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CHAPTER I

GEOGRAPHIC RESEARCH AND FLOOD DAMAGE REDUCTION

The way men view the risks and opportunities of their uncertain environment plays a significant role in their decisions as to resource management. Urban flood situations well illustrate this relationship. The studies of hazard and choice perception reported in this volume throw new light on the conditions under which men occupy flood plains and, at the same time, yield empirical evidence on the decision-making process.

This dual aspect introduces a certain awkwardness and repetition of elementary material for readers familiar with either flood problems or decision-making theory. For this, the reader's indulgence is craved, and as in all such multi-purpose endeavors, it is hoped that the benefits will outweigh the costs.

To provide the perspective in which geographic research into the human occupance of flood plains may be viewed, much of this chapter is devoted to a restatement of the paradox of greater flood control and increasing flood damages, and the ensuing search for alternative measures of flood damage reduction. The next chapter presents a general discussion of the relevance of decision-making schema in resource management for understanding flood plain occupance.

Later chapters develop the empirical data from a detailed study of one flood-prone community and from reconnaissance examinations of five others differing markedly in flood hazard and geographic setting. Among and within these communities, there is great variability in perception of hazard and alternatives of flood damage reduction. The differences are large even where there is a sharing of common experience with floods, and they are significant among people acquainted with advanced technical knowledge as well as among those having only a rudimentary popular knowledge of the situation.

The certainty of flood occurrence, as it differs from place to place, appears to underlie this diversity of perception and to influence the way men attempt to order their activities to reduce the threat of natural hazard.

Twenty-Five Years of Flood Control Activity

On June 22, 1936, the Congress of the United States declared that:

> It is hereby recognized that destructive floods upon the rivers of the United States, upsetting orderly processes and causing loss of life and property, including the erosion of lands, and impairing and obstructing navigation, highways, railroads, and other channels of commerce between the States, constitute a menace to national welfare; that it is the sense of the Congress that flood control on navigable waters or their tributaries is a proper activity of the Federal Government. . . .[1]

In the twenty-five years that have elapsed since the passage of the Flood Control Act of 1936, over four billion dollars have been expended in pursuit of this "proper activity" and annual appropriations now average 300 million dollars.[2] Within the past eight years, there have appeared a series of appraisals of the efficacy of this expenditure and the massive activity so engendered.[3]

Appraisals of the flood control program.--All evaluations of the national flood control effort are obscured by serious defects in data collection and interpretation, particularly estimates of flood damage.[4] Flood damages recorded by the Weather Bureau are probably understated in toto and considerably exaggerated

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[1] 49 U.S. Statutes 1570.

[2] U.S. Senate, Select Committee on National Water Resources, Floods and Flood Control, Committee Print No. 15, 86th Cong., 2d Sess., 1960, pp. 16-17.

[3] Appraisals and related information are included in the following: William G. Hoyt and Walter B. Langbein, Floods (Princeton: Princeton University Press, 1955), pp. 77-90; Gilbert F. White, Wesley C. Calef, James W. Hudson, Harold M. Mayer, John R. Sheaffer, and Donald J. Volk, Changes in Urban Occupance of Flood Plains in the United States (Chicago: University of Chicago, Department of Geography Research Paper No. 57, 1958), pp. 1-11, 203-227; U.S. Senate, Select Committee on National Water Resources, Floods and Flood Control, Committee Print No. 15, 86th Cong., 2d Sess., 1960, pp. 3-7, 27-28; U.S. Senate, Select Committee on National Water Resources, Flood Problems and Management in the Tennessee River Basin, Committee Print No. 16, 86th Cong., 2d Sess., 1960, p. 18; U.S. Senate, Select Committee on National Water Resources, River Forecasting and Hydrometeorological Analysis, Committee Print No. 25, 86th Cong., 2d Sess., 1960, p. 7; Walter B. Langbein, "An Assessment of Flood Control in the U.S.A.," Proceedings of Royal Geographic Society of Australasia, LXI (December, 1960), 9-12; Roland C. Holmes, "Composition and Size of Flood Losses," Papers on Flood Problems, ed. Gilbert F. White (Chicago: University of Chicago, Department of Geography Research Paper No. 70, 1960), pp. 11-18.

[4] See discussion in White et al., pp. 3-11.

in particular situations. Trends are obscured by the random effects of rare catastrophic floods and short-run increases in the amount of flooding. Despite these problems, most appraisals agree on the following relationships of flood control and flood damages:

1. The large investment in flood control works have not decreased the average annual flood damages. Data from Holmes would suggest that average annual flood damage doubled since the passage of the Flood Control Act of 1936 and now equals the average amount spent yearly in their prevention, $300 million.[1] Since the Weather Bureau series used by Holmes probably understates damage, a recent Corps of Engineers presentation attempted to estimate average damage potential which might be considered as the estimate of average long-run damages (including damages not actually recorded). The estimates for 1957 and a projection for the year 1980 are shown in Table 1.[2]

TABLE 1

CORPS OF ENGINEERS ESTIMATES OF DAMAGE POTENTIAL[a]
(MILLIONS OF DOLLARS)

Area	1957	1980
Downstream[b]	538	739
Upstream (total)[c]	417	574
Total	955	1,313

[a]Taken from U.S. Senate, Select Committee on National Water Resources, Floods and Flood Control, Committee Print No. 15, 86th Cong., 2d Sess., 1960, pp. 3-7, 27-28.

[b]Downstream damages occur at points along stream with drainage areas in excess of 390 square miles.

[c]Total upstream damages represents the enlargement of a partial upstream damage inventory by the application of some factor.

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[1]Holmes, p. 11, computed total damages for 34 years from 1903-1936 as $4.1 billion, and for a 22-year period, 1937-1958, at $6.6 billion in constant 1957 dollars. Average yearly damages are 2.5 times greater for the latter period.

[2]A comparison of the increase projected for 1980 of each component, downstream and upstream, suggest that they were projected at the same rate, an annual average growth of 1.4%. To the writer, this is an unjustified assumption.

2. Three factors have been suggested to account for the increases in estimated annual damages: (a) improvement in damage data collection, (b) a short-run increase in flooding, (c) the expanding investment in areas subject to flood.[1] After discounting the effects of data collection and the increase in flooding, the failure of the flood control program to reduce damages is primarily due to the steady pressure to occupy and develop flood plain land, particularly in urban and metropolitan areas. The Corps of Engineers' projection averages a 1.4 per cent annual increase in flood damage potential, and White has estimated the annual rate of increase at 2.7 per cent.

3. There is considerable evidence that flood control, while substantially reducing existing damages, actually encourages an increase in damage potential.[2] Almost all flood control works provide only partial flood protection, there being few known works protecting against the maximum probable flood. Partial protection eliminates damages from the more frequent floods, and in so doing, may intensify the ongoing trends to develop the flood plain regardless of protection. When some of the rare floods occur that are larger than the measure of protection provided for, catastrophic damages result. Furthermore, flood plain invasion has been triggered by the mere anticipation of future protection.

4. The trend of increasing protection being offset by increasing damage potential will continue into the future. At the present rate of federal investment in flood control, the United States is expected to expend some $10 billion by 1980, but the residual annual damage is estimated by the Corps to be only slightly under the 1957 damage potential of $698 million. With a 1970 level of protection expenditure of $500 million, the Corps of Engineers estimates that damage potential could be reduced to an annual average of $483 million.

5. The paradox of greater flood control and increasing damages strongly emphasizes the need to search for other alternatives that might be combined with engineering works to develop comprehensive programs of flood damage reduction. For over twenty years, a theoretical statement by White of possible alternatives

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[1] White et al., pp. 5-11.

[2] The Corps of Engineers (Select Senate Committee, Floods . . . , pp. 27-28) estimates that since 1918 $9 billion (current dollars) of gross damages have been prevented by protection works. However, gross damages prevented includes damage to both the existing development at the time of the introduction of flood control works and the subsequent development of the flood plain, some of which were induced by the protective works themselves.

to engineering works has existed.[1] These included: Bearing the losses with or without public relief; permanent or emergency evacuation of life and property and the rescheduling of production; elevating land and making structures flood resistant; insurance; and the regulation and change of land use. However, it is only within the last decade that there has been developed a widespread interest in searching among such a theoretical array of alternatives for those that most practicably might supplement engineering works in a flood damage reduction program.

A Future Flood Damage Reduction Program

The individual and community components of a flood damage reduction program.--The elements of a flood damage reduction program are still unclear, but might well involve a range of actions as has been summarized in Table 2.

The first column of the Table presents the theoretical range of choice. In the second column, subsumed under each theoretical choice, are the individual actions presently available. The third column suggests ways in which municipal, state, and federal authority might be judiciously used to either encourage, reinforce, or mandate the individual action.

Table 2 attempts to identify those components of a flood damage reduction program that can be carried out by individual land users. In this format community action, be it on the federal, state, or municipal level, can either encourage, reinforce or mandate individual actions. To illustrate, an individual might locate a structure on a parcel of flood plain land to minimize his hazard. This action can be encouraged by the availability of flood hazard information provided by a federal organization, reinforced by regulations making home loan assistance contingent upon such structure location, or mandated by a zoning regulation requiring a set back from the stream channel or elevation above a given flood height.

In practice, the actual elements of a comprehensive flood damage reduction program will emerge from the interaction of the alternatives described in Table 2, the need perceived by the

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[1]Gilbert F. White, Human Adjustment to Floods (Chicago: University of Chicago, Department of Geography Research Paper No. 29, 1945), pp. 128-202. Recently developments of this theme may also be found in Gilbert F. White, "The Choice of Use in Resource Management," Natural Resource Journal, I (March, 1961), 30-36; and Gilbert F. White, "Strategic Aspects of Urban Flood Plain Occupance," Journal of the Hydraulic Division, Proceedings of the American Society of Civil Engineers, LXXXIII (February, 1960), 99-100.

TABLE 2

ELEMENTS IN A FUTURE FLOOD DAMAGE REDUCTION PROGRAM

Theoretical Choice of Actions	Possible Individual Actions	Public Actions to Encourage, Reinforce, or Mandate Individual Actions	
		State-County-Municipal	Federal
Bearing the loss	Bear an unexpected loss** Bear an expected loss* Set aside funds for future loss*	Provide flood hazard information* Provide relief to ease suffering and distress but in such manner as to reduce future flood damages	
Emergency flood fighting, evacuation, and re-scheduling	Maintain stand-by preparations for flood fighting* Prepare advance plans for temporary evacuation of life and property and the re-scheduling of production*	Provide men and materials for emergency flood-fighting** Organize community warning and evacuation assistance plans*	Provide federal warning assistance and expanded radar network** Encourage local disaster plans to provide for flood-damage reduction*
Structural change and land elevation	Use wide variety of structural adjustments presently available for old and new buildings* Land elevation above flood level for new buildings*	Use building codes to make mandatory structural changes and/or land elevation Use channel encroachment laws to prevent increased damage to others as a result of land elevation (fill)*	Provide hazard information on which to design structural changes and land elevation* Require structural changes and/or land elevation in flood-prone areas as requirement for HHFA and other loan assistance

TABLE 2--Continued

Changing land use	Locate structures so as to minimize damage**	Mandate patterns of land use by flood plain regulations*	Provide hazard information for design of regulations*
	Change land to open use, such as: parks, playgrounds, parking lots, etc.*	Encourage open uses**	Require flood plain regulations as a provision for flood control, urban renewal, and similar assistance
	Abandon high hazard areas*	Prohibit uses subject to high damage or loss of life**	Use HHFA and other federal loan assistance powers to discourage improper flood plain use*
		Use condemnation power and/or urban renewal to change land use	Provide federal aid to permanently evacuate flood plain*
Controlling floods	Construct levees or walls, channel improvements, detention reservoirs*	Construct flood control projects*	Provide flood control in the form of levees, walls, channel improvement, land treatment, detention reservoirs**
	Request and promote local, state, and federal flood control projects**	Request and promote state and federal flood control projects**	
	Share in costs of local, state, and federal projects*	Share in costs of federal projects*	
Flood insurance	Obtain a policy* (Available under one of the following conditions: a) High premium b) Pooled risk with off-flood plain structures in comprehensive policies c) Structural adjustments reduce more frequent flood damage)	Provide standardized flood hazard information on which to base rate structure	
		State supervision of insurance companies to encourage commercial policies that promote minimization of flood damages	Subsidize a federal or federal-state insurance program (Administered to promote minimization of flood damages)
		Subsidize a state-federal insurance program	

*Present application limited

**Present application widespread

program executors for governmental action, and the prevailing trends of political organization.

The role of research.--The shape of a future flood damage reduction program could be substantially altered if the potential effectiveness of various damage reduction alternatives could be predicted. The appraisals of the effectiveness of engineering works, which helped create a receptiveness for a broader program, awaited many years of actual experience with protective works in order to be heeded. Hopefully, the development of a more predictive, though far from accurate, social science provides the basis for identifying some of the more fruitful elements of a flood damage reduction program.

To make effective predictions requires a deeper understanding of the complex process of flood plain invasion and occupance than presently available. Twenty years of geographic research has striven for such an understanding, and the concluding portion of this chapter will present a description of that research.

Flood Hazard Information: The Foundation of a Flood Damage Reduction Program

A research question with a vital but more limited import relates to flood hazard information. A recurring theme throughout Table 2 is the provision of accurate flood hazard information as a necessary if not sufficient condition for the installation of many of the alternative measures of flood damage reduction.

The federal information program.--The federal scientific and engineering agencies have always made their data on floods available to any who desired it.[1] Unfortunately, data on flood hazard were seldom in a form usable by laymen, and often required engineering interpretation. With the search for alternative flood damage reduction measures, the need became apparent for flood hazard data that could be used and understood by intelligent laymen with a minimum of technical assistance.

The pioneering effort was made by the Tennessee Valley Authority which had completed, by mid-1962, 97 flood hazard reports

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[1]Among the federal agencies that collect data on floods are the U.S. Army, Corps of Engineers; U.S. Department of Agriculture, Forest Service and Soil Conservation Service; U.S. Department of Interior, Bureau of Reclamation and Geological Survey; U.S. Department of Commerce, Weather Bureau, Tennessee Valley Authority and the International Boundary and Water Commission. For types of data, see Walter B. Langbein and William G. Hoyt, Water Facts for the Nation's Future (New York: Ronald Press, 1959), pp. 253-258.

for valley communities.[1] The U.S. Geological Survey has moved in two significant directions. Flood hazard mapping (overprints of topographic sheets) is underway in 21 communities.[2] A number of maps have been completed including the first 6 of 43 sheets partially defining flood hazard in the Chicago Metropolitan Area. Simultaneous with its own mapping program, the Survey is issuing a series of regional flood studies, which combined with a recent handbook makes flood plain mapping possible on a self-help basis for many communities.[3] Finally, and probably most significant, has been the authorization by Congress under which the Corps of Engineers is providing communities information concerning floods, flood damages, and engineering advice for the amelioration of flood effects.[4] As of this writing implementation of the program has been somewhat slowed.

The expanding information program raises a number of questions. What is the relevance of various types of flood hazard information to flood plain managers? Should information concerning flood hazard be extended to include information on alternative adjustments to flood hazard? How may flood hazard information be presented in order to be most useful for managers?

The value of basic research applicable to these questions made the study seem particularly timely.

Twenty Years of Geographical Research into Human Occupance of Flood Plains

Research and policy.--In the previous discussion, the ongoing shift from a policy of flood control to a policy which includes controlling floods and land use has been chronicled. This shift in emphasis has been influenced by over 20 years of research,

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[1]See Select Senate Committee, Flood Problems . . . Tennessee River Basin, pp. 18-20 for general discussion of program. Present status of program taken from a personal communication from the Flood Relations Branch, Tennessee Valley Authority, July, 1962.

[2]Ian Burton, "Education in the Human Use of Flood Plains," Journal of Geography, LX (November, 1961), 366.

[3]For an example of a map see: United States Geological Survey, Floods near Chicago Heights, Illinois, Hydrological Investigation Atlas HA. 39 (Washington: U.S. Geological Survey, 1960), (map with description). For the methodology of regional studies, see: Tate Dalrymple, Flood Frequency Analysis (Washington: U.S. Geological Survey Water Supply Paper 1543-A, 1960), pp. 25-48. For methods of defining the flood plain, see: Sulo W. Wiitala, Karl R. Jetter, and Alan J. Sommerville, Hydraulic and Hydrological Aspects of Flood Plain Planning (Washington: U.S. Geological Survey Water-Supply Paper 1526, 1961).

[4]Section 206, Flood Control Act of 1960.

primarily geographical, into the nature of the human occupance of flood plains. Although foreshadowing the shift in policy, the research also has evolved, moving from an earlier preoccupation with physical factors of land and flood, towards a synthesis of human behavior that might describe the occupance of flood plains.

The shift in emphasis in geographical study.--In 1942, in Human Adjustment to Floods, White was preoccupied with factors affecting human adjustment, primarily, but not exclusively, physical variables of land and water. Fifteen years later White was concerned with factors that enter into decisions as to flood-plain adjustment. The focus of research had moved from a somewhat deterministic geography of the physical milieu of flood plains, to an inquiry into man's choice in the complex social, economic and physical world that surrounds him. The change in emphasis has been accompanied by a series of recent studies.

Studies of changes in urban and rural occupance of flood plains.--A study of rural flood-plain occupance confirmed the value of the change in emphasis by finding that the particular manner in which flood plain utility is perceived depends in large measure on the matrix of economic factors and agricultural organization in which the flood plain is found rather than on primarily physical factors such as the frequency of flood.[1]

The urban study noted:

> This process of continued invasion (of the flood plains) was not everywhere of the same magnitude, it varied with conditions of site and of gross urban growth, it unfolded in different patterns of land use, and it involved a wide range of managerial decisions as to the use of flood-plain resources in the face of flood hazard.[2]

To better explain the variability in flood plain use noted, as well as lay the basis for measuring the impact of flood hazard maps, two related investigations were conducted of the attitudes of flood plain dwellers.[3]

The attitude studies.--Roder in Topeka, Kansas, sought to formulate the first descriptive statement of the relationship between attitudes towards flooding, socio-economic class, and levels

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[1]Ian Burton, Types of Agricultural Occupance of Flood Plains in the U.S. (Chicago: University of Chicago, Department of Geography Research Paper No. 75), pp. 42, 150.

[2]White et al., p. 203.

[3]Wolf Roder, "Attitude and Knowledge on the Topeka Flood Plain"; Ian Burton, "Invasion and Escape on the Little Calumet," Papers on Flood Problems, pp. 62-92.

of flood hazard and protection information. He classified his respondents as optimistic, pessimistic, or neutral, depending on whether the respondent's future flood expectancy underestimated, overestimated or coincided with a prevalent scientific expectancy of future floods. Burton then conducted a similar study in the Hammond-Munster area of the Little Calumet flood plain in Indiana. In general, they found no associations between attitudes towards future flooding and socio-economic class or knowledge of protective structures.

The disaster studies.--In the course of seeking analogs to the catastrophic disaster of nuclear attack, a group of behavioral scientists have carried out a series of studies into natural disasters, including floods, or the "behavior of people in extreme situations."[1] The utility of such studies for explanatory models of the human occupance of flood plains is limited because of differing emphasis. Disaster studies of floods have focused on the threat, warning, and impact of the disaster, and the subsequent recovery of individuals and community. Geographic research, in contrast, has centered on the long-term adjustment to a recurring hazard, in which disasters may or may not occur, and are of limited import in most situations.

Decision-making studies.--Still another body of theory which behavioral scientists, among others, have helped formulate, that of decision-making, contains much that may be useful in developing an increased understanding of the processes of flood plain occupance. The continual invasion of the flood plain is generally a summation of the many individual decisions to locate there. The selection of alternative measures of flood-damage reduction by an individual or even the nation is also a process of choice or decision. These and similar questions may be fruitfully explored within a framework of decision theory.

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[1]Anthony F. C. Wallace, Human Behavior in Extreme Situations: A Survey of the Literature and Suggestions for Further Research (Washington: National Academy of Sciences-National Research Council Pub. No. 390, 1956); Roy A. Clifford, The Rio Grande Flood: A Comparative Study of Border Communities in Disaster (Washington: National Academy of Sciences, National Research Council Pub. No. 458, 1956).