programs over the whole lifecycle of flood hazards.
- The functions of the various components of a delivery system—who should be transmitting information to whom and in what form—have not been clearly determined and assigned at the Federal agency level.
- There is no single information source for the data and information produced by the various Federal technical, planning, and operating agencies.
- The extent to which Federal agencies concerned with flood hazards management should take an active role in gathering information about flood hazards is not clearly mandated.
- There are shortcomings in the dissemination of information, both to the public and to public officials and organizations, about the potentials of flood hazards. The lack of coordination among Federal agencies is responsible.

### **Use of Information**

- The criteria for determining whether there has been a discernible impact on the decision processes of individuals and organizations have not been established.
- What are the ways in which the utilization of information differs from its dissemination and transmission?
- The absence of programming and policy goals and the lack of a client orientation undercut attempts at full utilization of information, even when available.

### **The Effect of Long-Established Hazards-Related Programs**

There is an almost complete lack of a useful knowledge base about the extent to which hazards are affected by such agencies as the Corps of

Engineers, the Federal Disaster Assistance Administration, the Small Business Administration, or those more remotely connected but potentially important agencies such as the Federal Home Loan Bank Board, the Federal Housing Administration, and the Veterans Administration. Similarly, the effects of the mortgage industry, insurance companies, and builders, are not known.

### **Flood Insurance Program Information Gaps**

- Who purchases flood insurance, and for what reasons?
- Which communities drop out of the program and why?
- How can Federal agencies relate better to local needs?
- Who at the local level are responsible for identifying the needs and making plans for their communities?
- What is the effect of new construction during the emergency program on the demands on NFIP that will be made in the future?
- To what extent has NFIP reduced or altered the need for disaster assistance? Which communities exemplify this change?

The recent formation of the Federal Emergency Management Agency (FEMA) is a significant step to correct or compensate for the above deficiencies in information generation, transmission, and utilization. (The many critical issues that a new organization faces, which are discussed in detail in a companion paper cited in the preface, suggest that the necessary changes to correct these deficiencies cannot come about without congressional intervention.)

## **POLICY RESEARCH PRIORITIES**

The policy-oriented research topics suggested below would put flood hazards management at all levels of government on sounder footing. The topics relate to six categories:

- planning for flood hazards management,
- integration and coordination of programs and projects,
- warning systems,
- legal issues,
- economics, and
- insurance.

Forty-six study and research proposals are shown in table 21. Rather than being presented in the above categories, they are arranged in relationship to four congressional functions—legislation, policy formulation, budget allocation, and oversight.

Professor Gilbert F. White and his associates at the University of Colorado have proposed a comprehensive flood hazards research program.<sup>1</sup> Their recommendations for areas of research are shown in tables 21 and 22. The recommendations suggested in this report emphasize policy and decision-oriented research. Although some of the subjects noted below have received some research support, on the whole it has been inadequate.

### **Budget**

**Use of remote sensing and other advanced data collection techniques.**—Remote sensing from space and aircraft, mapmaking using digitalized data storage, and other technologically sophisticated methods of information gathering could provide new and valuable data. Current efforts are largely uncoordinated and inadequately supported.

**The long-term** (25 to 50 years) merits investigation for—

- flood insurance with or without regulation and with various levels and patterns of regulation,
- acquisition of flood hazard lands, and
- strategies for flood hazards management.

**General cost-effectiveness of alternative mitigation techniques.**—The cost-effectiveness of alternative techniques for mitigating flood hazards warrants examination. (This is currently being done in the Connecticut River Basin under section 73 of the Water Resource Development Act of 1974.)

**Cost-effectiveness of warning systems.**—Warning systems provide information immediately preceding a potential disaster. Additional research is needed to ascertain the costs, benefits, and effectiveness of warning systems.

**Funding implementation programs for warning systems in small communities.**—Funds are needed to study ways that small-sized

<sup>1</sup>Gilbert F. White, *Flood Hazard in the United States*, Monograph #NSF-RA-E-75-006 (Boulder, Colo.: Institute of Behavioral Science, University of Colorado), p. xviii.

Table 21.-Funding Levels for Research Opportunity Sets

Research opportunities	Current annual level <sup>a</sup>	Suggested additional research in person-years	Time horizon for research
<b>Control and protection works</b>			
Urban sewer and storm drainage.....	1	100	10
Channel hydraulics.....	2	50	10
<b>Warning systems and flood-proofing</b>			
Forecasting methods and flood-proofing.....	1	100	10
Methods of improving warning programs.....	1	60	10
Flood-proofing technology.....	0	40	10
Physical and social aspects of flood-proofing.....	0	10	5
Feedback effects of flood-proofing.....	0	5	5
<b>Land use management</b>			
Adoption processes.....	0	30	10
Social effectiveness.....	1	8	5
Coordination of measures.....	0	30	10
<b>Insurance, relief, and rehabilitation</b>			
Hazard awareness and insurance adoption.....	1	?	10
Linkage with land use.....	2	—	
Compulsory flood insurance.....	0	5	5
Influence on flood loss potential.....	0	10	
Relief and rehabilitation impacts.....	1	50	3-10
Methods of providing relief.....	0	10	3
<b>Basic data and methods</b>			
Flood frequency estimation methods.....	3	100	10
Hazard mapping methods.....	1	25	5
Flood damage variables.....	1	100	10
Public participation in project choice.....	1	100	10
Optimal mix of adjustments.....	1	60	5

<sup>a</sup> 0 = no expenditures or less than \$10,000

1 = \$10,000-\$100,000

2 = \$100,000-\$1,000,000

3 = \$1,000,001-\$2,000,000

4 = \$2,000,001-\$4,000,000

SOURCE: Gilbert F. White and Eugene J. Haas, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 251.

communities can adopt suitable warning systems. The requests to the National Weather Service for implementing this objective are apparently beyond its capacity to meet the demand.

## Policy

**Reassessment of the efficacy of the 100-year flood guideline and study of the implications of alternative standards.**—The 100-year flood, which is the present standard in general use for planning, needs re-examination, particularly with respect to its long-term effectiveness and the desirability of a transition to alternative standards. In addition, the implications of such standards on the various participants in floodplain management, which include planners, engineers, designers, developers, homeowners, and Federal, State, and local officials, should be investigated.

**A handbook of maximum credible flood disasters in each flood-prone region of the United States.**—A handbook containing a description of the most serious flood hazards for each flood-prone region of the United States on a State-

by-State basis should be prepared. It should particularly emphasize areas of high population density or those subject to extensive flood hazards. There should also be efficient means for distributing the information.

**Development of options for local governments to accumulate disaster "war chests."**—State and local governments could be motivated and assisted by the Federal Government to develop some form of disaster funds.

**Preparation of a manual for States to ascertain the cost-effectiveness of different flood strategies.**—A manual for State and local governments containing information about costs and benefits in flood hazards management should be one element of the general delivery of information to these governments.

**A comprehensive guidebook to Federal grants and assistance for all aspects of disaster planning, response, and rehabilitation.**—A guide to Federal grants, aids, and assistance in the form of a regularly issued bulletin would keep

Table 22.-Research Opportunities-Hurricanes

	National aims								Research findings	
	Economic efficiency Reduction of net losses Benefits—costs		Enhancement of human hith. Reduction of casualties		Avoidance of social disruption		Environ.	Equity	Expected success of research	Likelihood of adoption
Hurricane modification . . . . .	High	Low-Neg	High	Low-Neg	High	Low-Neg	?	Low	Low	Med
Hurricane dynamics										
Technology										
Socioeconomic effects										
Warning systems . . . . .	Low	Low	High	High	Med	Med	NA	Med	High	Med
Evacuation methods										
Dissemination and response										
Land use management . . . . .	High	High	High	High	High	High	High	Low	High	Low
Hazard mapping method										
Adoption of management										
Socioeconomic effects										
Hurricane-proofing technology adoption										
Insurance . . . . .	Med	Low	Low	Low	Low	Med	Low	Med	Med	High
Policy formulation										
Adoption of insurance										
Relief and rehabilitation . . . . .	Low-Neg	Low-Neg	Low	Low	High	High	NA	High	Med	Med
Trends, policy, socioeconomic effects										

Med = Medium

Neg = Negative

? = In doubt

NA = Not applicable

SOURCE: Gilbert F. White and Eugene J. Haas, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 250.

those most in need of such information aware of the available help. This, in turn, might serve to encourage improved coordination among the various Federal programs.

One-stop government.—One stop in the Federal Government dealing with flood hazards management and information would simplify the efforts of State and local governments and private interests. Attention should be given to alternative ways of setting up specific management, budgetary, and organizational functions to coordinate the flow of information in all directions and to centralize responsibility and authority.

### Legislation

The value of integrating the management of flood hazards with the management of other hazards needs further study.

Further use of the “unified national program” approach to identify operational steps for converting concepts into programs and projects.—“A Unified National Program for Floodplain Management” is a Water Resources Council report submitted in response to section

1302 (c) of Public Law 90-448, the National Flood Insurance Act of 1968. This program could be used as the starting point from which to develop additional projects with the cooperation of States, local governments, and others with a stake in the outcome of reducing flood risks in floodplains.

The integration of flood warning with other natural and manmade hazards warning and information systems merits research.

Study of the existing authorities of the agencies, police powers, the “taking issue,” and tort liability as it applies to the engineering and design professions.—The existing authorities, policies, and activities of Federal agencies as these relate to the lifecycle of natural hazards should be analyzed with the object of identifying their present capabilities with respect to the management of flood hazards.

Alternative decisionmaking and conflict resolution methods.—The necessary flexibility in response to individual circumstances within the framework of maintaining and achieving public policy and statutory goals might be achieved bet-

ter through wider use of arbitration, mediation, or other more flexible judgmental mechanisms.

## **Oversight**

**Case histories of successful and unsuccessful flood management strategies.**—Case histories could help to develop an understanding of the conditions that lead to successful management of flood hazards.

**Alternative modes of information delivery.**—Face-to-face information delivery, as exemplified by the Agricultural Extension Service, is considered by many to be the most effective way to deliver information on a continuing basis. Further study is needed to determine its applicability to flood hazards.

**Effects of specific Federal predisaster, disaster, and postdisaster actions on floodplain management.**—Study is needed of the effects on floodplain management and flood risks and losses of Federal actions with respect to flood disasters. The effects of postdisaster aid, relief, and loans programs on future hazards is not well understood, although such measures could reduce future losses.

**Alternative decisionmaking arrangements for preparing plans and for the regulation of the floodplain.**—A systematic attempt should be made to apply innovative decisionmaking techniques to hazards management.

**The perception, interpretation, and use of information about risks by the public-at-large.**—Improving the public's understanding of the statistics relating to risks, probabilities, vulnerabilities, and hazards could have substantial payoff in information delivery.

**Analysis of the long-term geophysical and environmental phenomena related to floods.**—The study of geophysical and environmental phenomena with particular emphasis on the longer term effects would provide a perspective for the next 25 to 50 years. Topics for study include:

- catastrophic flood events,
- shore erosion,
- runoff patterns,
- changing sea levels,
- reservoir sedimentation,
- climate and weather changes,
- urbanization of watersheds and coastal zones,

- aging reservoirs and other fresh and waste water systems, and
- effects of civil works (e.g., dams, levees, and other similar flood control measures).

**Review of foreign experience pertinent to the U.S. situation.**—The experience of foreign industrialized nations in dealing with environmental hazards similar to those in the United States could be useful. For example, the recent Dutch experience in planning protection of the estuary at Oosterschelde may be applicable to U.S. circumstances. A recent study by the Canadian emergency planning group—"Asset or Liability in Land Use Control" (summarized in table 23) draws many similar conclusions to those discussed in this and other studies concerned with the flood hazards situation in the United States.

**The role of the mortgage industry.**—The mortgage industry and its regulations have an enormous influence on construction. Studies are needed of the effects of this influence and their implications for flood management policies.

**The National Flood Insurance Program (NFIP).**—

- actuarial future,
- subsidy and development in floodplains,
- as substitute for disaster assistance,
- choice of participation by individuals,
- retargeting of premiums to local communities,
- gap between adoption and implementation, and
- lessons for other hazards.

In view of the significance of the flood insurance program as part of the national strategy for flood hazards management, the program itself should be subjected to examination, particularly with respect to the following questions.

1. Are the present rates in the regular program considered to be actuarial sound?
2. What is the long-term feasibility of converting the whole program to a fully actuarial, self-sustaining basis?
3. What would be the necessary steps to accomplish this?
4. What would be the benefits and disadvantages to those involved in the program?
5. From the analysis of a series of maximum credible flood disasters, what would be the effect on the program, on communities, the Federal budget, on local economies?

Table 23.-An International Comparison of Flood Hazards: Canada

The following paragraphs are taken from the summary and highlights of the study *Flood Insurance—Asset or Liability*:

1. Floods and the threat of flooding are recurring problems in Canada; it has been estimated that floods pose a menace to over 150 communities.
2. Despite flood protection programs extended over the past 30 years the average annual flood hazard is now greater than it was before such programs were initiated.
3. Rapid increases in flood damages have been accompanied by increases in the payment of disaster assistance and relief by various levels of government.
4. The rising threat of flood damage is due not so much to an increase in the incidence of flooding as it is to a rise in the development of flood vulnerable land. In a sense, then, inappropriate land use is a major factor contributing to the increases in flood damage.
5. Increases in flood damage potential cause escalation in demands for protection from the eventuality of flooding. The costs for providing structural flood control works are spiraling yet flood damages also continue to increase. Obviously a new and complementary range of measures is required if risk, costs, and damages are to be controlled.
6. The benefits of flood protection accrue to a relative minority of the population but are financed out of "public treasuries." This transfer of income from a majority to a minority has raised a number of questions which ultimately relate to the issue of equitable distribution of costs and benefits.
7. Conventional structural measures aimed at controlling floods and reducing flood damages provide only a short-run prescription which fails to touch the roots of the problem. Longer range, more permanent solutions must also be considered.
- a. Inappropriate use of land is one of the key reasons for the increasing incidence of flood damage and the rises in flood hazard. Social, economic, and political goals often conflict with each other and with the mix of land uses. Evidence indicates that present trends will persist unless appropriate land use measures are introduced. In the study at hand "floodplain management" is an important aspect of land use control.
9. Reduction of flood risk and flood damages requires a rational mix of both structural and nonstructural measures. Insurance is presented as a strategy aimed at balancing this mix and achieving stated objectives. Carrying the flood insurance strategy one step further it is suggested that comprehensive disaster insurance also merits investigation.
10. Measures for reducing flood damage are not standardized across the country. Because they are derived from different sets of rules and regulations the magnitude of the problem varies from region to region. The existence of rules and measures is in some areas a reflection of the existence of a flood problem while in other areas their absence may serve to aggravate the flood situation.
11. Many flood-related programs are directed at relief rather than at control or prevention. Although it is recognized that such "ex post facto" measures have a valuable function it is also recognized that they tend to instill apathy in the minds of individuals resident in flood-prone areas. A central issue related to whether or not individuals should be asked to pay for a share of the risks they assume. Associated with the above is the more complex problem of how such measures could be implemented. Insurance is presented as one possibility.
12. If the present range of insurable items were expanded (on a national scale) to include insurance of houses and property (for example) against flooding then these items would no longer be eligible for ad hoc disaster relief (except under conditions of extreme hardship). Through a standardized insurance program people would thus be asked to pay for some of the risk they assume.
13. A crucial question related to how people can be convinced that the insurance strategy is a viable alternative (given that it is). How can individuals be "encouraged" to take out flood or perhaps disaster insurance policies? What range of choices or alternatives are available?
14. Before actuarial rates can be assessed on a sound and standard basis it is necessary that flood- or disaster-prone areas be designated and that an adjustable index of "degree of risk" be assigned to relevant areas. The flood hazard mapping program presently being undertaken by Environment Canada has the potential required to fill that need.
15. Further to the above issues is the question of how people living in disaster-prone areas will react to the availability of an insurance program. Evidence indicates that a system of incentives would be required to aid in marketing insurance policies. Rendering items recoverable by law or insurance ineligible for ad hoc disaster relief programs is one solution. In isolation, however, it is felt that the above mentioned measure would have its greatest impact after the fact. As it is not the aim of a flood damage or hazard reduction program to bankrupt members of the public it is obvious that parallel measures must also be adopted.
16. An example of such a measure exists in the idea that eligibility for federally approved housing loans and grants should be made conditional upon the purchase of disaster insurance. Another possibility rests with refusing loans or grants for development in areas with high flood risk.

SOURCE: Jennifer D. Willis, *Flood Insurance: Asset or Liability*, for Emergency Planning, Canada, April 1976, pp. 1-2.

6. Is the present insurance program structure, with its provisions for emergency participation, to any significant extent subsidizing the developments of new, vulnerable structures? To what extent is it accelerating the development of the floodplain, coastal zone, and other hazardous areas?
7. Should the actuarial and subsidized rates be more flexible to reflect Federal, State, and

local planning needs for flood hazards mitigation, or only for flood losses?

8. To what extent is the insurance program, which is based on historical cases, an effective substitute, a complement, or irrelevant to disaster assistance? An investigation of case histories could shed light on this question.
9. A series of questions relating to the choice by communities to participate or not participate

in the program, and the choice by individuals to buy or not to buy insurance should be examined in the light of aiding agency planning. Variables suggested as warranting examination are:

- physical environment characteristics;
- contextual characteristics-e. g., State regulations;
- demographic characteristics;
- community differentiation-i. e., complexity of organization network;
- political-legal characteristics;
- cultural characteristics;
- economic variables;
- community power structure; and
- implementing body characteristics.

10. Are there more effective alternative uses for flood insurance premiums? Should such premiums be reconsidered as resources available to promote and implement flood hazards management? For example, could premiums from a community form the base for its own implementation plan?
11. The gap between the adoption of a flood management program and its implementation could be enormous. The promises implicit in a program plan frequently fail to become explicit in action. This subject merits close continued review at the individual, county, and municipality levels.
12. The experience and knowledge gained with the **flood insurance program should be examined in the light of their applicability to dealing with other natural hazards as well as with manmade hazards.**

#### **Effects of relocation on business.**

**Examination of the land acquisition question.**—Altering population patterns in areas particularly prone to flood hazards, which are intensively developed, could be a long-term approach to **reducing the risks of disasters.** One approach would be land acquisition by Federal, State, and local, or private agencies. An examination of historical and contemporary projects for land acquisition could help identify appropriate data on which to base a three or four decade-long national program.

**Microeconomic evaluation of impacts of floodplain management.**—Questions about which homeowners and businesses, under what circumstances, would be able or unable to pay the cost of meeting alternative levels of floodplain

management regulation or changed construction costs, modified taxes, flood-proofing, etc., need to be resolved. The costs and effects of relocating business districts in floodplain communities require investigation. This raises questions of means and sources of financing.

**Models for State government programs.**—**Expanding State roles could be facilitated and enhanced by cooperative programs to develop State model programs for flood hazards management.**

**Evaluation of agency compliance with flood management objectives.**—Federal agency compliance with flood hazards management objectives, Policies, and statutes should be examined to determine whether more oversight and enforcement is needed to achieve effective integration of the actions of Federal agencies. At the State level, the objective should be to work towards integration of Federal activities with State programs.

**Opportunities in architectural design related to floods.**—New approaches in the architectural design of domestic and commercial structures to make them less prone to flood damage—particularly in such flood-prone areas as coastal zones and floodplains—should be considered. One approach might be to investigate drastically different architectural designs for these areas. The success of Frank Lloyd Wright in designing structures for hillsides gave us the split-level house. Various measures such as contests and competitions to develop designs for domestic and commercial structures specifically for flood plain and coastal zone hazards areas could lead to significant and useful advances in design.

**Role of tort liability in flood hazards management.**—There is a trend toward accountability in all professions, which is also seen in architecture and engineering. Tort liability is a principal means of activating that accountability. Because architects and engineers make many of the decisions about building design, structural choice, and siting, their potential liability could motivate them to make more prudent decisions. Government and its employees are also potentially liable for failure to adequately warn individuals and organizations of their exposure to risk.

**Use and limitations of cost-benefit analysis in flood hazards management.**—cost-benefit analysis is mandatory in flood control projects under the Flood Control Act of 1936. A re-



evaluation of cost-benefit procedures as used in flood hazards management needs to be undertaken to promote uniform standards and to reduce the potential for misusing this technique by

manipulating assumptions about such factors as discount rate, scope of benefits, and cost evaluation of competing projects.

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