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TOWARDS A COMMUNITY DISASTER MODEL FOR POLICY ANALYSIS*

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INTRODUCTION

The community disaster model is an interactive computer-based system whose principal purpose is to provide guidance to decision-makers in the United States on the relative benefits and costs of alternative mitigation and recovery policies for natural hazards. As a basic part of the system the user is able to design a community by describing the socio-economic and financial characteristics of the homeowners and the physical attributes of their structures. This approach thus complements earlier hazard simulation models which have been designed for the purpose of analyzing the impact of different disaster programs on a regional or national level (See James, 1964; Day, 1970; Friedman, 1975; Wiggins, 1976; and especially Cochrane, 1976 for a summary of the state of the art).

The unit of analysis upon which the model operates is the individual homeowner. Each homeowner has specific socio-economic traits (e.g., age, income, education); and financial characteristics (e.g., assets and debts); and resides in a particular type of structure (e.g., one-story, wood-frame house with a basement). Such attributes can be obtained through field survey data or by sampling from statistical distributions that the user specifies. In this manner the user constructs a community of his or her choice and is able to analyze the effects of different mitigation policies (e.g., specific building regulations) and relief policies (e.g., type of federal loans and grants) for disasters of different degrees of severity.

This project has been devoted exclusively to studying the flood hazard. In this paper we will show how the decision-maker can determine how sensitive different policies are to two key variables: (1) the socio-economic and physical characteristics of the hazard-prone area, and (2) the severity of flooding. In this sense the community disaster model for the United States offers the possibility of providing a rich array of descriptive data. These results have normative implications only to the extent that the decision-maker is able to conclude, after analyzing a number of different scenarios, that one set of policies is preferred to another.

The community disaster model is designed with the user in mind. It is extremely flexible so that it is relatively easy to extend or modify existing routines. Furthermore, it has a modular structure so that the decision-maker can suggest adding new policies or behavioral models of choice without forcing the programmer to redesign its entire structure. (See

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TABLE I

Purposes of Disaster Model for Different User Groups

Purpose \ User Group	FIA, SBA, FDAA	Community	Insurance Industry	USGS CE	Financial Sector
Evaluate mitigation measures: Land-use regulations, building codes, flood proofing, warning and emergency preparedness, control and protection works.	Given a certain community and a type of flood, what is the comparative cost-effectiveness of alternative mitigation measures?	Are certain mitigation measures more effective than others in terms of reducing losses?	What are the cost-benefits of tying insurance to various mitigation measures?	What are the cost-benefits of a particular control work?	To what extent do different mitigation measures change the pre-flood and post-flood financial characteristics of individuals?
Evaluate extent of flood damage:	To what extent will various flood heights, velocities, or durations affect damage? Given a certain flood, how will different communities be affected?	Can evaluate the extent of damage given a certain flood – for determing effectiveness of preparedness plans. Can evaluate losses for different types of floods.	Can evaluate expected losses for different types of floods.	Can evaluate extent of damage if a work is exceeded (for cost-benefit analysis).	Can evaluate financial losses for different types of floods.
Evaluate flood recovery program: Losses Grants Insurance Other aids	Will certain types of communities need more post-disaster aid than others? What affect will varying the interest rate, or size of available loans or grants have on overall cost of federal aid in a particular disaster? To what extent will insurance reduce the need for federal aid? To what extent will tax writeoffs aid flood victims?	How will different recovery policies reduce economic disruption?	What affect will mandatory insurance have in terms of cost after a disaster? Given a certain amount of damage, how does insurance aid in recovery? What are the cost-benefits of marketing insurance in a particular location or to a particular group of people? How will insurance in force change if insurance is required for SBA loans?	How will a particular control work reduce the need for relief after a flood of a certain magnitude?	How will different recovery policies minimize the financial disruption of victims? Can a particular policy or combination of policies be developed to minimize financial impact on all elements of the community?
Evaluate status of post-recovery community:	Will certain communities recover easier than others? How do post-recovery communities compare to pre-flood communities? To what extent do SBA loans aid recovery process?	What will be the economic status of the post-recovery community? How will the post-recovery community compare to the pre-flood community?	To what extent does insurance aid the recovery process? How will insurance in force change after a flood and how will this change affect future recovery?		Determine the change in the financial characteristics of post-recovery victims from pre-flood homeowners.

Katz and Miller, 1977 for a detailed description of the structure of the model). The model is also designed in such a way that the decision-maker can utilize it in an interactive manner at a computer terminal with only minimal knowledge of the technical details of the simulation. In undertaking this project our principal interest has been to develop a tool that decision-makers will want to use for policy analysis. This paper is designed to facilitate an understanding of what the flood model can do and to stimulate an interest on the part of decision-makers to construct communities, generate specific floods, and specify alternative mitigation and relief measures.

Table I outlines some of the questions decision-makers can examine through the use of the flood model. The columns of the table consist of different user groups that are impacted by the flood hazard. They are: governmental agencies concerned with flood recovery problems (e.g., the Federal Insurance Administration (FIA), the Small Business Administration (SBA), and the Federal Disaster Assistance Administration (FDAA)); the individual flood-prone community; the insurance industry; governmental agencies concerned with engineering aspects of flood control (e.g., the Army Corps of Engineers (CE) and the United States Geological Survey (USGS)); and the financial sector (e.g., banks, savings and loan associations).

The rows of the table represent various reasons for using the model. They are: to evaluate alternative mitigation measures, to evaluate the extent of flood damage, to evaluate alternative flood recovery programs, and to evaluate the status of the post-flood community. It is important to note that the specific questions posed in each of the cells could have been asked by other user groups or had an impact on other evaluation levels. In fact, the relative merits of a specific mitigation policy (e.g., flood proofing) could be of interest to many sectors (e.g., FIA, CE, insurance industry) and could be evaluated in terms of its effect on flood damage and recovery.

UTILIZING FIELD SURVEY DATA

The development of the community disaster model is a natural outgrowth of a recently completed NSF-RANN supported study (Kunreuther et al., 1977) in which a field survey was undertaken through face-to-face interviews with 2055 homeowners in 43 areas throughout the United States subject to coastal and riverine flooding and 1006 homeowners living in earthquake prone areas of California. Half of the respondents had purchased flood or earthquake insurance. Controlled laboratory experiments were also undertaken to determine how specific variables influenced the decision to buy coverage. The field survey provides insight into the decision processes and socio-economic characteristics of homeowners in the pre and post-disaster periods. The community disaster model enables the user to analyze the merits of alternative disaster programs based on these findings. Hence the data collection and policy analysis phases are inextricably interwoven.

Specifically, the field survey was designed to provide insight into the decision processes utilized by homeowners in determining whether to purchase insurance. The questionnaire elicited subjective estimates by homeowners of the probability of a severe flood or earthquake and the estimated loss if a disaster should cause damage to property. Data were also obtained on individuals' awareness of the hazard and insurance, past disaster experience, and the role that friends and neighbors play in information dissemination and decision-making. Multivariate statistical analyses have been utilized to estimate the relative importance of different factors on the probability that an individual would have flood or earthquake coverage (Kunreuther et al., 1977, Chapter 6).

The field survey also provides quantitative data on the impact of alternative disaster programs on the recovery process of disaster victims. For example, since 1953 the federal government has provided low interest loans to those suffering losses from severe natural disasters. The data indicate to what extent insured and uninsured victims with varying amounts of loss have utilized this source of relief.

Finally, the field survey data base offers a profile of the socio-economic attributes of homeowners in hazard-prone areas and the physical characteristics of their structures. The existing data base contains information on the age, income, education, marital status, family size, and occupation of all individuals interviewed. Data ara also available on the year and type of construction of the structure, number of stories, purchase price, estimated current value, and mortgage history. Hence, it is possible for us to construct a flood-prone community with actual data rather than having to synthesize relevant attributes. Furthermore, we are able to incorporate the results of the field survey analysis into the community disaster model. This has been done by utilizing behavioral models of choice on whether to purchase insurance and if so how much coverage to take out, and a model detailing the nature of the recovery process for disaster victims.

EVALUATING ALTERNATIVE INSURANCE PROGRAMS

A principal purpose of the community disaster model is to evaluate the relative performance of different adjustments to the hazard. In this paper we will be analyzing one such adjustment – the financial impact of alternative insurance programs on homeowners in a hypothetical flood-prone community. Specifically, we will be studying the following programs:

Program 1: Flood insurance is *mandatory* for all homeowners.

Program 2: Flood insurance can be purchased *voluntarily* by homeowners.

Program 3: Flood insurance is *not available* to homeowners because the community is not part of the National Flood Insurance Program.

We have chosen to study the insurance adjustment for detailed analysis for three reasons: (1) There is considerable information from the Kunreuther et al. (1977) field survey and laboratory experiments on the factors influencing the decision of homeowners to purchase insurance, and the role insurance plays in disaster recovery. (2) Flood insurance has been the focal point of recent reports and legislation (U.S. Water Resources Council, 1976) and a subject for critical analyses and discussion in the natural hazards literature (Kunreuther, 1973; Anderson, 1974; Brown and Lind, 1976; Platt, 1976). (3) Insurance can be utilized as a mechanism for coordinating other hazard mitigation adjustments as has been clearly pointed out by the Task Force on Federal Control Policy (U.S. Congress (1966), White (1966)). The community disaster model offers an opportunity to serve as an interactive mechanism for evaluating the costs and benefits of such coordination.

In evaluating the above three programs we will pay careful attention to the impact that they are likely to have on the different socio-economic groups in a community. In particular, we will want to determine how homeowners in specific income and age strata will be affected financially should they suffer damage from a flood and be forced to rely on different sources of relief in order to recover.

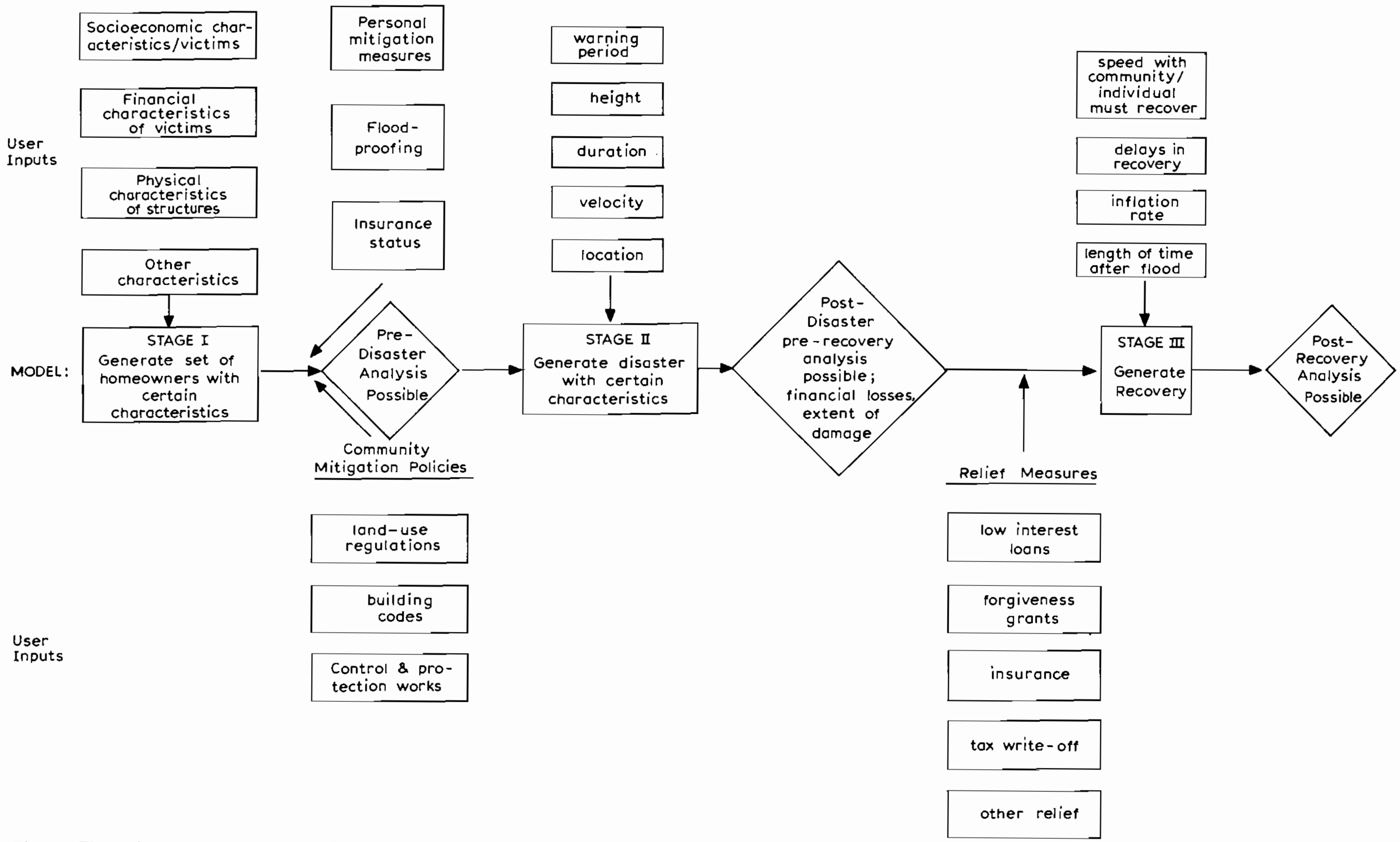


Fig. 1. Flow chart of disaster model from pre-disaster to post-disaster recovery.

STAGES OF ANALYSIS

For convenience and ease of exposition, we have divided the model into three stages corresponding to the pre-disaster period, the immediate post-disaster period, and the post-recovery period. The user has the option of determining the impact of alternative disaster programs on residents of the community after each of these stages. Figure 1 delineates these time periods and indicates a set of illustrative user inputs associated with each one. To facilitate an understanding of this figure we have assembled data in Table II on the Glenn Family, long-time residents of River City, Pennsylvania – a simulated flood-prone community which will be the subject of detailed analysis in this article.

Stage I is concerned with generating a set of homeowners with prescribed pre-disaster attributes. As can be seen from Table II we have listed certain attributes of the household head (Mr. Glenn) such as his age and educational level as well as socio-economic characteristics of the family (income and family size). Detailed balance sheet data on assets and liabilities including estimated house and contents value provide a picture of the financial status of the Glenn family in the pre-disaster period (See Vinso, 1977b). The user may also want to input data on the insurance status of the household if this in-

TABLE II

Selected Attributes of an Individual Homeowner

Pre-Disaster Attributes (Stage I)	
Socioeconomic	
Age of household head	50 years
Income (annual)	US $ 10,000
Education level	12 = high school graduate
Family size	4
Financial	
Total financial assets	$ 14,000
Total real assets	$ 40,000
Total current liabilities	$ 400
Total fixed liabilities	$ 4,600
Structure value	$ 24,000
Contents value	$ 12,000
Insurance Status	
Structure coverage	$ 10,000
Contents coverage	$ 5,000
Flood Proofing Measures Adopted	none
Physical (House)	
Date of construction	1948
Number of stories	2
Basement (with/without)	with
Type of construction	wood frame
Height of first floor above ground level	3 ft
Zone	100 year flood plain
Generate Flood (Stage II)	
Issuance of Offical Warnings	Yes
Time prior to flood	4 hours
Actions taken by homeowner	Move furniture upstairs
Height of Water Above Ground Level	12 ft
Damage Incurred	
Structural	$ 12,000
Contents	$ 6,000
Total damages:	$ 18,000
Estimated Savings from Heeding Warning	$ 1,000
Financial Attributes (Post-Flood, Pre-Recovery)	
Total financial assets	$ 14,000
Total real assets	$ 22,000
Total current liabilities	$ 400
Total fixed liabilities	$ 4,600
Structure value	$ 12,000
Contents value	$ 6,000
Generate Recovery (Stage III)	
Insurance Claim	
Structure	$ 10,000
Contents	$ 5,000
SBA Disaster Loan	$ 3,000
Insurance + Loan =	$ 18,000
Financial Attributes (Post-Recovery)	
Total financial assets	$ 14,000
Total real assets	$ 40,000
Total current liabilities	$ 400
Total fixed liabilities	$ 7,600
Structure value	$ 24,000
Contents value	$ 12,000

formation were readily available. Alternatively, one could develop a behavioral model of choice to predict whether a particular family is likely to purchase insurance coverage given their socio-economic characteristics and their interaction with the environment, such as whether they have experienced damage from previous flooding. We have followed this latter course of action in this paper.

Another important set of attributes associated with Stage I relates to the physical characteristics of the property in the community. In the case of the Glenn family we see from Table II that they reside in a 30-year-old, two-story, wood-frame house with a basement. The structure is located in the 100 year flood plain with the first story raised so it is three feet above ground level. These data enable the user to determine the potential damage to the structure from floods of different levels. By characterizing different families and their property in the same manner, the user can generate an entire flood-prone community.

Once the community has been constructed the user can undertake a set of pre-disaster analyses. For example, in this paper we will determine the proportions of homeowners in different income and age classes residing in River City. We will also provide a profile of the different types of structures and their location in relation to the river. The pre-disaster analysis can also provide information to users on the adoption patterns of different socio-economic groups with respect to such measures as the purchase of insurance or use of flood-proofing measures. In this paper we will determine the proportion of low, medium, and high income residents in River City who would have purchased flood coverage voluntarily if it was available to them.

Stage II of the model generates a flood with prescribed characteristics. These might include the height of the water above ground level, the velocity of the water, and the duration of the flood. One could also specify whether official warnings were issued by appropriate governmental agencies, and, if so, how they were disseminated to the community prior to the onset of flooding. The illustrative example in Table II assumes that the local radio stations broadcast warnings four hours prior to the onset of flooding. The Glenn family heeded these warnings by moving some of their living room furniture upstairs. The particular flood rose twelve feet above ground level causing $ 18,000 damage to the structure and its contents. The family estimates that the preventive steps taken prior to the flood saved them approximately $ 1000 in contents damage.

Once these damage figures have been determined for each specific structure one can update the financial balance sheets to reflect the change in assets and liabilities caused by the flood. In the case of the Glenn family the flood reduced the value of their house from $ 24,000 to $ 12,000, and the value of their contents from $ 12,000 to $ 6000. The other components of their balance sheet did not change, since this financial snapshot was taken prior to the injection of any recovery funds into the community.

After Stage II data have been generated, the model can provide summary statistics on the physical damage to different types of structures in each of the flood zones in River City (e.g., one-story wood-frame homes with a basement in the 100 year flood plain) from floods of different heights. To do this one has to translate flood stage to monetary losses through certain prescribed relationships; (See Wilson, Lepore and Duffy, 1977 for a discussion of such a damage model). The user can also determine the financial effects that different levels of flooding will have on specific classes of residents (e.g., homeowners with an annual income below $ 10,000 who are over 65 years old). Such analyses comprise the post-disaster pre-recovery analysis phase depicted in Fig. 1.

Finally the community disaster model enables one to evaluate the impact of different relief measures on the recovery process. We have listed the most obvious ones in Fig. 1: low interest disaster loans, insurance, and tax write-offs. The user has the option of generating the specific terms of these policies or creating other recovery measures. For example, he can specify the interest rate on SBA disaster loans and the maximum amount available to any disaster victim. The model can then determine how changes in the terms of a particular relief program financially affects disaster victims and the federal government.

Stage III generates data on the recovery of homeowners once they have taken advantage of the different relief measures available to them. In the case of the Glenn Family their losses exceeded the value of their insurance policy on both house and contents. As shown in Table II we have assumed that they took advantage of a low interest SBA loan to cover the uninsured portion of their $ 18,000 property damage. The dollar flows from these two sources of funds changed the composition of their balance sheet from what it was in immediate post-flood period. The value of their real assets increased by $ 18,000 to reflect the checks they received from both the Federal Insurance Administration and the Small Business Administration. On the other hand, the $ 3000 loan increased the level of their fixed liabilities to $ 7600. The actual costs to the Glenn family, the federal government, and the insurance sector from these transactions depend on the SBA loan interest rate and the type of sharing arrangement between the federal government and the private sector on insured losses [1].

Similar analyses at Stage III can be undertaken for all disaster victims in the community; however, it may be difficult to generate the precise sources of recovery for each household. The strategy followed in this paper is to utilize field survey data to develop a behavioral model of choice which determines the size of SBA loans as a function of the insurance status and magnitude of damage. The user can then compare the pre-flood, immediate post-flood, and post-recovery financial characteristics of different classes of victims under the alternative disaster programs described in the previous section.

DESCRIPTION OF THE COMMUNITY (STAGE I)

River City is composed of 427 households from the riverine portion of the Kunreuther et al. (1977) field survey. The 427 households were chosen from the 642 riverine households interviewed in the field survey because each respondent had answered all the survey questions related to the set of attributes which we have noted in Table III. (The remaining 215 homeowners either responded "don't know" or "no answer" to some of the questions.) These data describe the socio-economic characteristics of each household head, the physical characteristics of the property, the financial characteristics of the household, as well as certain behavioral traits which influence the household's decision to purchase

TABLE III

Attributes of Homeowners for Illustrative Example from Field Survey Data

Socioeconomic Characteristics
Age of household head
Income of household head
Education of household head
Marital status of household head
Physical Characteristics of Property
Basement or no basement
Number of stories
Height of first floor relative to ground
Financial Characteristics
Current value of house
Current value of the land only
Amount of first mortgage
Other Factors influencing Insurance Purchase Decision
Perception of severity of flood problems
Knowing anyone with flood insurance
Estimate of probability of severe flood in neighborhood
Estimate of damage to property from severe flood
Years lived in house
Degree of aversion to risk

insurance. Table IV provides the reader with an indication of the diversity of the actual sample, by summarizing the actual locations of the respondents who comprise the hypothetical community of River City.

TABLE IV

Number and Percentage of River City Respondents from Each State

	Absolute Count	Frequency (%)
California	28	6.6
Maryland	11	2.6
New Jersey	220	51.6
North Dakota	56	13.1
Oregon	26	6.0
Texas	40	9.3
Virginia	46	10.8
	427	100.0

In this illustrative example we are particularly interested in the impact of alternative disaster programs on different age and income classes. Figure 2 depicts the proportion of homeowners in the high, medium, and low income and age classes. The relevant ranges were arbitrarily specified so that between 20 and 30 percent of the households fall in the extreme categories. Thus we see that 30 percent of the residents of River City have annual incomes below $ 12,500; 28 percent have incomes above $ 25,000; the remaining percentage earn between these two amounts.

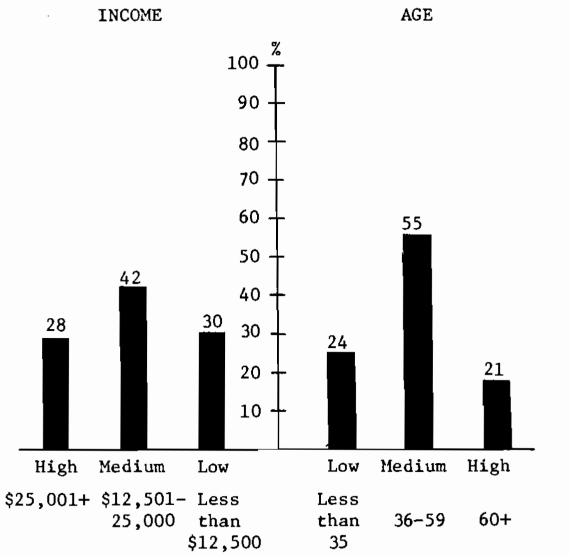
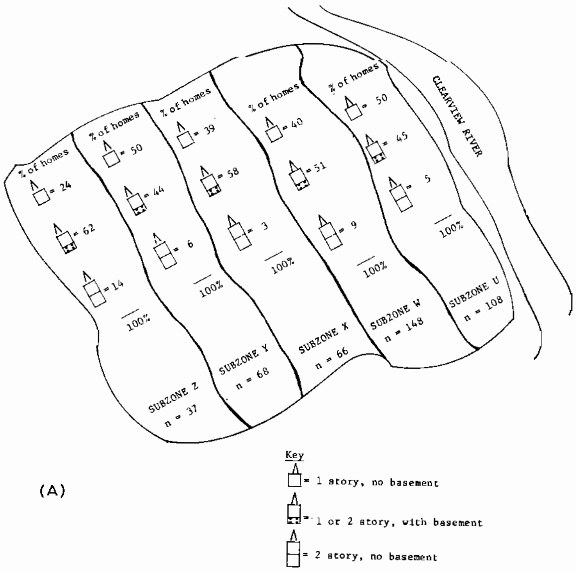


Fig. 2. Percentage of River City residents in income and age classes. (n = 427).

(A)



(B)

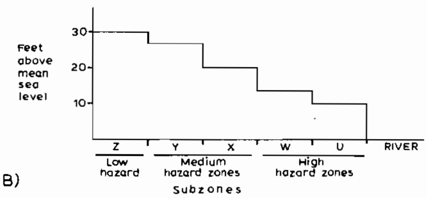


Fig. 3A. House types by subzones for River City.
Fig. 3B. Cross-sectional view of River City's elevations.

Land elevations in River City are assumed to range from 10–30 feet above mean sea level. Since water depth at particular sites within the community depends on elevations as well as flood height, logical groupings of elevation contours are specified by the user. As shown in Fig. 3A, we have assumed for this particular example that five different contours or subzones have been selected. Fig. 3B, which provides a cross-sectional view of River City's elevations, indicates that subzones U and W can be considered high hazard areas. We assume no flood protection works have been constructed in the community.

Households were assigned to the subzones according to certain field survey criteria. Of the 642 riverine households surveyed, 400 of them were located in the 100 year flood plain. Hence we assigned approximately 60 percent of the 427 River City households to subzones U (42%) and W (58%). The remaining 40 percent of the River City households were assigned to the other three subzones in the following arbitrary proportions: 15 percent to subzone X, 15 percent to subzone Y, and 10 percent to subzone Z.

The actual assignment of the four types of structures in each subzone shown in Fig. 3A was based on an analysis of the physical attributes of the 642 riverine homes comprising the field survey. For example, in riverine communities 7 percent of all the homes in high hazard areas were two-story wood-frame homes without a basement. Hence there was a 7 percent chance that each structure in zone U or W would be of this type.

FACTORS INFLUENCING VOLUNTARY PURCHASE OF INSURANCE (STAGE I)

In order to evaluate the performance of a voluntary insurance program (Program 2) it is necessary to determine which homeowners in the community are likely to purchase flood insurance by choice. Considerable statistical analyses were undertaken, as part of the Kunreuther et al. (1977) project, to isolate those factors which impacted on this decision. These results were utilized in the development of a subroutine for the "insurance purchase decision".

Table V presents a regression equation indicating the relative importance of different factors in influencing the insurance purchase decision. By far the most important variables in the analysis are whether the person considers the problem to be serious and whether he knows someone who has purchased the insurance. These two factors interact with each other. Someone who thinks the hazard is a problem and who also knows a policyholder, is more likely to purchase coverage than these variables would imply separately. As shown in Table V there is a 0.549 difference in the probability of having insurance between people who know someone with a policy and think the hazard is a serious threat and those residing in the same hazard zone who do *not* know someone and think there is *no* problem.

Another significant variable is whether the person expects any future damage from a catastrophic flood. The data in Table V show that a person who expects no damage is 15.9 percent less likely to have insurance than one who expects some damage. For every $ 10,000 increase in anticipated future damage, the likelihood that the homeowner has coverage increases by 1.5 percent.

All the coefficients in the model represent the effects of a given variable when all other factors are held at the same level. The socio-economic variables are statistically significant but do not have much effect on the probability of having insurance. Homeowners most likely to have insurance are older residents who are married, have at least a high-school education, and have incomes above $ 25,000. A person more averse to risk is more likely to have purchased coverage.

Finally, we see from Table V that those who have lived in their house for some length of time are less likely to have purchased insurance than are those who are relatively new to the area. The coefficient associated with this variable is so small (−.00039), however, that it does not change the overall probability of having insurance by very much (less than a 1 percent decrease in probability between one who just moved to his house and a homeowner residing there for 25 years).

We utilized the above regression equation to determine whether homeowners were insured or uninsured. Specifically if a resident

TABLE V

Insurance Purchase Regression for Flood Sample

Probability of homeowner purchasing insurance = 0.045[a] +

{ .0 if not high school graduate
.051 if at least high school graduate } +

{ .0 if low income
–.029 if medium income
–.055 if high income } +

{ .0 if not married
.030 if married } +

{ .0 if mildly risk averse
.069 if some risk aversion
.131 if highly risk averse } +

{ .549 if thinks hazard serious problem and knows someone with insurance
.434 if thinks hazard minor problem and knows someone with insurance
.245 if thinks hazard not a problem and knows someone with insurance
.198 if thinks hazard serious problem and doesn't know anyone with insurance
.142 if thinks hazard minor problem and doesn't know anyone with insurance
.0 if thinks hazard not a problem and doesn't know anyone with insurance } +

{ 0.17 × log (subjective probability of disaster) } +

{ .0032 × age (in years) } +

{ –.00039 × years lived in house } +

{ .015 if can't estimate future damage
–.159 if thinks will suffer no future damage
.0015 × estimate of future damage (in $ 1000) if thinks will suffer some } +

{ –.026 if lives in coastal zone A
–.010 if lives in coastal zone B
–.068 if lives in riverine zone A
–.0 if lives in riverine zone B }

· R^2 = 307

[a]Estimated probability of homeowner purchasing insurance who:
(a) is not a high school graduate,
(b) has low income,
(c) is not married,
(d) is not risk averse,
(e) thinks there is no hazard problem while not knowing anyone with insurance,
(f) expects $1 future damage,
(g) lives in riverine zone B.

of River City had a set of characteristics which resulted in a likelihood of having coverage which was greater than a certain prescribed value [2], the family was classified as being insured. Otherwise we assumed that he did not have coverage. This type of procedure is meaningful to the extent that the variables in Table V capture the decision process with respect to the insurance purchase decision.

Figure 4 presents a graphical picture of the percentage of homeowners in each income and age class that were assumed to have purchased coverage. The regression equation implies that other things being equal a larger proportion of high income residents will buy insurance than low income homeowners. The data in Fig. 4 reveals that more than 30 percent of the high income residents have coverage while only 18 percent of low income residents are insured. A comment from an uninsured homeowner interviewed as part of the field survey study provides some insight into why low income residents may not buy coverage even if they reside in a flood-prone area:

> A blue collar worker doesn't just run up there with $ 200 (the insurance premium) and buy a policy. The world knows that ninety percent of us live from pay-day to pay-day... He can't come up with that much cash all of a sudden and turn around and meet all his other obligations.

Figure 4 also shows that older residents in River City are more likely to be insured than the younger homeowners in the community.

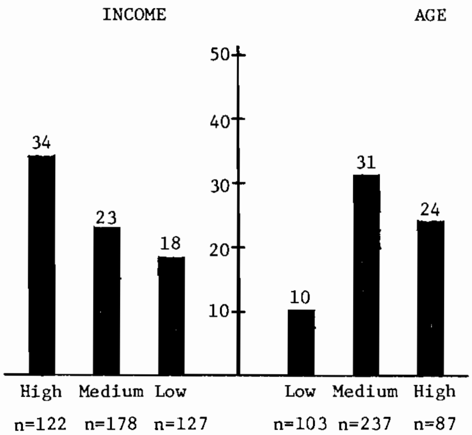


Fig. 4. Percentage of River City residents in each income and age group with flood coverage.

A similar statistical analysis was undertaken to determine the amount of structural and contents coverage purchased by each insured homeowner. Figure 5 summarizes the ratio of house and contents coverage to the value of the property for insured homeowners in the different income and age groups. The data suggest that residents in the community have coverage considerably below the value of their structure and contents. For example, in the low income group one out of every four insured households is covered against less than

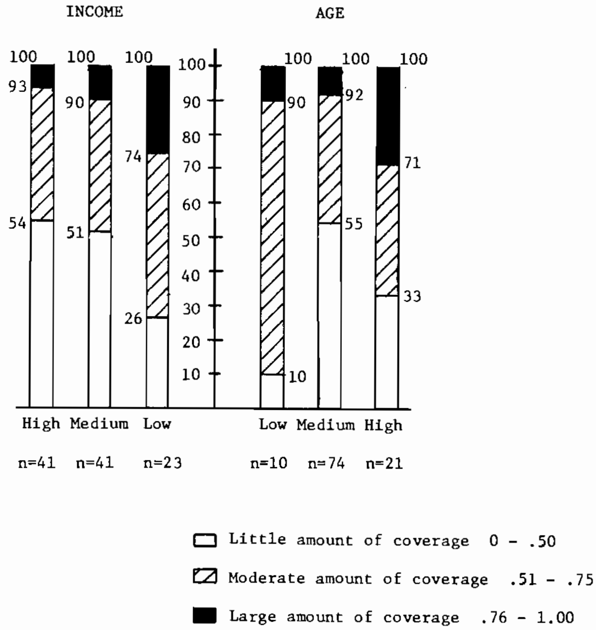


Fig. 5. Ratio of house and contents coverage to house and contents value, broken down by income and age classes. (For those who had coverage)

50 percent of its property value. Over half of the high income residents are in the same boat. For families with expensive homes, the decision to buy less than full coverage is partially impacted by the maximum amounts of coverage that they can purchase on their property [3]. Looking at the distribution of coverage by age groupings we see from Fig. 5 that young and senior citizens are better protected than the middle-age class of homeowners.

The community disaster model has thus provided the user with a picture of River City prior to the onset of any flooding. For this example we have chosen to focus on the insurance status of residents, classifying homeowners by age and income as well as location in the flood plain. Should the user be interested, he can enrich this descriptive analysis by developing other subroutines such as the adoption of hazard mitigation measures like flood proofing as a function of socio-economic characteristics and variables such as past flood experience. The field survey data base serves as a useful starting point in the construction of such behavioral models.

IMPACT OF SPECIFIC FLOODS ON RIVER CITY (STAGE II)

Once the community is constructed, it is possible to analyze the effect of floods of different heights on physical damage. To begin our analysis we have assumed that the Clearview River will rise to a height 22 feet above mean sea level, so that the first three subzones will be partially inundated (see Fig. 3B). The actual damage to each residence in the flood plain is determined by two factors: the elevation of the first floor in relation to the water level and a damage probability matrix. Given water height, the damage probability matrix indicates the proportion of damage to the structure and contents. It is thus conceivable that some houses in the more hazardous zones (U and W) will receive less damage than the same type of structures in zones generally subject to less flooding (Y and Z) either because they are higher above the ground and/or the water of a given height in relation to the structure causes less damage.

We will specifically examine the impact that flooding will have on different socio-economic groups in River City. Figure 6 focuses on the low income group and specifies the extent of the damage to their property from a 22-foot flood. For this particular configuration of houses, the dotted lines in the figure indicate that approximately 6 out of every 10 low income families would suffer damage to their property that equalled or exceeded 45 percent of its current dollar value. These homeowners would be severely hurt financially if they were uninsured. The graph also reveals that 22 percent of this class would have no damage; no family would suffer losses that exceeded 78 percent of its property's pre-disaster value. The reader is again cautioned that these percentages should be viewed as illustrative; if we had constructed the community in a different way or utilized different relationships between the height of the water and structural damage, the results may have been quite different than those depicted here. Such modifications can easily be incorporated in the model should the user desire to do so.

One way of illustrating the financial impact of a flood on disaster victims is to deter-

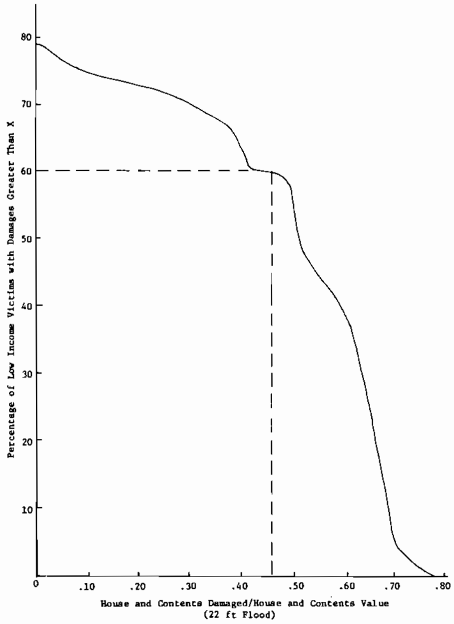


Fig. 6. Percentage of low income victims with ratios of house and contents damaged to house and contents value greater than values on x-axis.

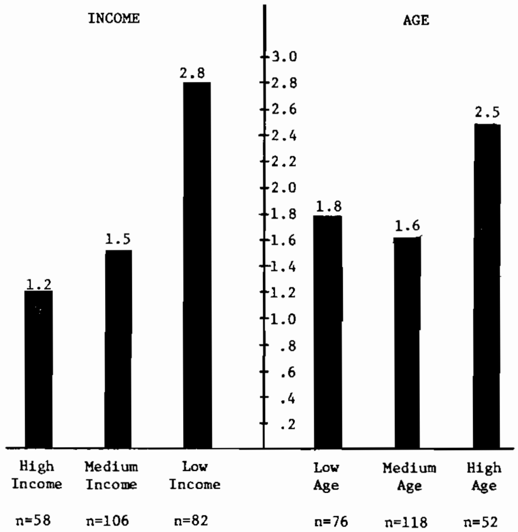


Fig. 7. Average damage/income ratio for uninsured residents suffering damage from a 22-foot flood.

mine the ratio of damage/income for different socio-economic groups. Uninsured homeowners who have high damage/income ratios may not be eligible for disaster relief because of their inability to repay a loan. Figure 7 portrays this ratio for uninsured victims in different age and income groups affected by a 22-foot flood. The data indicate that individuals in the low income class and those in the highest age bracket have substantially higher ratios than their respective counterparts. For example, uninsured homeowners with incomes below U.S. \$ 12,500 had, on the average, damage which was 2.80 times their annual income. The high income uninsured group, on the other hand, suffered losses which were approximately equal to their annual income. If this phenomenon is typical following disasters then individuals most in need of disaster relief will be the ones least likely to get it, because they will not meet the repayment standards imposed by the Small Business Administration as a condition for eligibility.

The damage/income ratio taken by itself has no causal significance since we are not able to predict whether individuals who have high incomes will also have high damage. On the other hand, this descriptive statistic can be used in combination with other financial ratios discussed by Vinso (1977b) to determine the impact that a disaster is likely to have on different socio-economic groups.

Figure 8 indicates how the damage/income ratio changes as the severity of flooding varies. Low income uninsured victims have much higher values than either of the other two groups whether there is minor flooding (14–18 feet), medium amounts of flooding (20–24 feet), or very severe flooding (26–30 feet). For relatively minor floods none of the income groups have unusually high ratios. As the magnitude of flooding increases, the ratio for the low income groups increases much faster than for the medium and high income homeowners. In fact at a flood height of

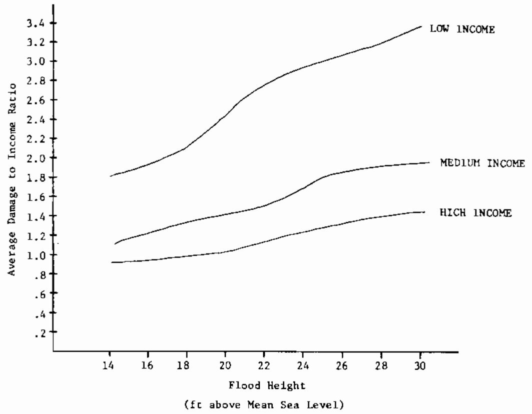


Fig. 8. Average damage/income ratios for River City income classes as a function of flood height (for uninsured residents suffering some damage).

30 feet the average ratio for those with incomes under US \$ 12,500 is over 3.4 compared to 1.9 (medium income group) and 1.4 (high income group). This type of analysis provides the user with a picture of the impact that changes in the magnitude of flooding have on the homeowner's financial status.

SPECIFYING A RECOVERY MODEL (STAGE III)

Immediately after the flood, the balance sheet figures of homeowners are altered by the dollar damage to house value and contents value. The financial recovery of homeowners in the area is determined by the amount of insurance coverage by victims, the type of recovery funds available, and the behavior of different victims with respect to different sources of relief.

In this illustrative example, SBA loans are assumed to be available at 3 percent to cover any uninsured damage sustained by victims. The field survey data revealed that many homeowners eligible for low interest loans did not take advantage of this opportunity particularly if their losses were below US \$ 10,000. Table VI details the percentage of insured and uninsured victims in the field survey who availed themselves of such relief as a function of their property damage.

Each victim in River City had a probability of obtaining an SBA loan based on the relevant percentages in Table VI. For those who qualified for SBA relief, an "amount received" subroutine specified the dollar amount by first determining the ratio of SBA loan/total damage and then multiplying this value by the amount of damage incurred by the victim. The distribution of the loan/damage ratios were obtained for each of the eleven cells in Table VI in which some victims used SBA loans for recovery purposes. In other words we assumed that the victims of River City utilized SBA funding in approximately the same manner as did homeowners interviewed in the field survey.

TABLE VI

Percentage of Uninsured and Insured Victims in each Damage Class Using SBA Loans for Recovery

Damage	Insured(%)	Uninsured(%)
1– 500	0	6
501– 1,000	0	13
1,001– 2,500	0	17
2,501– 5,000	27	34
5,001–10,000	19	55
10,001–20,000	29	69
20,000+	22	72

COMPARISON OF ALTERNATIVE PROGRAMS

Loans and insurance will have different effects on the financial status of the victim in the post-disaster period. At one extreme, if a homeowner is able to utilize insurance to finance his entire recovery then the value of his house and contents are restored to their pre-disaster condition and his net worth is also augmented by the amount of the insurance payment. At the other end of the spectrum if debt in the form of an SBA loan is used to finance recovery then total assets, as represented by the value of the house and contents, will be increased by virtue of the funds used to restore it; however, the level of debt will also increase. For this reason the type of insurance program in effect will have a significant impact on the financial recovery of homeowners in the community.

To illustrate the impact of different programs on the financial recovery of socioeconomic groups in River City, we have compared in Table VII the ratio of total debt to total assets at three points of time: (1) the pre-flood period (Stage I); (2) the immediate post-flood period (Stage II); and (3) the period after recovery funds have been provided (Stage III). Table VII considers differences between the three insurance programs (i.e.,

TABLE VII

Comparison of Average Debt/Asset Ratio for Residents in River City under Alternative Insurance Programs

	Pre-Flood	Immediate Post-Flood	After Recovery Funds Provided
Income			
Low (n=127)			
Program 1	.20	.30	.21
Program 2	.20	.30	.33
Program 3	.20	.30	.36
Medium (n=178)			
Program 1	.24	.36	.26
Program 2	.24	.36	.38
Program 3	.24	.36	.41
High (n=122)			
Program 1	.25	.33	.26
Program 2	.25	.33	.36
Program 3	.25	.33	.38
Age			
Low (n=103)			
Program 1	.35	.55	.37
Program 2	.35	.55	.58
Program 3	.35	.55	.59
Medium (n=237)			
Program 1	.22	.30	.23
Program 2	.22	.30	.32
Program 3	.22	.30	.36
High (n=87)			
Program 1	.12	.15	.13
Program 2	.12	.15	.20
Program 3	.12	.15	.21

mandatory, voluntary, and no insurance) by income and age class.

The comparisons are interesting. When insurance is required for all homeowners in River City (Program 1), the debt/asset ratio significantly decreases between the period immediately following the flood to when recovery funds were provided for all income and age groups (e.g., for the low income group the ratio dropped from .30 to .21). Furthermore, in all income and age groups the value of this ratio after recovery funds were provided under Program 1 is approximately the same as it was prior to the disaster. At the other extreme one finds that if no insurance is available (Program 3), then the debt/asset ratio rises during this interval because victims are forced to rely on loans to finance their recovery (e.g., for the low income group the ratio rose from .30 to .36) [4]. As one would expect a voluntary program produces debt/asset ratios which are between those resulting from Programs 1 and 3 in the period after recovery funds have been provided (e.g., for the low income group the ratio rose slightly from .30 to .33).

A more detailed comparison of the recovery process for River City residents under the three programs is provided in Table VIII. The first portion of the table shows that 76 percent of the homeowners in the community suffered some damage from a 22 foot flood with the per capita total loss for these victims averaging approximately $ 28,200. As one would expect the nature of recovery differs greatly among the three programs. Only one-fourth of the victims are assumed to have insurance when it was voluntary so that many of them relied on the SBA (56%) for relief with an average loan of approximately $ 14,700. More than two thirds of the victims took advantage of the SBA when flood insurance was not available in River City; the average loan under this program also increased to US $ 14,800. (For comparable data in the Wilkes Barre flood, see Vinso, 1977a). When insurance was mandatory then insurance claims naturally dominated the recovery picture. Only 25 percent of the victims supplemented their insurance coverage with SBA funds; under this program the average loan amounted to less than US $ 9,000.

Table VIII also depicts the magnitude of recovery by indicating the ratio of recovery

TABLE VIII

Comparison of Recovery Process for River City Residents under Alternative Insurance Arrangements

	Effect of Disaster Damage due to 22 ft flood		Sources of Recovery (for those Suffering Damage) Insurance Claims		SBA loans	
	Per capita damage for victims (US $)	Percentage of houses damaged	Per capita* (US $)	Percentage using source	Per capita* (US $)	Percentage using source
Program I	28,200	76	24,300	100	8,600	25
Program II	28,200	76	22,300	24	14,700	56
Program III	28,200	76	0	0	14,800	70

Effect of Recovery

Recovery Funds/Total Damage (for those Suffering Damage) (Percentage in Each Class)

	0	.01–.25	.26–.50	.51–.75	.76–1.00	1.00+
Program I	0	0	0	6	71	23
Program II	26	15	15	15	16	13
Program III	30	21	20	13	4	12

*Based on those using specific source

TABLE IX

Comparison of Rccovery Process for *Low Income* River City Residents under Alternative Insurance Arrangements

	Effect of Disaster Damage due to 22 ft flood		Sources of Recovery (for those Suffering Damage) Insurance Claims		SBA loans	
	Per capita damage for victims (US $)	Percentage of houses damaged	Per capita* (US $)	Percentage using source	Per capita* (US $)	Percentage using source
Program I	21,500	79	19,200	100	8,400	17
Program II	21,500	79	16,300	18	13,400	56
Program III	21,500	79	0	0	12,300	65

Effect of Recovery

Recovery Funds/Total Damage (for those Suffering Damage) (Percentage in Each Class)

	0	.01–.25	.26–.50	.51–.75	.76–1.00	1.00+
Program I	0	0	0	2	81	17
Program II	30	14	14	13	14	15
Program III	35	20	16	12	3	14

*Based on those using specific source.

funds to total damage under each of the three programs. Whenever this ratio is below 1.0, homeowners will not have received enough funds to restore their property to its pre-disaster condition. When insurance is required only 6 percent of the victims did not obtain enough funds from their coverage and SBA loans to restore their property to at least 75 percent of its pre-disaster value. On the other side of the ledger, one finds that if no insurance was available 30 percent of the disaster victims did not utilize the SBA for any disaster relief and hence have a ratio of recovery funds/ total damage equalling zero. These families would have had to turn to other sources such as personal savings, bank loans, or Red Cross aid to restore their property.

An analogous comparison is presented in Table IX for low income residents of River City to illustrate the types of analyses which can be generated using the community disaster model. The per capita damage figures for this group are lower than for the community as a whole as are the average amount of insurance claims and SBA loans for those who utilized each of these sources. When insurance is mandatory practically every low income family recovers to at least 75 percent of its pre-disaster value. Under a program of no insurance more than 1/3 do not utilize the SBA for any relief, a higher percentage than for the community as a whole.

EVALUATING PRIVATE AND SOCIAL RISKS

The community disaster model enables one to determine the impact of different programs on private and social risks. *Private risks* refer to actions taken by an individual that affect himself but not society. An example would be a decision by a person to construct a house near a river knowing full well that he would have to bear the entire financial burden should the structure suffer damage from a flood. *Social risks* arise if the general public bears the costs of negative outcomes associated with a particular action. The above location decision would be classified as a social risk if the federal government were to pay for all flood losses to private property.

Most actions involve both types of risks (Lave, 1971). The relative magnitude of the private and social costs will depend upon the nature of the public policies in force and the time horizon under consideration. For example, should a flood occur tomorrow the physical destruction will be identical whether homeowners expect to be compensated by insurance or by federal relief. Their decision to locate in these hazard-prone areas has an element of social risk to the extent that other taxpayers bear some of the recovery costs through either federally subsidized insurance or generous federal relief. Any difference in the social risks between these two programs will also be reflected in the resulting income distributions of victims and non-victims following a disaster.

Let us now consider the impact of the programs discussed above on private and social costs. To begin with let us consider Mr. Glenn who has suffered US $ 12,000 damage to his house and US $ 6000 to the contents from a 22-foot flood in River City. If the Glenn family had purchased sufficient flood insurance to cover their entire loss (except for the deductible) then the social costs associated with the claim will be determined by the proportion of insurance subsidized by the federal government [5]. Suppose that at the time of the River City flood 55 cents out of every dollar in insurance claims was paid by the federal government through the Federal Insurance Administration. Then the social cost would be .55 multiplied by the insurance claim payment. Since the private sector would pay the remaining 45 percent through insurance premiums this portion of the payment to the Glenn family would be treated as a private cost.

The same analysis could be applied to all victims in River City who have insurance coverage. For any given flood the social cost of the flood insurance program will increase as the percentage of the government subsidy in creases and as the amount of coverage in force within the community increases. If victims do not have insurance coverage then they may want to rely on other disaster relief programs to aid their recovery. For example, in Program 3 the only source of relief was SBA disaster loans. The social cost of each dollar in SBA relief will be directly related to the difference between the subsidized interest rate and the market rate of interest. If, as in the illustrative example, the interest rate were 3 percent on loans of any size and the market rate of interest were 9 percent then the general taxpayer would be subsidizing the recovery by 6 percent for every dollar loaned to disaster victims. Naturally if the SBA disaster relief program included forgiveness grants, then the social costs of this recovery measure would be increased.

The community disaster model is *not* intended to provide direct answers as to which set of adjustments are the most desirable from the viewpoint of private and social costs. What it can do is provide information to policy-makers which will help them understand the positive and negative aspects of any policy. For example, in the above discussion on the recovery problems in River City, Program 1 (required insurance) and Program 3 (no insurance available) will have very different impacts on the distribution of wealth in River City after the flood. On the basis of the behavioral models utilized to describe the recovery pattern, we have seen that if no insurance were available in River City, many victims would choose not to utilize any governmental funds to aid in their recovery efforts. The social costs of Program 3 would thus be relatively small but many of the victims, particularly those in the low income class, would be financially crippled for many years after the disaster [6]. These stark figures produced by the community disaster model highlight critical problems and choices facing federal, state and local governments as well as the insurance industry in designing disaster programs.

EXTENSIONS OF THE MODEL

The illustrative example and the discussion of private and social costs are designed to stimulate further suggestions by users and decision-makers in the United States as to ways in which this tool could be improved for policy purposes. Extensions of the model include: (1) the construction of alternative scenarios; and (2) analysis of alternative adjustments; these areas are discussed below.

(1) Construction of Alternative Scenarios

By constructing different communities using either field survey data or by having users generate characteristics through the use of statistical distributions, one can determine the effect that alternative adjustments will have on different groups in the flood-prone area as a function of their socio-economic characteristics, the types of physical structures and their location in relation to the river. Depending upon how runs of the model are constructed, a user can vary different inputs (e.g., income levels or age distributions of the community), or enter new mitigation or recovery policies (e.g., requiring all homes in the 100 year flood plain to be flood proofed) to determine the effects such changes will have on physical damage and the financial status of different socio-economic groups; (for a detailed description of how to use the model see Katz and Miller (1977)).

For example, one could determine the impact that flood proofing homes to different protective levels would have on the actual damage and financial status of classes of disaster victims in a community such as River City. One could also examine the impact of changes in the interest rate of SBA loans on the financial recovery. Another question that could be addressed is what effect a mandatory flood insurance program would have on the recovery process should a community suffer losses from disasters of differing degrees of severity. The computer model has been designed so that the user can undertake these types of sensitivity analyses with relative ease.

(2) Analysis of Alternative Adjustments

The community disaster model can serve as a vehicle for analyzing alternative adjustments to the flood hazard taken individually or as part of a coordinated disaster program. Specifically, it should be possible to examine the impacts on different user groups should several adjustments be successfully coordinated. White's (1973) critical assessment of the flood hazard provides a meaningful point of departure for this analysis by indicating which adjustments are closely linked, which ones have only weak interrelationships, and others where there is no solid evidence for estimating the relation. Future analysis of the types of hazard mitigation and recovery measures outlined below should be undertaken by recognizing the limits of our understanding as to how these adjustments relate to each other.

In developing such interactions the user should recognize that some of the adjustments are linked in a dynamic fashion and may change over time. For example, White and Haas (1975) point out that testimony from flood insurance hearings indicated that once land-use regulations are enacted in communities participating in the National Flood Insurance Program, they either lead to a reduction in the development of the flood plain or cause action on the part of the developers to either "modify the insurance provisions or eliminate land-use planning and accompanying insurance guarantees in the community" (p. 67). Thus land-use regulation and insurance may complement each other in certain localities by reducing the physical and financial consequences of the hazard while they may exacerbate problems in other areas.

In the discussion that follows we will outline specific hazard mitigation and recovery measures which users may want to incorporate into the community disaster model. The reader is cautioned that the evaluation of these adjustments will be dependent on the quality of data and accuracy of the behavioral models of choice in the pre- and post-disaster periods. Future research and data collection efforts should improve our understanding of these decision processes and will increase the quality of the data analysis.

Flood Proofing

Preliminary analyses of the cost and potential benefits of flood proofing have been undertaken by Wilson, Lepore and Duffy (1977) in presenting their findings on the damage sector. Their analysis has concentrated on the impact that specific flood proofing requirements will have on reducing losses to residential structures from floods of different magnitudes. A user could also incorporate the flood proofing adjustment into a more extensive disaster program. For example, he could analyze the costs of adopting specific flood proofing measures and the potential benefits in the form of lower insurance premiums reflecting a reduction in the expected annual flood losses to the property. In the same manner one could evaluate the pre- and post-disaster financial effects of utilizing flood proofing techniques. For example, the community disaster model could analyze balance sheet effects following specific floods, should specific groups of homeowners choose to adopt or not utilize available flood proofing techniques.

Warnings

Mileti (1975) has pointed out that an integrated warning system actively incorporates three processes: (1) the *evaluation* of data on which to base a warning (2) the *dissemination* of the information to the threatened population and (3) the *response* by those who receive the warnings. The community disaster model would enable the user to evaluate the effectiveness of different warning systems if data is available on the impact of such messages on behavior of selected groups in population. Anderson (1970) has provided considerable insight into the subject in his study of the response to warnings by residents of Crescent City, California and Hilo, Hawaii. A limited amount of data on response to warnings in past disasters has been collected from the field survey of 2000 homeowners in flood-prone areas. Considerably more information should be forthcoming in a current research project study on the subject at the University of Minnesota.

To evaluate the relative merits of a warning system one would need to have cost data associated with the installation and implementation of a warning system for different communities threatened by floods. One might also be able to determine what impact this adjustment would have in combination with flood insurance. If homeowners have advanced warning of a flood they may decide to either protect some of their possessions or not to take any action should they prefer to replace used items by a claim. Their action will undoubtedly be influenced by the size of the deductible on the flood policy.

Flood-Prone Land Acquisition

The National Flood Insurance Act includes a section (1362) that enables the federal government to acquire flood-prone lands subject to the following restrictions:

(a) the property must be located in a flood-risk area;
(b) the property must be covered by flood insurance;
(c) the property must have been damaged "substantially beyond repair" by flooding while covered by flood insurance.

The community disaster model may be a useful tool for analyzing the impact that the implementation of Section 1362 is likely to have on individual residents of different flood-prone areas, the community as a whole, as well as state and federal governmental agencies responsible for providing mitigation and recovery funds for natural hazards.

In order to determine the relative performance of 1362 when compared to other relief programs one should have data on the socioeconomic characteristics of the community under study, the types of damage that can be expected from floods of different magnitudes, as well as the insurance status of the population and alternative relief measures that they are likely to utilize if the government were not to reimburse them for substantially damaged property. This type of analysis thus suggests that one has to integrate other adjustments (e.g., insurance purchasing decisions, degree of flood proofing, decisions to obtain loans) explicitly into the analysis.

SBA Loan Programs

Consider the changes in the SBA disaster loan program in the past six years. Following Tropical Storm Agnes in June 1972 disaster victims were able to receive forgiveness grants of up to US $ 5000 and loans to cover the remaining portion of their loss at an annual interest rate of one percent. In April 1973 legislation was passed (PL 93-24) rescinding the US $ 5000 forgiveness grants authorized after Tropical Storm Agnes and increasing the annual interest rate from one to five percent. The interest rate was raised even further to 6 5/8 percent in August 1975 (PL 94-68). The severe drought in the West and spring flooding in Appalachia during 1977 led Congress to liberalize the disaster relief provisions once again. Legislation passed in August 1977 (PL 95-89) permits individuals to obtain one percent interest loans on the first US $ 10,000 of uninsured damage, three percent loans on the next US $ 30,000, and 6 5/8 percent loans for that portion of a loan covering uninsured losses exceeding US $ 40,000. Any victim who has received an SBA loan related to a disaster that has occurred since July 1, 1976, can take advantage retroactively of the above provisions.

The community disaster model can examine how changes in the terms of this program will impact the recovery process under different assumptions about victims' behavior following a disaster. What impact will different interest rates and forgiveness grant features have on the decision as to how large a loan, if any, will be requested and approved? What are the private and social costs associated with these programs?

CONCLUSION

If the community disaster model is to be considered a successful tool for policy purposes then it must meet the needs of users who are interested in investigating the effects of different mitigation and recovery policies. Katz and Miller (1977) have provided extensive documentation on how to use the interactive computer model. As they point out, a major design objective is to provide a high degree of flexibility so that it is possible to make substantial modifications without having to incur large amounts of time, skill, and confusion in reprogramming. The next step in the process is for users to be willing to make the initial commitment to experiment with the model. Only then will we be able to determine whether the community disaster model is a useful tool for policy analysis.

ACKNOWLEDGEMENT

The community disaster model was developed by an interdisciplinary team at the University of Pennsylvania consisting of Bradley Borkan, Norman Katz, Howard Kunreuther and Louis Miller (Decision Sciences), Joseph Vinso (Finance), and Brogan Duffy, John Lepore and John Wilson (Civil and Urban Engineering). The overall design and implementation of the model is due to Katz and Miller. A more detailed description of the capabilities of the community disaster modeling system appears in Kunreuther et al. (1978).

NOTES

1 Currently flood insurance is offered on a nationwide basis at subsidized rates through the cooperation of the federal government and the private insurance industry. For a detailed discussion of the National Flood Insurance Program, see Kunreuther et al. (1977), Chapter 2.
2 For this illustrative example we arbitrarily chose a critical value of .88. This cutoff point resulted in approximately 28 percent of the homeowners in River City having coverage.
3 The limits on coverage were set at US $ 70,000 for the structure and US $ 20,000 for contents
4 Analyzing the low income, high age group showed an even more dramatic increase. The pre-flood debt/asset ratio was .10, immediately after the flood it was .13, and following the recovery it was .19. This is consistent with the finding of Vinso (1977a) in a study of a flood-prone community (Wilkes Barre, Pa.) characterized by low income, high age residents where virtually no one had purchased flood insurance prior to Tropical Storm Agnes. The actual ratios in River City are slightly lower than those found by Vinso due to the lesser damage incurred by River City. However, the relative magnitudes of the ratios are similar.
5 In recent years this percentage subsidy borne by taxpayers has been reduced from 90 percent to slightly above 50 percent so that the social cost of flood insurance has decreased.
6 Vinso (1977a) has shown that many uninsured victims in Wilkes Barre were saddled with severe debts following Tropical Storm Agnes. They have thus been financially crippled despite the generous SBA loan policy provided them after the disaster.

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