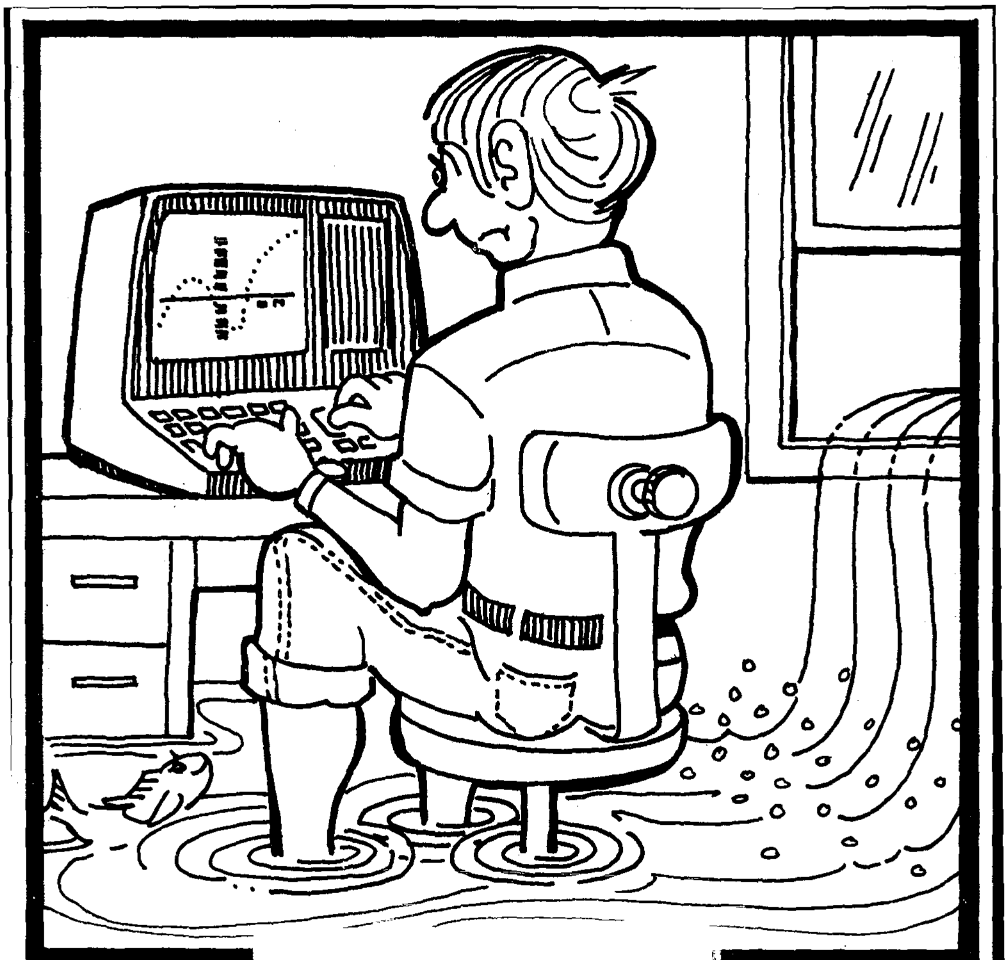
PB 296976

AN INTERACTIVE MODELING SYSTEM FOR DISASTER POLICY ANALYSIS

Howard Kunreuther
John Lepore
Louis Miller
Joseph Vinso
John Wilson
Bradley Borkan
Brogan Duffy
Norman Katz



50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. NSF/RA-780293	2.	3. Recipient's Accession No. PB296976

4. Title and Subtitle
Interactive Modeling System for Disaster Policy Analysis, (Program on Technology, Environment and Man, Monograph No. 26)

5. Report Date 1978

6.

7. Author(s)
H. Kunreuther, J. Lepore, L. Miller, J. Vinso, J. Wilson et al

8. Performing Organization Rept. No. 26

9. Performing Organization Name and Address
University of Colorado
Institute of Behavioral Science
Program on Technology, Environment and Man
Boulder, Colorado 80302

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G) ENV7612370

12. Sponsoring Organization Name and Address
Applied Science and Research applications (ASRA)
National Science Foundation
1800 G Street, N.W.
Washington, DC 20550

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

The Community Disaster Modeling System, an interactive computer-based modeling system, was developed for studying the relative costs and benefits of alternative hazard mitigation and recovery programs. The system is capable of dealing with sets of individual homeowners and businesses enabling users to construct representations of hazard-prone communities and to examine impacts of mitigation and recovery programs on residents of a community as well as on local, state, and federal agencies. This system was designed to provide a high degree of flexibility so that it is possible for the user to make substantial modifications without having to invest large amounts of time and skill or risk confusion in reprogramming. These features are illustrated by the construction of the hypothetical community of River City and a demonstration of how the system's damage and financial submodels are explicitly utilized in evaluating the impacts of floods as a function of alternative scenarios and policies. It is pointed out that users must make the commitment to experiment with the system to ascertain its value as a meaningful tool for policy analysis.

17. Document Analysis a. Descriptors

Disasters	Hazards	Data processing
Policies	Materials recovery	

b. Identifiers/Open-Ended Terms

Policy analysis

c. COSATI Field/Group

18. Availability Statement
NTIS

19. Security Class (This Report)

20. Security Class (This Page)

22. Price A08-A01

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

AN INTERACTIVE MODELING SYSTEM FOR DISASTER POLICY ANALYSIS

Howard Kunreuther
John Lepore
Louis Miller
Joseph Vinso
John Wilson
Bradley Borkan
Brogan Duffy
Norman Katz

Program on Technology, Environment and Man
Monograph #26

Institute of Behavioral Science
University of Colorado
1978

Prepared with the Support of the
National Science Foundation
Washington, D.C. 20550

NSF Grant Number ENV 76-12370

This report was prepared with the support of National Science Foundation Grant No. ENV 76-12370. Any opinions, findings, conclusions or recommendations expressed herein are those of the authors and do not necessarily reflect the views of NSF.

Library of Congress
Catalog Card No.
78-61772

PREFACE

This monograph describes an interactive modeling system that was developed at the University of Pennsylvania for the purpose of providing guidance to decision makers on the relative benefits and costs of alternative hazard mitigation and recovery policies. This effort has been supported by funds from the National Science Foundation and brings together concepts from Civil Engineering, Decision Sciences, and Finance.

The work is an outgrowth of earlier research concerned with how individuals behave in protecting themselves from losses in floods and earthquakes, focusing particularly on the decision to purchase insurance. In the course of that effort, it became apparent that in choosing among policy options there was a need for a supporting tool that could project outcomes of interactions among hazards, populations at risk and policies. Such a vehicle should have several attributes:

- it should integrate information of several types--physical, social, economic, behavioral, and engineering.
- it should deal with representative samples of entities--homeowners, businesses, farms, and public facilities--at a disaggregated level because these are the entities upon which hazards and policies act.
- it should be sufficiently flexible that extensions and adaptations to new situations, policies, theories, and types of analyses should be relatively easy to accomplish.

- it should be embodied in an interactive person-computer system that is designed to be as convenient to use as possible.

The monograph is organized into six chapters with the following purposes:

1. provide a conceptual framework to indicate how alternative scenarios and their implications for hazard policy are analyzed.
2. describe the software package that supports this effort in order to provide insight into how models are organized internally and how users interact with them.
3. develop a methodology for estimating damage using probability matrices to reflect local conditions.
4. provide a detailed description of the types of data required to examine the impact of a disaster on the financial status of the victim.
5. illustrate different types of analyses that can be undertaken using the disaster modeling system through the construction of a hypothetical community and a set of alternative disaster programs.
6. to investigate the public policy implications of the model and discuss proposed extensions.

For us to consider this project a success, meaningful policy analyses will have to be carried out by governmental bodies with the support of the interactive modeling system. We hope this monograph serves to alert potential users to the capabilities of the system and aids them in formulating questions that are germane to their needs. A currently funded National Science Foundation project should enable us to determine whether the modeling system can be a valuable instrument for policy analysis. We look forward to the future with great anticipation.

The Authors

June, 1978

ACKNOWLEDGMENTS

Throughout the project we had excellent counsel and advice from members of our advisory committee and their representatives. They were:

William Anderson, National Science Foundation
J. Robert Hunter, Federal Insurance Administration
Edward Ignall, Columbia University
Harry Markowitz, IBM
Jack McGraw, Federal Disaster Assistance Administration
Jerome Milliman, University of Florida
George R. Phippen, U.S. Corps of Engineers
Andrew Shaw, Wilkes College
John Sheaffer, Sheaffer and Roland, Inc.
Frank Thomas, U.S. Water Resources Council
Samuel Weese, National Flood Insurers Association
Gilbert White, University of Colorado.

We benefited greatly from the lively interchange of ideas that took place at these meetings and the informal discussions with individual members of the committee at other times during this period.

The Philadelphia Corps of Engineers deserves special mention for providing us with considerable information and data on damage assessment used by the Corps in their own analyses. John Wiggins and D. Earl Jones provided useful comments on drafts of the monograph and reports.

A special note of thanks goes to Gilbert White who enabled us to demonstrate the modeling system at the Natural Hazards Workshop in Boulder in May 1977. As a result of the demonstration we gained insights into the usefulness of models to decision makers at local, state, and federal levels. Susan Tubbesing and Penny Waterstone of the Institute of Behavioral Science, University of Colorado, assisted us in organizing the demonstration at the Workshop.

We are grateful to Laura Weinstein who officially managed the project since its inception. We also owe a debt of gratitude to our program manager William Anderson who took an active interest in the project from beginning to end. Not only did he provide discerning comments and advice on the directions of the project, but he also organized meetings with user agencies to discuss possible implementation.

ABSTRACT

An Interactive Modeling System
For Disaster Policy Analysis

This monograph introduces the reader to an interactive computer-based modeling system for studying the relative benefits and costs of alternative hazard mitigation and recovery programs. The approach differs from existing systems in that it has the capability of dealing with sets of individual homeowners and businesses. This feature enables users to construct representations of hazard-prone communities and examine impacts of mitigation and recovery programs on residents of a community as well as on local, state, and federal agencies.

The interactive system is designed with the user in mind. It is extremely flexible making it relatively easy to extend or modify. We illustrate these features in this monograph by constructing the hypothetical community of River City and demonstrating how the damage and financial submodels are explicitly utilized in evaluating the impacts of floods as a function of alternative scenarios and policies. The eventual success of the interactive system can only be determined after there are efforts by policy makers to experiment with it. The material presented should thus be viewed as a first step toward creating a dialog between potential users and researchers desiring to develop meaningful policy-evaluating tools.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

AN OVERVIEW OF THE SYSTEM

One of the challenges facing decision-makers concerned with developing meaningful policies for coping with the consequences of natural hazards is to determine the relative benefits and costs of alternative mitigation and recovery programs. As pointed out by White and Haas (1975) in their Assessment of Research on Natural Hazards, there are a set of adjustments to natural hazards which interact with each other in different ways and vary depending upon local conditions. One of the authors' principal points is that one must examine options in relation to the physical features and the socioeconomic characteristics of the locale. This suggests that there is a need to develop model-based approaches which enable interested parties to consider the unique features of hazard-prone areas in evaluating alternative policies.

This monograph describes such an approach. Our specific purpose is to introduce the reader to an interactive computer-based modeling system that can deal with sets of individual homeowners and businesses. This feature enables the user to construct representations of hazard-prone communities and examine impacts of mitigation and recovery programs on inhabitants as well as on external sectors (e.g., federal, state, and local governments and industry). We have chosen to label this system the Community Disaster Modeling System (CDMS).

The material presented below should be viewed as a first step toward creating a dialog between potential users interested in analyzing alternative programs and researchers who wish to develop meaningful policy making tools. To begin this interaction it is useful to examine the way the modeling system thinks. In doing so we will restrict our attention to homeowners residing in a flood-prone community. The concepts presented below, however, are general; they can also be applied to other community entities such as business, commercial, and public sector units, as well as to other hazards.

Nature Of The Modeling System

The individual homeowner provides the basic unit of analysis upon which the CDMS operates. Each homeowner has specific socioeconomic traits and financial characteristics, and resides in a particular type of structure such as a one story wood frame house with a basement. Such data on individuals can be obtained by means of field surveys or by sampling from statistical distributions. In this manner the user constructs a community of his choice. The user can then analyze the effects of different mitigation and relief policies on disasters of varying degrees of severity from a variety of viewpoints (e.g., federal government, general taxpayer).

By varying the types of communities and the height of the river, the decision-maker can determine the sensitivity of different policies to two key variables: the composition of the hazard-prone area and the severity of flooding. In this sense the CDMS can provide a wide array of descriptive data. The simulation has normative implications to the extent that the decision-maker is able to conclude, after analyzing a number of different scenarios, that one set of policies is preferable to another.

The CDMS is designed with the user in mind. It is extremely flexible and so is relatively easy to extend or modify. 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 the entire structure. Chapter II contains a further discussion of the computer implementation of the system.

The CDMS has two basic components, the damage submodel and the financial submodel, for analyzing the impact of floods as a function of alternative scenarios and policies. In utilizing the CDMS one can vary community data (e.g., income or age distributions) or enter new policies (e.g., requiring all homes in the flood plain to be floodproofed) to determine the effects such changes will have on physical damage and the financial recovery of different socioeconomic groups.

The damage submodel determines the structural and contents losses for different house types as a function of the height of the water in relation to the first floor elevation. Rather than pinpoint damage figures with certainty for a given flood height and structure class, we have chosen to express the potential loss in probabilistic terms using the damage probability concept described by Whitman et al. (1975). This uncertainty with respect to damage figures is due to variations in building techniques and local conditions as well as differences in flood characteristics as a function of geographical location. This is discussed in more detail in Chapter III.

Given the probability distribution of losses, a specific level of physical damage is determined for each house in the community. This damage figure is translated into monetary losses which are then used to analyze the financial impact of the disaster on different victims and the community as a whole. Of primary concern is how individual homeowners finance their repairs or replace lost property. Large amounts of cash are required to duplicate as closely as possible the same conditions that existed prior to the disaster; these funds must come from either the homeowner's own resources or from such external sources as insurance or loans. The choice of a particular source, though, has its own consequences. For example, using loans to finance recovery increases the debt owed by the household. This debt, coupled with a possible loss of income, has long-range effects on the individual who may lose his home if the debt cannot be paid, as well as on the community which could lose a substantial number of households and hence future tax revenue. The financial submodel of the CDMS, discussed in Chapter IV, provides a means to determine how disasters and alternative mitigation and recovery policies affect the financial position of the household.

A Conceptual View Of The CDMS: Stages Of Analysis

For convenience one can view the CDMS as being divided into three stages corresponding to the pre-disaster, immediate post-disaster, and post-recovery periods. Figure

I-1 delineates these time periods and indicates a set of user inputs associated with each one. To explain this figure more fully we have assembled data in Table I-1 on the Glenn family, long time residents of River City, Pennsylvania--a simulated flood-prone community which will be the subject of detailed analysis later in this report.

In Stage I, the user is concerned with generating a set of homeowners with certain pre-disaster attributes that will be important in analyzing particular adjustments. As can be seen in Table I-1 we have listed certain attributes of the household head (Mr. Glenn) such as his age and educational level as well as socioeconomic characteristics of the family (income and family size). Detailed balance sheet data on assets and liabilities including estimated house and contents value illustrate the financial status of the Glenn family in the pre-disaster period. The user might also want to include data on the insurance status of the household if this information were readily available. Alternatively, he could develop a behavioral model of choice to predict whether a particular family is likely to purchase insurance coverage given its socioeconomic characteristics and its interaction with the environment (e.g., whether the family has experienced damage from previous flooding). Such a model is presented in Chapter V.

Another important set of attributes associated with Stage I relates to the physical characteristics of the property in the community. From Table I-1 we see that the Glenn family resides in a 30-year old, one story, wood frame house with no basement. The structure is located in the

FIGURE I-1

FLOW CHART OF DISASTER MODEL FROM PRE-DISASTER TO POST-DISASTER RECOVERY

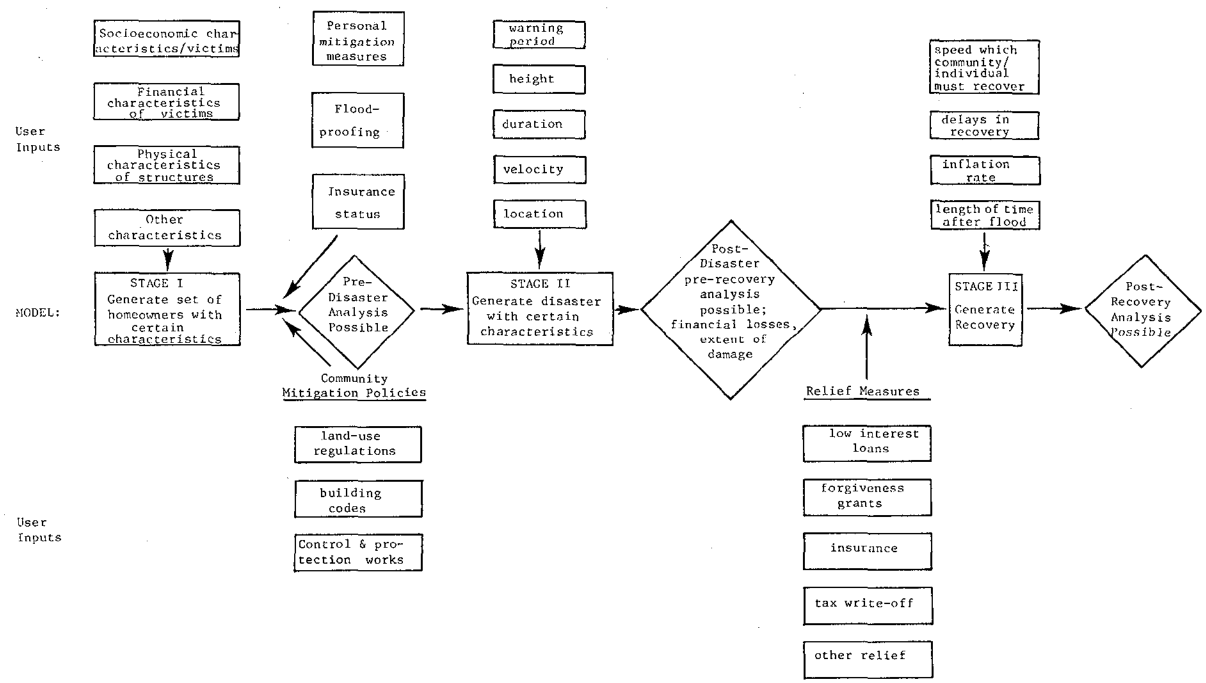


TABLE I-1

SELECTED ATTRIBUTES OF AN INDIVIDUAL HOMEOWNER

Pre-Disaster Attributes (Stage I)	
Socioeconomic	
Age of Household Head	50 years
Income (annual)	$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	1947
Number of Stories	1
Basement (with/without)	Without
Type of Construction	Wood frame-asbestos siding
Height of First Floor Above Ground Level	3 ft
Zone	100 year flood plain
Generate Flood (Stage II)	
Height of Water Above Ground Level	12 ft
Damage Incurred	
Structural	$12,000
Contents	$ 6,000
Total damages:	$18,000
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

100-year flood plain with the first story raised so it is three feet above ground level. These data will be used to calculate the potential damage to the structure from floods of different magnitudes. By characterizing different families and their property in the same manner, the user can describe the residents of an entire flood-prone community.

Once the community has been constructed, the user can undertake a set of pre-disaster analyses. These analyses can be particularly helpful in determining what alternative hazard mitigation and recovery programs are worthy of study. For example, the pre-disaster analysis can provide information to users on the behavior patterns of different socioeconomic groups in purchasing insurance or flood proofing. The analysis can also aid the user by providing an indication of meaningful flood heights to consider in Stage II given the types and elevations of the structures in the flood plain.

Stage II of this conceptual view involves the generation of 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. Once damage figures have been determined for each structure, the financial balance sheets can be updated to reflect the resulting change in assets and liabilities. In the case of the Glenn family, the flood reduced the value of the house from $24,000 to $12,000 and the value of its contents from $12,000 to $6,000. 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, we can obtain summary statistics on the physical damage to different type 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, the flood stage has to be translated into monetary losses through certain prescribed relationships as discussed in Chapter III. In addition, the user can 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 information comprises the immediate post-disaster analysis phase depicted in Figure I-1. Analyses undertaken at this point can be particularly helpful in determining what types of recovery policies to investigate. For example, if one observed that uninsured low income victims suffered severe financial losses, then special relief programs for this group could be explored.

The Community Disaster Modeling System then enables us to evaluate the impact of different relief measures on the recovery process. We have listed the most obvious ones in Figure I-1: low interest disaster loans, forgiveness grants, insurance, and tax write-offs. The user can, for example, specify the interest rate on SBA disaster loans and the maximum amount available to any disaster victim. The system can then determine how changes in the terms of a particular relief program financially affect disaster victims and/or 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, losses exceeded the value of their insurance policy on both house and contents. As shown in Table I-1 the family 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 the immediate post-flood period; the value of their real assets increased by $18,000 to reflect the checks they received from both the National Flood Insurance Program and the Small Business Administration. On the other hand, the $3,000 loan increased the level of their fixed liabilities to $7,600. 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 private industry on insured losses.

Comparison Of The CDMS With Existing Models

The CDMS complements other computer modeling efforts on natural hazards. To our knowledge all of these efforts focus on the impact of disaster programs at a regional or national level. One such model was developed for the Corps of Engineers to study the effects of land-use planning and development (Institute for Water Resources, 1972). This computerized procedure enabled the Corps to analyze the costs and benefits of alternative levels of flood protection on present and future land utilization with specific emphasis on the effects at the national level. For this reason there was interest in such questions as the effect of protective works on economic activity and land prices rather than on the impact of different socioeconomic groups residing in the flood plain area.

More recently Friedman (1975) has constructed a computerized model for analyzing the loss potential for natural hazards affecting the United States with particular emphasis on earthquakes, inland flooding, and hurricanes. Central to Friedman's system is a natural hazard generator which produces a geographical pattern of severity (e.g., flood height, earthquake intensity) based upon the physical characteristics of the geophysical event modified by the effect of local conditions. Friedman has produced a spatial distribution of the buildings as well as the residents exposed to different hazards, so one is able to determine the vulnerability of the population-at-risk to specific types of losses. His model is also able to determine the average annual damage to structures from specific hazards (e.g., damage to residential structures due to earthquakes in San Francisco) as well as potential damage to an area from a single catastrophic event.

The John H. Wiggins Company has modified Friedman's approach in order to examine the losses caused by nine natural hazards: earthquake, expansive soils, landslide, hurricane wind, tornado, severe local wind, riverine flooding, storm surge and tsunami (see Wiggins, 1976). The effort most closely related to the CDMS presented here is a model designed by the Wiggins Company to determine the impact of alternative mitigation measures on flood losses in the United States from 1970 to 2000. The authors provide measures of expected national losses as the catastrophic loss potential should an event such as Tropical Storm Agnes (1972) occur in the future (Wiggins, 1976).

The CDMS differs from the above simulation models since it is concerned with the consequences of alternative mitigation and recovery programs on a specific hazard-prone area, rather than on a regional or national level. Furthermore, previous simulations, unlike the CDMS, have determined the expected costs and benefits of adjustments without detailing how the composition of the community or the severity of different floods affect the results.

This disaggregated view of the effects of alternative adjustments is important because certain classes of residents are likely to be affected in special ways by a disaster and by alternative recovery programs. To illustrate, consider the impact that an SBA low interest disaster loan program is likely to have on residents in contrast to a grant program. The adverse effect of the increased debt created by these loans on the future lifestyle of low income residents would be much greater than on that of higher income victims. To determine whether the federal government may want to develop special policies for victims with low incomes, it is necessary to show the differential effects of proposed policies on this class in contrast to the more well-to-do residents of the area. The CDMS enables one to determine what these effects are likely to be while enabling policy makers to consider special arrangements for special groups.

Table I-2 outlines some of the questions decision-makers can examine through the use of the modeling system. The columns consist of different user groups affected by the flood hazard. They are: governmental agencies concerned with flood recovery problems [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 dealing with engineering aspects of flood control [e.g., the Army Corps of Engineers (CE) and the United States Geological Survey (USGS)]; and financial institutions (e.g., banks, savings and loan associations).

The rows of the table present various reasons for using the system--i.e., to evaluate alternative mitigation measures, the extent of flood damage, alternative flood recovery programs, and the status of the post-flood community. It is important to note that the specific questions posed could have been asked by other user groups or could have had an impact on other evaluation levels. In fact, the relative merits of a specific mitigation policy--floodproofing, for example--could interest many sectors and could be evaluated in terms of the policy's effect on flood damage and recovery.

TABLE I-2

PURPOSES OF DISASTER MODEL FOR DIFFERENT USER GROUPS

Uses \ User Group	FIA, SBA, FDAA	State and Local Government	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 determining* 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 programs: Loans 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 costs 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 re-*quired 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.

Two Scenarios

To illustrate how a user might employ the CDMS let us present two hypothetical scenarios--one from the viewpoint of a local government official and the other from the viewpoint of a federal agency concerned with disaster relief.

Scenario 1

As a city manager of a riverine community faced with potential flooding problems you are interested in analyzing alternative hazard mitigation measures, their effects on the financial status of residents of the community prior to a disaster, as well as the impact that floods of different heights have on damage to the community. At present, the community is not a part of the National Flood Insurance Program but there has been considerable pressure upon it to join. If the community joined the program then land use regulations and building codes would be imposed on flood prone portions of the community. The CDMS has been proposed as a useful tool for helping you (as city manager) analyze the benefits and costs of joining the flood program. Answers to questions related primarily to the pre-disaster period (Stage I) and the post-disaster pre-recovery period (Stage II) would be helpful:

1. What impact would insurance coverage have on the financial status of current residents as well as new homeowners?

2. What proportion of homeowners are likely to voluntarily purchase insurance prior to a disaster and what are their socioeconomic characteristics?

3. What would the costs to the homeowner be for floodproofing existing as well as new structures in the community?

4. What impact would certain land-use regulations have on the growth of the community over time and on the community's tax base?

5. What would be the financial impact on the community if it provided low-interest loans to homeowners for floodproofing their structures?

For Stage II, a city manager might be interested in determining answers to such questions as:

1. What are the potential reductions in damage should the community enter the flood program and adopt specific land-use regulations and building codes?

2. What damage would the community incur should it decide not to enter the flood program and hence maintain its current set of regulations?

3. What impact would each of these options have on the socioeconomic condition of residents in the community?

Each of these questions could be investigated for alternative flood heights.

Scenario 2

As an administrator of the SBA disaster loan program you are particularly interested in the impact that alternative hazard mitigation measures may have on the recovery needs of homeowners suffering flood damage. For this reason, you wish to investigate the impact that insurance coverage, building codes, and land-use regulations have on required relief for communities suffering flood damage of different magnitudes. The concerns of the SBA on the other hand, are much more at a national level than those of the city manager. Hence its interests would be on a set of representative riverine and coastal communities around the country rather than one specific community.

The interest by the SBA would be primarily on the post-recovery analysis (Stage III) in relation to the alternative hazard mitigation measures which might be adopted by the community. Specifically, the following questions might be raised:

1. What would the financial cost of alternative SBA disaster loan programs be given specific hazard mitigation measures adopted by the community?

2. What would the financial impact be on the homeowner and federal government if interest rates and loan terms were varied and alternative forgiveness features were introduced?

3. Should an SBA loan program be based on pre-disaster income level of disaster victims? What would be the impact of such a policy on specific socioeconomic groups suffering losses?

These questions would obviously be highly dependent on the hazard mitigation measures adopted by different communities, and on the severity of the flooding and the socioeconomic and physical composition of the community.

In order to undertake the above analyses depicted by each of the two scenarios, the city manager and an SBA disaster loan administrator must be in a position to provide the following types of information:

1. A set of Stage I attributes for potential victims similar to those of Mr. Glenn presented at the beginning of the chapter. The data could be provided through U.S. Census information on the community or by survey information on a representative sample of communities throughout the country subject to coastal and riverine flooding.

2. A designated set of policy options that can be translated into computer routines.

3. A set of specifications for analyzing data at each of the different stages of the model. The analysis routines can provide information on such features as average homeowner cost, average federal cost, and community cost.

In the case of the city manager we may want to analyze the average cost to residents in the community of different policies as well as the variance and/or range of these costs. The SBA might want to undertake similar analyses with respect to the costs of alternative policy options to the federal government as well as the individual homeowner. In Chapter V, we will provide an illustrative example of several alternative insurance programs for a hypothetical community. Potential users can modify the options presented in that chapter to suit his or her needs. It is thus useful to attempt to construct a variety of scenarios in one's own mind in order to be able to expand the usefulness of the CDMS for policy purposes.

Outline Of Other Chapters

Chapter II provides a more detailed description of the software package used by the CDMS. The chapter's principal purpose is to discuss issues of computer implementation--how models are organized internally and how users interact with them.

As discussed previously, the CDMS in its present form consists of two principal submodels--the damage submodel and financial submodel. Chapter III develops a methodology for estimating damages using probability matrices to reflect local conditions. This approach reflects the uncertainty associated with the damage to a particular structure from a flood of a given height. It thus permits one to utilize empirical data in estimating the distribution of losses to different property on the flood plain.

Chapter IV provides a detailed description of the types of data required to examine the impact of a disaster on the financial status of the homeowner. Particular emphasis is placed on the elements of the household balance sheet and the impact that a disaster will have on the asset and liability components of the family's balance sheet.

With this background we construct in Chapter V the hypothetical community of River City to illustrate different types of analyses which can be undertaken at each of the three stages of the model. The community will be generated using data from a field survey of 2000 homeowners in flood-prone areas; the financial and damage characteristics of different age and income groups will be portrayed, and a set of alternative insurance programs will be analyzed.

The concluding chapter discusses policy implications and proposes extensions of the model. It is designed to stimulate suggestions by potential users and decision-makers as to how this tool can be improved for policy purposes. As should be clear from the discussion in this chapter, the relative success of the CDMS can only be determined after policy makers have experimented with it.

CHAPTER II

RUNNING THE SYSTEM

The software package that supports the Community Disaster Modeling System is novel and ambitious. This chapter is mainly devoted to issues of implementation--how models are organized internally and how users interact with them. In this chapter we only touch on basic ideas as a manual is available describing the system in great detail[1]. The overall system does contain a large number of bits and pieces, but they all fit together into a unified whole.

Rationale For Design

Experience has shown that attention to implementation issues in modeling efforts is important. Poor "packaging" frequently results in models that are virtually incapable of change, incomprehensible, and difficult to work with. The two main considerations in the design of the disaster modeling system were flexibility of content (i.e., the mathematical and logical relationships in a model) and the advantage of modern time-shared, interactive computing.

Rather than build a rigid computer program that embodies very specific concepts of what the content of a disaster model should be, we designed the modeling system so that it would be relatively easy to adapt to a wide variety of circumstances, availability of data, and types of analyses without having to incur large amounts of time, skill, and confusion in reprogramming. Closely related to the flexibility inherent in the system is its capacity for graceful growth. New capabilities can be added without tearing apart what already exists, and it will be possible to choose among different submodels for various aspects of the overall process being studied. These characteristics will be crucial to future applications.

Under the batch computing concept, the user prepares inputs for the computer and submits the job, receiving the results some time later. With interactive computing, the user holds a conversation with the computer. This is far more convenient because the computer can prompt the user for his inputs, errors can be detected and fixed on the spot, and the user can ask for information about the system directly rather than having to thumb through a manual. The system can even supply considerable information about specific models and their components on request. The Community Disaster Modeling System runs on the Digital Equipment DEC-10 computer, which was designed specifically for time sharing.

A Simple Example

The material in this chapter will seem less abstract if we use an illustration. The set of attributes for Mr. Glenn listed in Table I-1 is more than is needed here, so we shall select a smaller and slightly different set. The following are the Stage I attributes:

```
'INCOME'
'AGE'
'STRUCTURE VALUE'
'CONTENTS VALUE'
'STRUCTURE COVERAGE'
'CONTENTS COVERAGE'
'NUMBER OF STORIES'
'BASEMENT'
'TYPE CONSTRUCTION'
```

'ELEVATION'

Assume that we have in a computer file, residing on the computer's disk, records which contains values for these attributes for each of the sample "victims" in the community to be simulated. ("Victim" is the generic name for the entities with which models deal.)

Our illustrative model will process these victim records one at a time, computing for each victim the following additional attributes:

'MODIFIED HOUSE COVERAGE'
'MODIFIED CONTENTS COVERAGE'
'STRUCTURAL DAMAGE'
'CONTENTS DAMAGE'
'DEDUCTIBLE'
'INSURANCE CLAIM'

The output will be a new file of victim attribute records, with each victim's record containing values for the input attributes and the newly computed attributes.

One purpose of running models with this particular set of attributes might be to compare the amounts of insurance claims under a variety of assumptions regarding insurance conditions. The MODIFIED COVERAGE attributes facilitate such comparisons; a portion of the model will modify the amounts of insurance coverage in response to inputs from the user. Such inputs would be made at the time the model is run. Options open to the user might be alternatives such as:

No victims have insurance.

Everyone has insurance amounting to 80% of value.

Insurance status is determined by the 'STRUCTURE COVERAGE' and 'CONTENTS COVERAGE' attributes in the input records.

The recomputed amounts of insurance then are recorded as the MODIFIED COVERAGE attributes, and the part of the model that deals with with insurance claims would be directed to use the MODIFIED COVERAGE attributes rather than the COVERAGE attributes that were in the input records.

At the end of the chapter, beginning on page 35 , there is an annotated reproduction of a sample terminal session where such a model is employed. Throughout the chapter references will be made to that exercise in order to show how some of the ideas presented manifest themselves in the person-computer interactions. The reader should glance at the sample session now and notice the alphabetic keys to the annotations on the extreme left of the pages.

Model And Analysis Subsystems

We have seen that the gross action of the model is to process a file of victim records, producing as output another file of victim records that contain the input attributes along with additional attributes. These additional attributes represent the results of the simulation. That much is carried out by a subsystem that we call "model". Naturally, results in an output attribute file are not directly usable by humans, so a second subsystem, called "analysis", is employed to aggregate, summarize, and perform statistical procedures on files of victim attribute records. The results of the analysis subsystem are statistics arranged into displays that users can work with. The model and analysis functions are operated by two person-computer interface systems that have been designed to be similar in appearance. That is, they have many common or analogous commands.

One advantage of separating the analysis function from the running of models is that it allows the results of several model runs to be processed simultaneously, making it much more practical to employ procedures for comparing the results of differing experimental conditions. Another advantage is that breaking analysis away from setting up and running models provides a convenient organization of activities for the user interacting with the computer.

Note that victim attribute files are both inputs and outputs of the model system and also inputs to the analysis system. It is this commonality that offers the option of breaking up a model into stages, with analysis done between stages, as suggested in Chapter I[2].

In the sample terminal session, both the model and analysis subsystems are employed. At note (a), the user enters the model subsystem in order to make additions and modifications to an existing model, save the modified model, and run it twice. Then at (s), the user leaves the model subsystem and activates the analysis subsystem by means of the model subsystem command: ANALYSIS.

Modularity And Routines

Throughout this discussion we have been trying to convey the notion that we have a flexible model builder that can run a large variety of models. The key to flexibility is modularity, which means that a model is created by combining a number of submodels or routines. Associated with the model system is a file or "library" of routines. Each routine has some specific purpose and is designed to compute one or a small number of related attributes. For example, there are routines that compute damage, insurance claims, etc. To plan a model, a user decides what attributes should be computed by the model, and selects appropriate routines from the library based on what input attributes are available. (There need not be an input file; the system can create victims without inputs. The Stage I attributes in Table I-1 could have been generated by means of the "Monte Carlo method".)

The library can contain several different routines for computing the same attributes. Thus, for example, a user could choose from among several damage routines differing from one another in underlying theory, level of detail, or data requirements. If the library does not contain a routine suitable for computing desired attributes, one can be written and added to the library. (There is also a third subsystem called "library" for the purpose of managing the library. This is used to incorporate new routines into the library.)

In our example, the model contains routines based on the damage submodel described in Chapter III along with two uses of a routine called INSUR.MODCOVRG. One use recalculates insurance coverage on the structure, and the other is for coverage on contents. The model also contains a routine called INSUR.CLAIM to compute 'DEDUCTIBLE' and 'INSURANCE CLAIM'.

In the terminal session reproduced below, the user first brings into the computer a model that contains only the damage routines. This is the LOAD command at (c). The other routines are added to the model at points (d) and the first lines of (i) and (j). The user designates a routine to be included in a model by means of the COMPUTE command. As part of the command, the user also specifies names by which he would like to refer to the attributes computed by a routine. These are called "user names" to distinguish them from the often unintelligible names that are employed in programming routines.

There is a similar type of modularity in the analysis system. Here too, a library of analysis routines for various purposes is available. The user decides what kinds of analyses he needs and chooses the appropriate routines by means of ANALYZE commands like the one at point (t). The ANALYZE command in the analysis system is analogous to the COMPUTE command in the model system. Here, however, the routine operates on the attributes named--i.e., the attributes are inputs to the routine rather than outputs.

Levels Of Use

We do not expect that all users will want to become involved with the entire system. Users may, however, interact with the system at three levels which are discussed below from most to least technical.

Writing Routines

Whenever a user wants to create a model or do a kind of analysis for which appropriate routines do not exist, new routines must be written and added to the library. Writing routines is a technical job requiring skills as a computer programmer along with considerable understanding of the system and knowledge of the subroutine documentation language (which will be discussed later).

Setting Up Models And Analyses With The Interface Systems

To operate at this level requires some understanding of the system, but no programming skills. The interface language is English-like, and the system reacts quite well to errors and incomplete commands so that it is to some degree self-teaching. setup activities are illustrated in the demonstration in notes (b) through (l) for the model system and (t) and the beginning of (w) for the analysis system.

Since a considerable amount of effort may go into setting up a model or analysis, a mechanism for saving setups is crucial. The model and analysis interface systems have SAVE commands for this purpose and LOAD commands for bringing a previously saved model or analysis setup back into the user's workspace within the computer. Model and analysis setups are saved in "template files". These files are readable by humans and contain commands to the interface systems which, if typed by a user, would create the model or analysis setup. A user specifies the model or analysis to be executed by giving the name of its template file as part of the RUN command.

In the example, the LOAD command is used at note (c), and, after additions to the model are made, the expanded model is saved as part of the RUN command at note (n). Templates can be loaded into the user's workspace to be modified: routines can be added (through the COMPUTE command in the model system; the ANALYZE command in the analysis system), data associated with routines can be changed through the MODIFY DATA command, routines can be removed with the ERASE ROUTINE command, and linking information can be changed.

Making Runs And Analyses

At this level, the user would mainly issue RUN commands and supply answers to prompts for data (discussed in the next section). Run commands in the model system are at notes (m) and the beginning of (r). Activity indicated in notes (o) through (q) and the rest of (r) are also at this level. For the analysis system, RUN commands are issued at note (u) and the fourth line of (w).

We thus have an interactive system through which a user can easily make and analyze simulations once a technician sets things up on the system's lower two levels.

User Supplied Data

In our terminology, attributes are information about victims. In addition, a model generally employs information associated with its routines and supplied by the user. For example, if the author of a routine responsible for computing insurance claims believes that users will want to experiment with various deductible fractions or minimum deductibles, he would permit users to put in the values; they would not be fixed in the computer program implementing the routine.

Through the routine documentation language (discussed below), the system knows the data requirements for each routine as well as the text of the prompts to elicit the data from users. The data solicitation process is executed in response to a user's request at level 2 that a routine be included in a model by means of the COMPUTE command. A user responding to a prompt for data has three options: type the desired values, type "defer", or type "default" and then the desired values. If the second or third options are taken, the prompt will be repeated in response to the RUN command where a user is asking that a particular model be executed. When there are default values, the user need only respond with "default" to have those values used. If default values are not to be used, other values can be supplied.

With this scheme it is possible to specify the bulk of the data requirements when a model is set up, so that a user running a model need only be concerned with submitting data that is to be varied as part of the experimental design[3].

The sample terminal session contains many illustrations. At note (g), the user (setting up a model) is prompted for data required by the routine INSUR.MODCOVRG in response to the COMPUTE command issued at note (d). Since the purpose of our experiment is to test the various conditions of insurance coverage offered by the modifications that this routine can make in the amount of coverage, the user defers all four questions, with the second and fourth questions receiving default values. Since definite answers are not given here, the questions are asked again at note (q) after the RUN command at note (m). Note (q) includes questions from both uses of INSUR.MODCOVRG.

By way of comparison, at note (k) the level 2 user fixes the deductible fraction and minimum deductible in the INSUR.CLAIM routine during the model setup process. These questions are not repeated when the RUN command is issued.

A useful feature of the data solicitation scheme is that in designing the prompts, the routine writer can make the questioning subject to logical operations on previously asked yes/no questions. Referring back to note (g), a "yes" answer to the third question renders the fourth question irrelevant, and the system knows not to ask it.

More Specialized Aspects

This section introduces several elements of the system that are important to the overall design of the system, but can be skipped without loss of continuity.

Attributes Of A Routine

The attributes that a routine is responsible for computing are called its "created" attributes. On the other hand, routines generally need values of other attributes as data; these are called a routine's "given" attributes. For example INSUR.CLAIM needs to know the amount of damage and amount of insurance coverage for each victim. Central to the modularity concept is the notion that a routine's given attributes are available to it somehow, although their precise sources are irrelevant to the routine. That is, INSUR.CLAIM has to be given the amount of insurance each victim has on the structure, but that value could be either an input attribute or, as in our example, a value created by some other routine (namely, INSUR.MODCOVRG).

For a model to be run, the system must be able to make associations between each routine's given attributes and their sources as input attributes or attributes created by other routines. We call such association "linking". Sometimes linking can be done automatically through consistent usage of names for the attributes in the routines' programs. Otherwise, the user must help by giving LINK commands. A series of these appear in the sample terminal session at note (1).

Closely related to the "linking problem" is the determination of a feasible sequence in which to execute the routines of a model for each victim. It is obvious in our example that the two uses of INSUR.MODCOVRG must be carried out before INSUR.CLAIM is called upon. The ordering and linking operations are carried out by the system as part of the RUN command. The interface system has a CHECK command which is a dress rehearsal for RUN and produces a display of links that would be made with the information available and reports any difficulties. The analysis subsystem also has a CHECK command to verify that the attributes to be passed into the analysis routines are present in the victim files to be processed.

The Subroutine Documentation Language

Many features of the system depend on the system's having available information about the routines in the library. Such information is introduced through special "documentation language" statements prepared by authors of routines and processed by the library system when routines are entered. Documentation statements contain information employed both by the system itself and its human users. The statements cover the following topics:

> Identification of the routine by its "computer" name and its more descriptive "user" name along with descriptive text.
>
> Descriptions and internal names for the routine's created and given attributes. (The names are used for passing attribute values to and from the routine and for linking.)
>
> Setting up the prompts for user data.

This aspect of the design provides a convenient vehicle for documenting models. The purely descriptive material in the documentation language statements is available for display to the user in response to DESCRIBE commands. Some of it is also shown when a user issues a COMPUTE or ANALYZE command to verify that the desired routine was specified.

Documentation statements along with the modular and sequential organization of models go a long way toward solving the problem of making models understandable. Because the documentation is in an easy-to-read, English-like format, it is a valuable aid to communication among diverse groups within a single project.

Descriptor Files

Victim attribute files, which are both inputs and outputs of the model system and inputs to the analysis system, contain only values of attributes with no clues as to what they mean. Therefore, every attribute file has associated with it a "descriptor" file readable by humans which identifies the fields in the victim attribute records by giving their user names -- a process called "formatting". In addition, descriptor files produced as outputs of the model subsystem contain a great deal of information documenting the run that produced them. This even includes the user supplied data for the routines in the model that was run.

Frequently the victim attribute file used as input to the model system is obtained from a source other than the model system itself. For such a file to be used there must be a descriptor file to provide formatting information, and for this reason the interface system contains a FORMAT command to allow a descriptor file to be created by the user.

A Sample Terminal Session

To give the reader something of the flavor of a session with the interface system, an annotated example is reproduced below. In the example, the model will be run on a set of victims for which the following attributes are recorded in the input victim file: value of the structure, value of the contents, amounts of coverage for structure and for contents, type of house, and elevation of the first floor relative to the ground. These attributes all have user defined names recorded in a descriptor file (PRODAT) which goes with the input victim file.

A run setup (template) in a file called DAMAGE has already been created to compute structure and contents damage from floods, with heights specified by the user, relative to an index point in the community. Amounts of damage are calculated by routines based on the work described in Chapter III. We wish to experiment with variations in conditions of insurance. To do this there is a routine termed INSUR.MODCOVRG which, through data supplied by the user, allows choices among the options listed on page 23 .

We load the template file (DAMAGE) that already exists and add to it the routine to modify insurance coverage conditions (it is added twice; once for structure, and once for contents). Also added is the routine that computes insurance claims from values of the structure and contents damages and coverages. This routine is designed to allow the user to put in the fraction deductible and the minimum deductible. Then we run the model twice, varying some of the input data, and finally analyze the result with a particularly simple analysis routine.

In the person-computer interaction reproduced beginning on page 37 , typing by the user is underlined; all other material was produced by the system. The notes below are keyed to the display by letters in the left margin.

KEYNOTES

(a) User tells the computer to activate the model subsystem.

(b) User tells system to supress some kinds of outputs.

(c) User tells system to bring in an existing template file.

(d) Add to the victim records a new attribute that the user is naming 'MOD STRUCTURE COVERAGE'. This attribute will be computed by a routine named INSUR.MODCOVRG.

(e) System reports back name of routine selected, internal name of the attribute computed by the routine, the user's name for the attribute, and a short description of the attribute.

(f) System reporting the attributes for which the routine needs values. Shown are the internal names by which the routine knows them, temporary substitutes for the user's names ('G.8', etc.), and descriptions.

(g) User is prompted for data required by the routine. These data will control the choice among alternative policies. Answers are deferred to be asked later when the model is run. Default values are supplied for some.

(h) User being given opportunity to modify his or her responses to the prompts. User declines.

(i) Similar to steps (d) through (h), but now dealing with contents coverage.

(j) User calling for the computation of two more attributes by the routine, INSUR.CLAIM, that deals with insurance settlements.

(k) User responds to prompts for data required by this routine. Numbers are given, so questions will not be asked when model is run.

(l) Because INSUR.MODCOVRG is used twice the system will not be able to figure out which specific attributes are the inputs and outputs for each of the usages. LINK commands connect given attributes in a routine to created attributes supplied by another routine. In most cases the system can link without human help through recognition of internal or user names.

(m) User asking for the model that has been set up to be executed. PRODAT is the descriptor for the input victim file, and DEMO1 is the name being given to the descriptor for the output file to be created.

(n) User invited to save the model setup just created. He or she accepts and types some text to be placed in the template file.

(o) User types some text to go into the descriptor file for the output victim file.

(p) The routine that computes damage needs to know how high the water is relative to the index point. These had been deferred, so the user gives values now.

(q) User being prompted for data that was deferred in steps (g) and (i). Note operation of logic in that asking of questions depends on yes/no responses to previous questions.

(r) User runs the model again, this time changing the upper limits of coverage.

(s) User switches over to analysis system to see some results of the runs that have been made.

(t) User wants to employ an analysis routine named STATS.COMPAR on three attributes that he or she specifies by giving their user names. User did not finish command on one line and is prompted for completion.

(u) User asks that the analysis specified in step (t) be done.

(v) Output from the analysis.

(w) Another analysis similar to steps (t) through (v). This time different attributes are specified, and outputs from both runs made in this session are to be analyzed.

(x) User leaves the system.

SAMPLE SESSION

Notes

```
(a)  + .x imsys

        Please report any bugs through .X BUG and suggestions
        via .X MAIL to KATZ or MILLER.

        Type ? anytime for help and # anytime to ignore current command.

        Under what account can libraries be found (<CR> for default)? _
(b)  +  Command: verify
        Verify off.
(c)  +  Command: load damage

        Returning input to the terminal.
(d)  +  Command: compute 'mod structure coverage' using insur.modcovrg
        Routine INSUR.MODCOVRG:
(e)     Creates COVRAG called 'MOD STRUCTURE COVERAGE', is MODIFIED
        INSURANCE COVERAGE.
(f)     Given VALUE called 'G.9', is VALUE OF INSURED ITEM.
        Given COVAMT called 'G.10', is ACTUAL COVERAGE AMOUNT.
        1. IS INSURANCE AVAILABLE: defer
        2. TYPE THE MAXIMUM COVERAGE AVAILABLE: default 70000
(g)     3. TYPE YES IF THE COVERAGE IS VOLUNTARY AND NO IF IT IS
        MANDATORY AT A FIXED FRACTION OR PROPERTY VALUE: defer
        4. TYPE THE FRACTION OF COVERAGE: default .8
(h)  +  Type CHECK, LINE #, or hit return if data ok: _
        Command: compute 'mod contents coverage' using insur.modcovrg
        Routine INSUR.MODCOVRG:
        Creates COVRAG called 'MOD CONTENTS COVERAGE', is MODIFIED
        INSURANCE COVERAGE.
        Given VALUE called 'G.12', is VALUE OF INSURED ITEM.
(i)     Given COVAMT called 'G.13', is ACTUAL COVERAGE AMOUNT.
        1. IS INSURANCE AVAILABLE: defer
        2. TYPE THE MAXIMUM COVERAGE AVAILABLE: default 20000
        3. TYPE YES IF THE COVERAGE IS VOLUNTARY AND NO IF IT IS
        MANDATORY AT A FIXED FRACTION OR PROPERTY VALUE: defer
        4. TYPE THE FRACTION OF COVERAGE: default .8
        Type CHECK, LINE #, or hit return if data ok: _
```

```
(j)  Command: compu 'insurance claim' 'deductible' usi insur.claim
     Routine INSUR.CLAIM:
     Creates INSCLM called 'INSURANCE CLAIM', is INSURANCE CLAIM.
     Creates DEDUCT called 'DEDUCTIBLE', is DEDUCTIBLE.
     Given STRDMG called 'G.14', is STRUCTURAL DAMAGE.
     Given CONDMG called 'G.15', is CONTENTS DAMAGE.
     Given STRCVG called 'G.16', is HOUSE COVERAGE.
     Given CONCVG called 'G.17', is CONTENTS COVERAGE.

(k)  1. TYPE THE DEDUCTIBLE AS A FRACTION: .02
     2. TYPE THE MINIMUM DEDUCTIBLE: 200
     Type CHECK, LINE #, or hit return if data ok: _

(l)  Command: link 'g.9' to 'structural value'
     Command: link 'g.10' to 'structural coverage'
     Command: link 'g.12' to 'contents value'
     Command: link 'g.13' to 'contents coverage'
     Command: link strcvg to 'mod structure coverage'
     Command: link concvg to 'mod contents coverage'

(m)  Command: run * on prodat creating demo1

(n)  Current work has not been saved. Would you like to? yes
     Save as (template file): demo
     Type template file description (end with <cr>!<cr>):
    Demonstration of model for NSF-RANN report.
    Saving template file.
    !

(o)  Type descriptor file description (end with <cr>!<cr>):
    Flood height will be 15 ft.  Flood insurance will be available
    with maximum coverage 70000 on structure and 20000 on contents.
    !

(p)  For routine DAMAG.NPLANES computing 'HGT WATER REL 1ST FLR'
     'CONTENTS DAMAGE' 'STRUCTURAL DAMAGE':
     3. TYPE HEIGHT OF FLOOD (IN FEET) RELATIVE TO INDEX POINT: 15

(q)  For routine INSUR.MODCOVRG computing 'MOD STRUCTURE COVERAGE':
     1. IS INSURANCE AVAILABLE: yes
     2. TYPE THE MAXIMUM COVERAGE AVAILABLE (default is 70000): defau
     3. TYPE YES IF THE COVERAGE IS VOLUNTARY AND NO IF IT IS
     MANDATORY AT A FIXED FRACTION OF PROPERTY VALUE: ye
     For routine INSUR.MODCOVRG computing 'MOD CONTENTS COVERAGE':
     1. IS INSURANCE AVAILABLE: y
     2. TYPE THE MAXIMUM COVERAGE AVAILABLE (default is 20000): 20000
     3. TYPE YES IF THE COVERAGE IS VOLUNTARY AND NO IF IT IS
     MANDATORY AT A FIXED FRACTION OF PROPERTY VALUE: yes
     Log file number is 1.
```

```
     Command: run demo on prodat creating demo2
     Type descriptor file description (end with <cr>!<cr>):
     Flood height will be 15 ft. Flood insurance will be available
     with maximum coverage 35000 on structure and 10000 on contents.
     !
     For routine DAMAG.NPLANES computing 'HGT WATER REL 1ST FLR'
     'CONTENTS DAMAGE' 'STRUCTURAL DAMAGE':
     3. TYPE HEIGHT OF FLOOD (IN FEET) RELATIVE TO INDEX POINT: 15
(r)  For routine INSUR.MODCOVRG computing 'MOD STRUCTURE COVERAGE':
     1. IS INSURANCE AVAILABLE: ye
     2. TYPE THE MAXIMUM COVERAGE AVAILABLE (default is 70000): 35000
     3. TYPE YES IF THE COVERAGE IS VOLUNTARY AND NO IF IT IS
     MANDATORY AT A FIXED FRACTION OF PROPERTY VALUE: y
     For routine INSUR.MODCOVRG computing 'MOD CONTENTS COVERAGE':
     1. IS INSURANCE AVAILABLE: y
     2. TYPE THE MAXIMUM COVERAGE AVAILABLE (default is 20000): 10000
     3. TYPE YES IF THE COVERAGE IS VOLUNTARY AND NO IF IT IS
     MANDATORY AT A FIXED FRACTION OF PROPERTY VALUE: y
     Log file number is 2.

(s)  Command: analysis

     Under what account can libraries be found (<CR> for default)? _
     Command: analyze 'structural value' 'contents value'
             'structural damage'
     Analyze 'STRUCTURAL VALUE' 'CONTENTS VALUE' 'STRUCTURAL DAMAGE'
(t)  ('attrib list' or USING): 'contents damage' using stat.compar
     Routine STAT.COMPAR assigned id# 1 COMPARES AVERAGED ATTRIBUTES
     ACROSS FILES.

(u)  Command: run * on demo1
     Current work has not been saved. Would you like to? n


    For file #  1: DEMO1.DES

    Description:
    Created on 27 JUL 1977 at 17:32:19.
    Flood height will be 15 ft.  Flood insurance will be available
    with maximum coverage 70000 on structure and 20000 on contents.


(v)        'STRUCTURAL VAL       'CONTENTS VALUE       'STRUCTURAL DAM
           UE'                   '                     AGE'
    FILE             % Cases               % Cases               % Cases
      #    Average   Not = 0    Average    Not = 0    Average    Not = 0
      1    37863.48  100.0      13672.01   100.0       9291.53    66.0

           'CONTENTS DAMAG
           E'
    FILE             % Cases
      #    Average   Not = 0
      1     4440.90   68.0
```

```
Command: analyze 'insurance claim' 'deductible' usin stat.compar
Routine STAT.COMPAR assigned id# 1 COMPARES AVERAGED ATTRIBUTES
ACROSS FILES.
Command: run * on demo1 demo2
Current work has not been saved. Would you like to? n


For file #  1: DEMO1.DES

Description:
Created on 27 JUL 1977 at 17:32:19.
Flood height will be 15 ft.  Flood insurance will be available
with maximum coverage 70000 on structure and 20000 on contents.


(w)  For file #  2: DEMO2.DES

Description:
Created on 27 JUL 1977 at 17:33:00.
Flood height will be 15 ft. Flood insurance will be available
with maximum coverage 35000 on structure and 10000 on contents.


       'INSURANCE CLAI      'DEDUCTIBLE'
       M'
FILE             % Cases             % Cases
  #    Average   Not = 0    Average  Not = 0
  1    13275.22   68.0       294.66   68.0
  2    12612.25   68.0       280.50   68.0


(x) + Command: quit
```

FOOTNOTES

1. Complete documentation exists in the form of a 133 page document titled "An Interactive Modeling System" (Katz and Miller, 1977). The document contains complete descriptions of the commands with examples, along with directions on writing routines and other matters.

2. It should be emphasized that the organization of models into stages is not required by the software package. However, dealing with small pieces of a larger model is often appealing from a human engineering standpoint.

3. An analysis system routine may also have user data requirements to control the action of the routine.

Page Intentionally Left Blank

CHAPTER III

THE DAMAGE SUBMODEL

The losses suffered by a household in a disaster can have a significant impact on its financial status. To determine this impact we must estimate the amount of damage a particular house and its contents will sustain from a given flood. Obviously this damage will vary depending on building techniques, local conditions, location of the house with respect to the flood plain, and other factors. Consider, for example, Mr. Glenn. As shown in Table I-1 he owns a one story wood frame house built in 1947, with asbestos siding and no basement. It is located in the 100 year flood plain and has the first floor three feet above ground level. We can expect that the damage sustained by that house and contents will vary with the height as well as the velocity of the flood waters. Even after the damage has been determined in physical terms, however, these losses must be converted to dollar figures for purposes of analyzing recovery.

Alternative Models Of Damage[1]

FIA Depth-Damage Curves

The Federal Insurance Administration (FIA) approximates the damage levels using depth-damage curves which relate the loss ratio (damage as a percent of total value) to the height of water relative to the first floor. The FIA has published two sets of curves, one in 1970 and another in 1974, each set having a curve for different types of houses. One problem

Preceding page blank

with these curves is that all houses of the same type experiencing the same height flood are assumed to suffer equal damage levels. No consideration is given to variation in such factors as quality of construction or water velocity; yet two houses sitting side by side, having the same apparent construction can and do sustain different levels of damage from a given flood. For example, Table I-1 indicated that Mr. Glenn experienced a flood of nine feet relative to the first floor and lost half the value of his structure and contents--a moderate loss. The damage to a similar house next door though could have ranged from very light to heavy. It is necessary then to develop a methodology to estimate these levels of damage for each household in the community.

Damage Probability Matrices

Rather than assume that all houses involved in a flood of a certain height suffer the same damage, we utilize the concept of a damage probability matrix (DPM) proposed by Whitman et al (1975). Table III-1 illustrates such a DPM for structural damages. Similar matrices are developed for contents damage. For purposes of this discussion, the following definitions are appropriate:

Set: A set of DPM is classified according to the groups of buildings under investigation. That is, there might be one set corresponding to each of the following building classes: residential, commercial, public, and industrial.

Dimension: For each building class there are two

One-Story Single Family Dwelling, Wood Frame with Asbestos Siding, No Basement

Structural Damage Level (Percentage of Total)	Depth of Water Relative to First Floor Elevation														
	-4'	-3'	-2'	-1'	0'	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'
0	100	98	94	91	83										
0-10%		2	6	9	17	2	5	2							
10-20%						20	76	31	5	2					
20-30%						66	16	64	69	22	5	2			
30-40%						8	0	0	22	70	79	50	6	6	5
40-50%						2	3	3	2	3	13	44	82	82	83
50-60%						2			2	3	3	2	9	9	9
60-70%												2	3	3	3
70-80%															
80-90%															
90-100%															

TABLE III-1
DAMAGE (STRUCTURAL) PROBABILITY MATRIX

dimensions. The first dimension relates to the rows of the matrix. Here, the structural damage level is expressed as a percent of total damage[2]. The second dimension refers to the columns which indicate the depth of water relative to the first floor.

Plane: Each matrix, as shown in Table III-1, constitutes a plane. There is one plane for each possible combination of number of stories, type of construction, quality of construction, and whether or not a basement exists.

Cell: An element of the matrix that refers to the probability that a specific type house will sustain a given amount of damage for a prespecified height of water.

To estimate damage, one specifies the physical attributes of that house. Based on these attributes and the height of the flood, the appropriate column in the damage probability matrix is accessed. The amount of damage is then randomly chosen using the distribution of damages for that height as indicated by the cells in the column. If, for example, we were considering a one story wood frame house with asbestos siding and no basement, the damage matrix corresponding to Table III-1 would be utilized to estimate damages. Assuming a flood of nine feet above the first floor, we would choose a damage estimate at random such that the frequencies were those shown in Table III-1 for a nine foot flood. That is, for each one story wood frame house in the community under consideration which had asbestos siding and no basement, there is a high probability (.82) that it would suffer structural damage between 40 and 50% of structure value. It could, however, sustain structural damage as little as 30-40% (.06 probability) or over 50% (.12 probability) of structural value. The same method is utilized for estimating contents damage.

In Chapter V we will employ this procedure to estimate the damage to each house and its contents in the community of River City. If there are a large number of houses of the same type and elevation with respect to the river then the resulting damage distribution would approximate the one given in the relevant DPM. For example, if we had 1000 identical one story wood frame homes with nine feet of water then approximately 60 of them would have damage between 30 and 40% structural value, approximately 820 would have damage between 40 and 50% of structural value, and so on.

It is important that we assume that identical houses with identical water heights can suffer different percentage losses, because the efficacy of alternative policies depends upon whether a household suffers light or heavy losses. If we had only determined the average damage to a class of structures, by using FIA depth-damage curves for example, we might have ignored relevant variation. To illustrate this point let us consider the following extreme example: suppose that in a flood half of the houses of a given type of construction suffer 60% damage and the other half are totally destroyed; the average damage then is 80%. Furthermore, suppose that insurance was mandatory and covered 80% of a structure's value. If we had only calculated average damage to the structure, it would appear that all households were fully covered by insurance (with the exception of a deductible). In reality though, those homeowners suffering total destruction would be forced to supplement their insurance coverage with other resources to restore their homes. The incorporation of damage probability matrices in the CDMS permits the user to examine the impact of this variation on the performance of alternative disaster programs[3].

Special Considerations

While the damage estimates developed here are appropriate for still-water flooding, there are adjustments which must be made to handle several special situations. These include: exceeding of protective works, flood resistant construction techniques, velocity of water, variable sediment loads, variable wave heights, duration of flooding, and rate of rise/fall of water. Considering the state of the art and available data, the first three considerations are applied in determining damages in the system described in this monograph. It should be noted, however, that when more complete data are available for a community, the probabilities based on these additional factors may be determined and added to the damage submodel.

Protective Works (Dams And Levees)

As part of the damage submodel, a routine has been developed which analyzes the effect of protective works (i.e., structural measures which control the flood) on damage to structures in the community. We assume no damage when the flood depth is less than the height of the dam or levee; obviously a problem arises when the flood depth exceeds the height of the protective structure. Under these circumstances, the dam or levee is "topped"--that is, the flood water flows over the top of the protective structure and inundates the buildings located in the subzone[4]. As a general practice, the U.S. Army Corps of Engineers assumes that the victims would be subjected to the full depth of the flood when the protective structure is topped. This procedure does not seem very realistic: if a 20 foot protective structure is topped by one foot, it is unreasonable to expect 21 feet of water to inundate the community.

In the damage submodel topping of protective works is treated more realistically. When the flood depth exceeds the height of the protective structure by not more than 10% of its height[5], buildings will suffer some damage but less than they would have had the dam or levee not been constructed. When the flood depth is greater than 1.10 times the height of the protective structure, the damage to each structure is considered to be the same as if there had been no protective work.

Flood-Resistant (Proofing) Measures

Another consideration in determining damage levels is the presence of measures that control the exposure to flooding (non-structural). Currently the non-structural measures explicitly considered in the damage submodel are the elevation of a house on various levels of fill between two and six feet, and flood walls and levees of three and five feet.

For a particular dwelling, we assume no damage until the protection level is exceeded. Should this occur, damage would be determined as in the following two examples. If a five foot flood occurred and a protective wall was only three feet high, the depth used to determine damage would be five feet. If a five foot flood occurred and the house was raised on fill to three feet, then the appropriate depth for damage determination in the DPM would be two feet.

Of course these protective measures have associated costs. Table III-2 gives, for each measure, the level of protection and the initial costs per house for those structurally sound homes considered in Long Beach Island, New Jersey[6]. A user can determine if a particular measure is worthwhile by first determining damages without any protective measures and then re-estimating damages with the protective measure in place. If the aggregated benefits exceed the aggregated cost of flood protection, such protection measures should be strongly considered. (Appendix A contains a brief analysis of the effect that protective measures and works have on River City.)

TABLE III-2
FLOOD-RESISTANT (PROOFING) MEASURES AND ASSOCIATED COSTS. (MARCH, 1977 $ FOR NEW JERSEY)

Raise on Fill	Brick 2 Story w/Base	Frame 2 Story w/o Base	Brick, Stone 1 Story w/o Base	Frame 1 Story w/o Base
2 ft	$ 5500	$3600	$5300	$3600
3 ft	6200	4300	6200	4000
4 ft	7200	5100	7200	4900
5 ft	8500	5800	8100	5200
6 ft	10,800	6600	9100	6300

Wall: 3 ft - $4900

Levee: 3 ft - $2250

Wall : 5 ft - $6750

Levee: 5 ft - $3100

Notes: 1. All 1.5 story houses are treated as 2 story houses for flood-proofing costs.

2. Asbestos and wood houses are both treated as frame houses for flood-proofing costs.

Velocity

The dynamic effects of a flowing body of water on a structure must also be considered. Flood water velocity during overbank conditions has several substantial effects on community damage. The moving water accelerates scouring of the bed, transmits sediment and debris, and impinges a dynamic load on community structures. It is well documented (U.S. Army Corps of Engineers, 1972) that flood velocities up to six ft/sec are quite common and that velocities of 10 ft/sec sometimes occur, particularly in those regions of a community lying near the flood source.

The flow of water against and around a structure induces hydrodynamic loading on structures. These imposed loads consist of the frontal impact by the mass of moving water against the projected width of the structure. In accordance with Flood Proofing Regulations (U.S. Army Corps of Engineers, 1972), when water velocities do not exceed 10 ft/sec[7], dynamic effects of the moving water may be converted into an equivalent hydrostatic load by increasing the depth of the flood. In the CDMS this increase in the depth of the flood is added to the height of still water affecting the victim. The resultant pressure is applied to, and uniformly distributed across, the vertical projected area of the structure.

Summary

To evaluate alternative policies through the CDMS, damages must first be reliably estimated. Using the statistical approach developed here, the damage submodel provides a means of expressing the complex interrelationship of factors influencing damages. Relations are developed between the population-at-risk and degrees of vulnerability as functions of various assigned levels of risk. Employing this concept of damage probability matrices, this procedure should prove useful in producing reliable estimates of potential losses for local communities or regions.

FOOTNOTES

1. Extensive literature exists concerning flood related damages to buildings and communities. The reader is referred to Owen (1977), Johnson (1977), Wiggins (1976), and White and Haas (1975) as sources for this information. Pertinent documents upon which the damage submodel has been built may be grouped into three categories. First, the works of Friedman (1975), Wiggins (1976), and Lee and Collins (1976) are notable in the area of natural hazard simulation and risk management. The work of Grigg and Helweg (1975) has aided in presenting a method of damage estimation that is state of the art. Third, several articles exist on flood-resistant measures: Lardieri (1975), Johnson (1977), Jones (1977), Sheaffer (1967, 1977), and U.S. Army Corps of Engineers (1972).

2. Structural damage is presented as a percentage of total damage, but since the damage cannot exceed the value of the structure, the percentages shown here are actually damage as a percent of home value. A similar assumption holds for contents damage.

3. A generalized computer program exists that permits a community to obtain their own damage probability matrices directly from local depth-damage data (see Wilson, Lepore and Duffy, 1977).

4. The amount of flood water affecting the victims varies according to several factors (e.g., slope of hydrograph, elevation profile of the community, soil conditions, volume of flood backwater) which must be measured and/or calculated. While these hydrological calculations can be made, the constraint of limited existing data need not be included in the damage submodel at this stage of its development.

5. The 10% value is arrived at through interviews with U.S. Geodetic Survey and U.S. Army Corps of Engineers Districts.

6. Basic cost information was obtained from U.S. Army Corps of Engineers Hydrologic Engineering Center (1975, 1977) and translated to Long Beach Island, New Jersey, using the Design Cost File (1976).

7. For flood-proofing purposes a velocity of 10 ft/sec should be considered the upper limit for which flood proofing measures are effective and economically feasible (Lardieri, 1975). Consequently, the damage submodel only considers the effects of velocities up to 10 ft/sec.

CHAPTER IV

THE FINANCIAL SUBMODEL

How does one determine the financial impact of a disaster on the unfortunate victims? This question must be addressed if one is to gain a more complete picture of the relative costs and benefits of alternative hazard mitigation and recovery programs. The unanticipated financial consequences of even a generous relief policy have recently been revealed by Vinso (1977). Through a detailed survey of victims in Wilkes-Barre, Pa. two years after Tropical Storm Agnes, he found that many low income homeowners who availed themselves of 1% SBA disaster loans have been saddled with such large debts in relation to their assets that they may not be able to meet their monthly payments in the future. Should this occur and should the federal government decide to foreclose on their houses, Uncle Sam would be the largest real estate owner in the Wilkes-Barre area.

By taking a disaggregated view of the community, the CDMS can examine the potential impacts that alternative disaster programs, such as SBA disaster loans, will have on the financial status of victims. To motivate such an analysis we will focus on two standard accounting measures--the balance sheet and financial ratios.

The balance sheet indicates what a family or business owns (i.e., the composition of its assets) as well as what it owes (i.e., the composition of its liabilities). This statement enables one to measure the likely changes in the financial position of different groups as a function of the severity of the disaster, the types of programs in effect and the homeowners' actions both preceding and following a disaster.

Financial ratios provide a more detailed picture of the ability of different groups to repay their debts and to recover from a disaster should certain programs be in force. These ratios, which are determined from balance sheet data, provide evidence of the long-term consequences of certain disaster programs.

This chapter describes the types of routines which have been incorporated in the CDMS for analyzing the financial impacts of a disaster. To illustrate these concepts let us examine the impact of the flood on Mr. Glenn and his household.

Mr. Glenn's Financial Position

Table IV-1 presents a snapshot of the Glenn family's balance sheet prior to the flood, immediately after the disaster, and after they have collected on their flood insurance claim and received a $3,000 SBA low interest loan to cover the uninsured portion of their $18,000 property damage.

The asset side of the balance sheet for the household is divided into two sections: (1) financial assets, which are cash or assets easily converted into cash, and (2) real assets, which are more permanent in nature and/or not easily (quickly) converted into cash[1]. Liabilities are delineated by maturity: current liabilities come due in the near future, and fixed or long-term liabilities require regular

TABLE IV-1

STATUS OF THE GLENN FAMILY'S BALANCE SHEET

Assets		Liabilities	
Pre-Disaster (Stage I)			
Financial Assets	$14,000	Current Liabilities	$ 400
Real Assets	40,000	Fixed Liabilities	4,600
Total Assets	$54,000	Total Liabilities	$5,000
Post-Disaster (Stage II)			
Financial Assets	$14,000	Current Liabilities	$ 400
Real Assets	22,000	Fixed Liabilities	4,600
Total Assets	$36,000	Total Liabilities	$5,000
Post-Recovery (Stage III)			
Financial Assets	$14,000	Current Liabilities	$ 400
Real Assets	40,000	Fixed Liabilities	7,600
Total Assets	$54,000	Total Liabilities	$8,000

payments over long periods of time (e.g., 20 - 30 year mortgages). Appendix B provides a more detailed description of these balance sheet components.

The table reveals that even with insurance covering most of his damage, Mr. Glenn's long-term debt, that is his fixed liabilities, has risen from $4,600 prior to the flood to $7,600 in the post-recovery period by virtue of the SBA low interest loan. This loan coupled with the insurance claim enabled the Glenns' to restore their real assets to their pre-disaster position. Had the Glenns been uninsured, as were almost all of the Wilkes-Barre victims of Tropical Storm Agnes, they would have had to utilize an $18,000 SBA loan to restore their property. Such an adjustment would have created a severe financial hardship.

To anticipate a bit, suppose that we wanted to examine the impact of two alternative scenarios on the Glenn family's financial status. One way to do this would be to examine the change in the ratio of total liabilities/total assets (T.L./T.A.) between stages depicted in Table IV-1 under each policy. Table IV-2 depicts the differences in these two ratios for the following two scenarios:

Scenario 1: The Glenn family has $15,000 insurance and takes a $3,000 SBA loan to cover the remaining portion of their damage.

Scenario 2: The Glenn family is uninsured and takes an $18,000 SBA loan to restore their property.

TABLE IV-2

TOTAL LIABILITY/TOTAL ASSET RATIOS FOR THE GLENN FAMILY UNDER TWO ALTERNATIVE CASES

	Pre-Disaster	Post-Disaster	Post-Recovery
Case 1 ($15,000 Insurance)	.09	.14	.15
Case 2 (No Insurance)	.09	.14	.43

As seen in the comparisons in the table, the only difference between the ratios is in the post-recovery period. Under Case 1 the T.L./T.A. ratio is only .15 because insurance covers most of the loss; should the Glenn family be nonpolicyholders this ratio would rise to .43 because of their SBA obligation. The higher the ratio, the greater the financial hardship imposed by the disaster. Should the value of this ratio exceed one, the household is in danger of defaulting on its obligation and may be forced into bankruptcy. (Chapter V will illustrate how this ratio can be utilized to evaluate the impact of alternative programs on different socioeconomic groups in a community.)

From this illustration we see that balance sheet data and financial ratios are both necessary to depict the economic impact on the household. The remainder of the chapter will provide more detail on the construction of these measures for inclusion in the CDMS and their usefulness for policy analysis.

Determination Of Pre-Disaster Accounts

To evaluate the impact of alternative programs on different groups in a community, it is first necessary to estimate pre-disaster balance sheet accounts. For this purpose, we have utilized existing data on the financial characteristics of households collected from a sample of 1,776 households by the Federal Reserve System[2]. These data enabled us to estimate the correlation between different asset and liability accounts and such socioeconomic characteristics as age and income.

The approach undertaken here was stimulated by several recent studies by economists which estimate the relationship between household financial characteristics and socioeconomic variables. Dunkelberg and Stafford (1971), for example, show that the desired levels of installment debt and certain real assets are a function of such characteristics as age, education, and occupation of the household head. Similarly, Friend and Lieberman (1974) demonstrate that household savings are also a function of income, family size, and age of household head. Finally, Projector and Weiss (1966) suggest that the total wealth of a household is related to income and age of the household head as well as other socioeconomic characteristics.

The data provided by the Federal Reserve Board study was sufficiently detailed for us to estimate specific asset and liability accounts of the household. Table IV-3 disaggregates the pre-disaster balance sheet of the Glenn family shown in Table IV-1. The definitions of the components are found in Table IV-4. In general, each of these balance sheet accounts can be estimated quite accurately through statistical regression using such economic characteristics as age and income. As one would expect, there is a strong positive relationship between the level of income and the size of both asset and larger liability accounts[3]. Older families tend to have higher asset levels and more short-term liabilities than their younger counterparts. On the other hand, long-term debts, such as home mortgage levels, decline with age. This finding is consistent with the life-cycle hypothesis developed by Ando

TABLE IV-3

BALANCE SHEET AND FINANCIAL RATIOS FOR THE GLENN FAMILY

Assets		Liabilities + Equity	
Financial Assets:	$	Current Liabilities:	$
Cash	500	Unsecured debt	100
Marketable securities	4,000	Personal notes	300
Savings accounts	5,000	Insurance borrowing	0
Savings bonds	1,500		
Cash value of insurance	3,000		
Total financial assets	14,000	Total current liabilities	400
Real Assets:		Fixed Liabilities:	
Automobiles	2,000	Home mortgages	4,000
House value	24,000	Other mortgages	0
Home furnishings	12,000	SBA-home	0
Other assets	2,000	SBA-other	0
		Bank loans	600
Total real assets	40,000	Total fixed liabilities	4,600
		Total liabilities	5,000
		Personal equity	49,000
Total assets	54,000	Total liabilities and equity	54,000

Ratios For Typical Homeowner

Description		Value
Financial assets/Total assets	---	.26
Financial assets/Total liabilities	---	2.8
Financial assets-sec./Total liabilities	---	2.0
Total liabilities/Total assets	---	0.09

TABLE IV-4

DEFINITIONS OF BALANCE SHEET ACCOUNTS

Financial Assets

Cash--Demand deposits and cash-on-hand.
Marketable securities--Corporate stocks and bonds.
Savings accounts--Time deposits (interest earning).
Savings bonds--Government interest bearing bonds.
Cash value of insurance--Total cash value of life insurance policies.

Real Assets

Automobiles--Market value of all automobiles.
House Value--Market value of structures plus land.
Home furnishings--Market value of all household contents.
Other assets--The value of any assets not covered in the above categories (e.g., boats, furs, etc.).
Other Real Estate--Real Estate owned by the household but not the principal residence.

Current Liabilities

Unsecured debt--Indebtedness having no security by way of collateral (e.g., charge accounts).
Personal notes--Outstanding notes of debt held against an individual (e.g., loan company or credit union borrowing).
Insurance borrowing--Any money borrowed against the cash value of the life insurance policies.

Fixed Liabilities

Home mortgages--Total amount of unpaid mortgages on the residence of the individual.
Other mortgages--Total amount of unpaid mortgages on any properties other than home.
SBA-home--Outstanding amount of any existing SBA disaster loans obtained for use in home repair or contents replacement.
SBA-other--Outstanding SBA disaster loans issued for purposes other than home repair (e.g., to retire debt).
Bank loans--All outstanding long-term debts to banks (e.g., 1-10 year loans).

Other debt--Other long-term debt which does not fit any of the above categories.
Personal Equity--Wealth of net worth (i.e., total assets less total liabilities); the amount an individual would be worth if his assets were converted to cash and all his debts paid off.

and Modigliani (1961). Vinso (1978) provides a more detailed discussion of the estimating procedure and the final regression equations.

Determining The Post-Disaster Balance Sheets

Once we have a pre-disaster balance sheet, a determination of the impact of different scenarios on the financial status of homeowners in a hazard prone community is relatively straightforward. We have already provided an illustrative example in Table IV-1 for the Glenn family. The relevant adjustments open to them were voluntary flood insurance in the pre-disaster period and SBA loans in the aftermath of the flood. The resulting changes in the balance sheet reflected the Glenn family's damage from a 12 foot flood, their amount of insurance coverage, and their SBA loan decision.

In the illustrative example in Chapter V, we have assumed that a flood produces damage to only the homeowner's house and contents, so that these are the only two asset accounts affected by the event. The postflood value of the house is decreased by the amount of structural damage while the land value is assumed to remain the same as it was prior to the disaster. The contents value of the victim's postflood balance sheet must reflect the difference between market value and replacement value. Contents value in the pre-disaster balance sheet reflects market value, assumed to be 80% of replacement value, while the flood damage to contents is normally based on replacement value. We thus convert this damage figure to its equivalent market value in order to obtain a consistent picture of the balance sheet accounts over time. Finally, property damage also leads to a decrease in the net worth position of the household.

The post-recovery balance sheet reflects the different adjustments adopted by the homeowner. On the asset side, both the structure and contents value of the property are increased by the amount of the insurance claim and the size of the SBA loan. On the other side of the balance sheet, the insurance claim produces an increase in the net worth account; the SBA loan increases the long-term liability account.

Calculation Of Financial Ratios

These balance sheet comparisons provide a picture of absolute changes in the household's financial status but do not detail completely the effects of a disaster. We have already indicated the importance of financial ratios by analyzing Mr. Glenn's financial position under two scenarios (Table IV-2). Another illustration may be instructive here. Suppose a high and low income family suffer identical losses from a flood and utilize the same recovery sources and dollar amounts to restore their damaged property. The changes in their balance sheets over time would be identical, but the adverse impact of the disaster on the two families would be quite different. The high income family is likely to have much greater financial assets than the low income household. A wealthy family can thus utilize these reserves to pay off its debts should it be strapped for funds. On the other hand, the low income family may be forced to declare bankruptcy should it have this problem.

The following four ratios provide a picture of the household's financial condition in the pre- and post-disaster periods:

1. Financial Assets/Total Assets (F.A./T.A.). Gives an indication of how much liquidity a homeowner prefers to have (i.e., what percentage of total assets are quickly convertible to cash).

2. Financial Assets/Total Liabilities (F.A./T.L.). Can be used to judge the ability of the household to meet outside obligations with cash or easily obtainable cash.

3. Financial Assets less Securities/Total Liabilities [(F.A.-S.)/T.L.]. Same as F.A./T.L. except that it reflects the possible reluctance of a household to take a capital loss on the sale of marketable securities because, of all financial assets, only marketable securities may be priced below cost of acquisition.

4. Total Liabilities/Total Assets (T.L./T.A.). Indicates household's desire and ability to take on debt obligations. It also indicates how much of a claim on assets creditors will have.

The functions of these ratios are threefold. First the ratios enable one to compare households at any point in time with each other or possibly with some average household. One can group households using such characteristics as age or income and determine how the ratio for a given age or income class differs, for example, from the average of all households.

Secondly ratio analysis can highlight changes in a homeowner's balance sheet between two points in time (e.g., pre-disaster vs. post-recovery). One can examine a ratio for a particular household (or group of households) and observe to what extent financial position has changed due to the disaster, the recovery, or similar event.

Finally these ratios serve as a recovery barometer. If we assume that the pre-disaster balance sheet represents the preferred financial position of the household, subsequent ratios can be examined to determine the extent to which a particular recovery policy returns a household to its pre-flood position[4]. (Appendix B provides more detail on ratio analysis for readers unfamiliar with its use.)

It is useful to show the importance of these specific ratios in analyzing alternative recovery measures. The F.A./T.A. ratio is a measure of the percentage of total assets held by the household in a fairly liquid form which are readily available to meet expenses. While it might appear that these financial assets are available for recovery, some of these assets are needed by all households just for normal expenditures. But to the extent that this ratio for a given household is higher than for other households of similar socioeconomic characteristics, some of these funds could be used for recovery in lieu of debt acquisition. Analysis of these assets as potential sources of recovery must be accompanied by an income-expenditure analysis as well as by some indication of a mechanism for choosing among the following options: (1) increasing debt, (2) decreasing financial assets, and/or (3) the replacement of real assets.

The F.A./T.L. ratio gives an indication of the ability of the household to meet obligations without selling real assets. The higher this ratio, the greater the ability of the household to meet its bills. The third ratio [(F.A.-S.)/T.L.] is similar to the F.A./T.L. ratio, but reflects the ability of the household to meet debts without incurring a possible loss by selling securities below cost. Since most recovery programs involve the replacement of assets through debt or equity, these last two ratios can provide an indication of the extent to which debt can be used as well as the change in the ability of a household to meet its debt obligations under different recovery measures.

Finally the T.L./T.A. ratio provides an indication of the household's desire and ability to take on obligations. As a household increases the proportion of debt, fixed claims on income increase. All other things remaining constant, the probability that the household will be unable to meet these fixed charges also increases. Debt also represents a claim on assets. If the head of the household dies, debts must be satisfied before any assets pass to heirs. This ratio provides information on the level of fixed charges as well as the claim on assets. Since various recovery measures include debt financing, this ratio indicates the impact of such financing on fixed charges (the higher the ratio, the higher the fixed drain on income) and the change in claims on assets of the household by outsiders (the higher the ratio, the higher the claims on assets).

It is important to analyze these ratios with respect to different socioeconomic groups. Low-income and/or older households will prefer higher levels of financial assets and lower debt levels. So while it appears that programs which require the use of debt or a decrease in financial assets might be appropriate for younger or higher income households, in fact these programs can be highly detrimental to older or lower income families.

The Glenn Family Revisited

Now that the elements of the financial submodel have been discussed, it is useful to examine the types of information generated in Table IV-3 for the mythical household headed by Mr. Glenn. We observe that this household preferred to finance less than 10% of its assets with debt. Likewise, more than one quarter of total assets are in the form of financial assets. Finally, the household could pay off all its debt using only financial assets--i.e., its liabilities could be discharged without having to sell its home or other assets (financial assets are 2.8 times its liabilities). These ratios indicate, therefore, the pre-disaster financial position of this household. One can now compare the changes in this financial position caused by the disaster and subsequent alternative recovery programs.

Disaster Insurance

Assume that Mr. Glenn carried adequate disaster insurance and that no low interest loans were available. After the Glenns have suffered the above losses, sufficient money would become available to repair or purchase assets to restore the original level. Since no new debts are incurred and assuming that the insurance money can immediately be converted to real assets, the resulting financial position will be identical to the pre-disaster position presented in Table IV-3.

SBA Disaster Loans

In our example, Mr. Glenn can borrow $12,000 for structural repairs to his home and $6,000 for repairs and replacement of home furnishings from the SBA after the flood. When this money is used to restore his property, his current assets will be identical to his pre-disaster assets, while his liabilities will have increased by an equal amount. This new condition will be reflected in the liabilities side of his balance sheet and in the financial ratios.

Evaluation

The results of the previous analyses have been summarized in Table IV-5. We see that the disaster and subsequent recovery can have a profound impact on the financial position of the household. For example, we observe that using SBA loans for recovery would result in a deteriorating financial position for Mr. Glenn (total debt is 43% of assets as opposed to 9% before the flood); in addition, the household can no longer meet its obligations using financial assets only (financial assets are less than total liabilities since the ratio of financial assets is less than 1--in this case 0.61). If the debt had to be repaid immediately, Mr. Glenn would have to sell his home and other tangible assets. Insurance, on the other hand, returns the household to its pre-flood condition. While our purpose is not to advocate one policy over another, this analysis does demonstrate how the financial submodel of the CDMS can be used to investigate the effects of a given policy on the financial characteristics of households and then to compare

TABLE IV-5

SUMMARY OF FINANCIAL RATIOS

	Financial Assets / Total Assets	Financial Assets / Total Liabilities	Financial Assets less Securities / Total Liabilities	Total Liabilities / Total Assets
Pre-flood	.26	2.80	2.00	.09
Post-flood--Pre-Recovery	.39	2.80	2.00	.14
Recovery Options:				
(a) Disaster Insurance	.26	2.80	2.00	.09
(b) SBA Loans	.26	0.61	0.43	.43

the impact of various policy alternatives.

Summary and Conclusions

The financial submodel generates the financial position of the household at each point in the analysis. While we have an interest in the single homeowner, we are primarily concerned with groups of individuals (as shown in Chapter V). Subsequent analyses will focus on financial ratios since these measures offer a way to compare groups of households. However the reader should always remember that the generation of individual balance sheets underlies all these ratio analyses.

FOOTNOTES

1. While values are provided in this paper for real assets, we realize that it is difficult to determine these values unambiguously since secondary markets in real assets are not very efficient. For the purposes of this paper, we assume that best estimates are provided while recognizing that such estimates will be subject to measurement error.

2. For a description of the data used in this project see Projector and Weiss (1968).

3. Socioeconomic variables such as education and sex of household head have no explanatory power in determining the pre-disaster balance sheet.

4. This use assumes that households were at their preferred financing levels prior to the disaster. While any particular household may not have been, assuming that in the aggregate they were should not lead to an error. A more serious problem involves the assumption of asset replacement. Households may prefer to have fewer assets if these assets must be financed by debt. For the purposes of this discussion, such possibilities are ignored but they provide an avenue for future research.

CHAPTER V

EVALUATING ALTERNATIVE INSURANCE PROGRAMS: AN ILLUSTRATIVE APPLICATION

A principal purpose of the Community Disaster Modeling System is to evaluate the relative performance of different adjustments to the hazard. In this chapter we will be analyzing the financial impact of one such adjustment on homeowners in a hypothetical flood-prone community, River City. Specifically, we will be studying the following alternative insurance programs:

Program 1: Flood insurance is mandatory for all homeowners in River City.

Program 2: Flood insurance can be purchased voluntarily by homeowners in River City.

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

We have chosen the insurance adjustment for detailed analysis for three reasons. First, there is considerable information from the Kunreuther *et al.* (1978) field survey and laboratory experiments on the factors influencing the decision of homeowners to purchase insurance and the role insurance plays in disaster recovery[1]. Next, flood insurance has been the focal point of recent reports and legislation[2] and a subject for critical analyses and discussion in the natural hazards literature[3]. Finally, 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) and White (1966).

In evaluating the three insurance programs we will pay careful attention to the impact they are likely to have on different socioeconomic 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 thus be forced to rely on different sources of relief to recover.

Description Of The Community (Stage I)

River City is composed of 427 households selected from the riverine portion of the Kunreuther et al. (1978) field survey. These households were chosen from the 642 riverine households interviewed in the field survey because each respondent had answered all the survey questions relating to the set of attributes noted in Table V-1. (The remaining 215 homeowners either responded "don't know" or "no answer" to one or more of the questions.) These data describe the socioeconomic 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 insurance. Table V-2 identifies the actual locations of the respondents comprising the hypothetical community of River City.

In our example we investigate the impact of alternative disaster insurance programs on different age and income

TABLE V-1

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 problem
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

TABLE V-2

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%

classes. Figure V-1 depicts the proportion of homeowners in the different income and age classes. The relevant ranges for each class were arbitrarily specified so that 20 to 30% of the households fall in the extreme categories. Thus, we see that 30% of the residents of River City have annual incomes below $12,500, 28% have incomes above $25,000, and the remainder earn between these two amounts.

River City faces the threat of flooding by the Clearview River. Land elevations in the community have been selected so that they vary from 10 feet to 30 feet above sea level. As shown in Figure V-2, we have assumed for this particular example that five different groupings of elevation contours or subzones have been selected. Figure V-3, which provides a cross-sectional view of River City's elevations, indicates that subzones U and W can be considered high hazard areas, X and Y are medium hazard zones, and Z is a low hazard zone. We assume no flood protection works have been constructed in the community[4].

Households were assigned to the subzones based on distributions obtained from the field survey data. Of the 642 riverine households surveyed, 400 of them were located in the 100 year flood plain. Hence, we assigned 60% of the 427 River City households to subzones U and W[5]. The remaining 40% of the River City households were assigned to the other three subzones in the following arbitrary proportions: 15% to subzone X, 15% to subzone Y, and 10% to subzone Z.

The actual assignment of the four types of structures in each subzone shown in Figure V-2 was based on an analysis of the physical attributes of the 642 riverine homes comprising

FIGURE V-1

PERCENTAGE OF RIVER CITY RESIDENTS IN
INCOME AND AGE CLASSES

n = 427

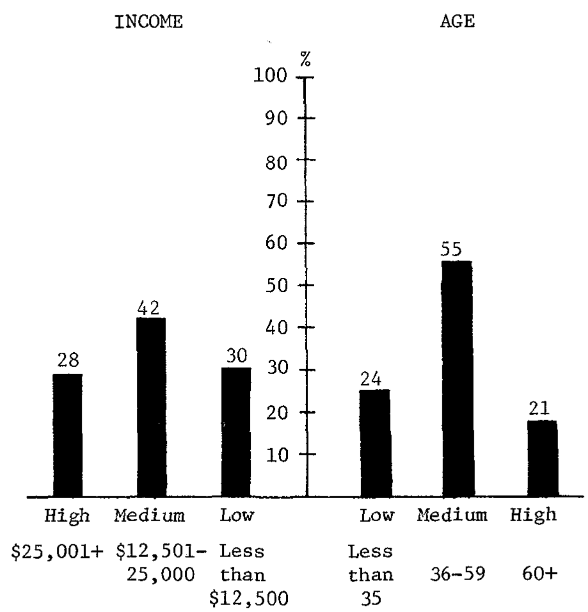


FIGURE V-2

HOUSE TYPES BY SUBZONES FOR RIVER CITY

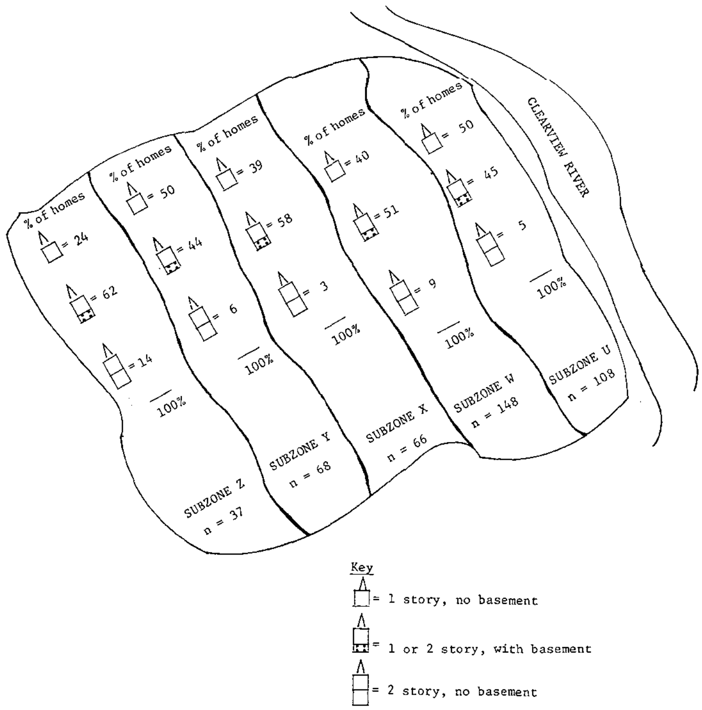
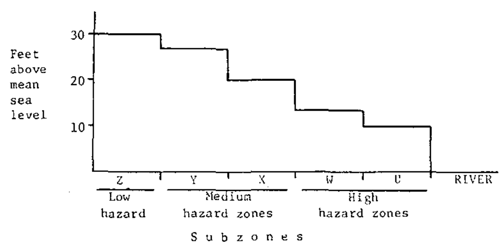


FIGURE V-3

CROSS-SECTIONAL VIEW OF RIVER CITY'S ELEVATIONS



the field survey. Thus, in riverine communities 7% of all the homes in high hazard areas were two story wood frame homes without a basement. There was then a 7% chance that each structure in zone U or W would be of this type.

Factors Influencing Voluntary Purchase Of Insurance (Stage I)

To evaluate the performance of a voluntary insurance program (Program 2) we must 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._ (1978) project to isolate those factors which affected this decision. These results were utilized in the development of a submodel for the "insurance purchase decision".

Table V-3 presents a regression equation indicating the relative importance of different factors influencing the homeowner to buy flood coverage. 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 the presence of either factor alone would imply. As shown in Table V-3, 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.

TABLE V-3

INSURANCE PURCHASE REGRESSION FOR FLOOD SAMPLE

Probability of homeowner purchasing insurance = 0.045[a] +

$$\left\{\begin{array}{ll} .0 & \text{if not high school graduate} \\ .051 & \text{if at least high school graduate} \end{array}\right\} +$$

$$\left\{\begin{array}{ll} .0 & \text{if low income} \\ -.029 & \text{if medium income} \\ -.055 & \text{if high income} \end{array}\right\} +$$

$$\left\{\begin{array}{ll} .0 & \text{if not married} \\ .030 & \text{if married} \end{array}\right\} +$$

$$\left\{\begin{array}{ll} .0 & \text{if mildly risk averse} \\ .069 & \text{if some risk aversion} \\ .131 & \text{if highly risk averse} \end{array}\right\} +$$

$$\left\{\begin{array}{llll} .549 & \text{if thinks hazard serious problem} & \text{and} & \text{knows someone with insurance} \\ .434 & \text{if thinks hazard minor problem} & \text{and} & \text{knows someone with insurance} \\ .245 & \text{if thinks hazard not a problem} & \text{and} & \text{knows someone with insurance} \\ .198 & \text{if thinks hazard serious problem} & \text{and} & \text{doesn't know anyone with insurance} \\ .142 & \text{if thinks hazard minor problem} & \text{and} & \text{doesn't know anyone with insurance} \\ .0 & \text{if thinks hazard not a problem} & \text{and} & \text{doesn't know anyone with insurance} \end{array}\right\} +$$

$$\left\{ .017 \times \log \text{(subjective probability of disaster)} \right\} +$$

$$\left\{ .0032 \times \text{age (in years)} \right\} +$$

$$\left\{ -.00039 \times \text{years lived in house} \right\} +$$

$$\left\{\begin{array}{ll} .015 & \text{if can't estimate future damage} \\ -.159 & \text{if thinks will suffer no future damage} \\ .0015 & \times \text{ estimate of future damage (in \$1000) if think will suffer some} \end{array}\right\} +$$

$$\left\{\begin{array}{ll} -.026 & \text{if lives in coastal zone A} \\ -.010 & \text{if lives in coastal zone B} \\ -.068 & \text{if lives in riverine zone A} \\ .0 & \text{if lives in riverine zone B} \end{array}\right\}$$

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.

Another significant variable is whether the person expects any future damage from a flood. The data in Table V-3 shows that a homeowner expecting no damage is 15.9% less likely to have insurance than one expecting some losses. For every $10,000 increase in anticipated future damage, the likelihood that the homeowner has coverage increases by 1.5%.

All the coefficients in the equation represent the effects of a given variable when all other factors are held at the same level. The socioeconomic variables while statistically significant 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. Furthermore, a person more averse to risk is more likely to have purchased coverage than one who is less averse.

Finally, we see from Table V-3 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% decrease in probability between one who just moved to his house and a homeowner residing there for 25 years).

Using the above regression equation, we determined whether homeowners were insured or uninsured. Specifically, if a River City household had a set of characteristics which resulted in a probability of having coverage which was greater than a certain prescribed value[6], the family was classified as being insured. Otherwise, we assumed that the household did not have coverage. This type of procedure is meaningful to the extent that the variables in Table V-3 describe the factors influencing the insurance purchase decision.

Figure V-4 depicts 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 Figure V-4 reveal that more than one out of three of the high income residents have coverage while fewer than one out of five of low income residents are insured. In addition, Figure V-4 shows that older residents in River City are more likely to be insured than the younger homeowners in the community.

A statistical analysis similar to the one described above was undertaken to determine the amount of structural and contents coverage purchased by each insured homeowner. Figure V-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 of our hypothetical community. The data suggest that residents have coverage considerably below the value of their structure and contents. In the low income group, for example, one out of every four insured households is covered against less than half of its property value. Over 50% of the high income residents are similarly insured. For families with expensive homes, the

FIGURE V-4

PERCENTAGE OF RIVER CITY RESIDENTS IN EACH INCOME AND AGE GROUP WITH FLOOD COVERAGE

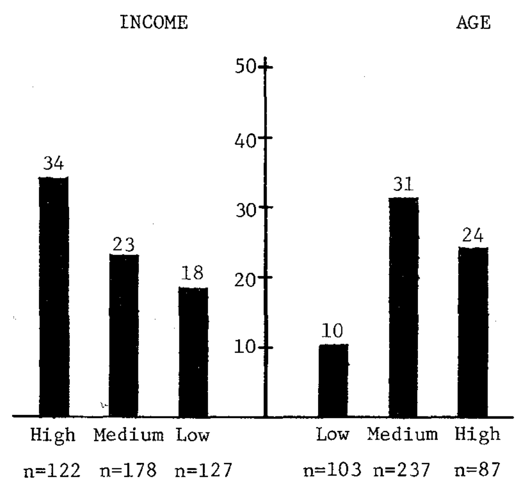
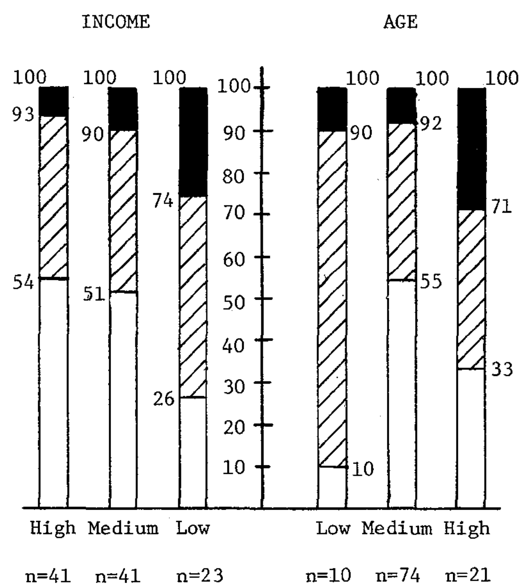


FIGURE V-5

RATIO OF HOUSE & CONTENTS COVERAGE
TO HOUSE & CONTENTS VALUE
BROKEN DOWN BY INCOME, AGE CLASSES*



Little amount of coverage 0 - .50

Moderate amount of coverage .51 - .75

Large amount of coverage .76 - 1.00

*For those who had coverage.

decision to buy less than full coverage is partially affected by the maximum amounts of coverage that they can purchase on their property[7]. Looking at the distribution of coverage by age groupings we see from Figure V-5 that most young and senior citizens have either a moderate or large amount of coverage in contrast to middle-aged homeowners where a majority (55%) have no insurance or little coverage.

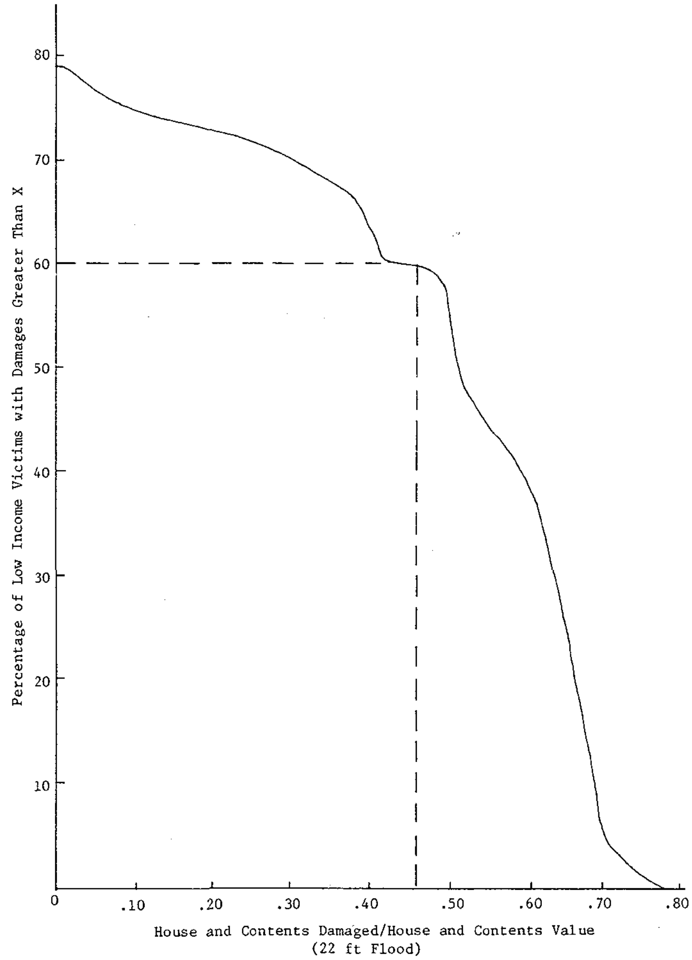
Impact Of Specific Floods On River City (Stage II)

We can now analyze the physical damage caused by floods of different heights. From the outset, we have assumed that the Clearview River will rise to a height 22 feet above sea level, so that the first three subzones will be partially inundated (see Figure V-3). 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 the height of water, 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 be less damaged than the same type 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 type of structure causes less damage.

There may be substantial differences in the impact of a disaster on socioeconomic groups. Figure V-6 focuses on the low income class and indicates the extent of the damage to its property from a 22 foot flood. For this particular set

FIGURE V-6

PERCENTAGE OF LOW INCOME VICTIMS WITH RATIOS OF HOUSE AND CONTENTS DAMAGED TO HOUSE AND CONTENTS VALUE GREATER THAN VALUES ON X-AXIS

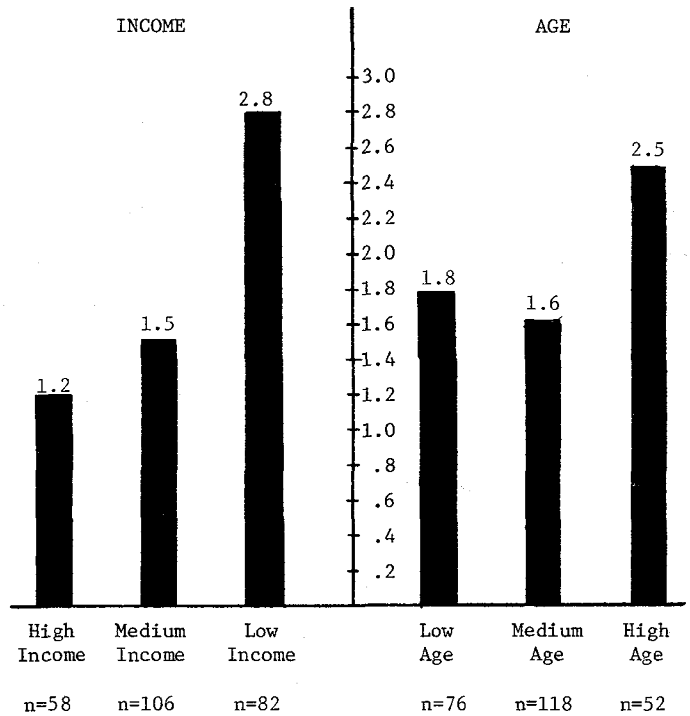


of houses, the dotted lines in the figure indicate that six out of every 10 low income families would suffer damage to their property that equaled or exceeded 45% of its current dollar value. These homeowners would be severely hurt financially if they were uninsured. The graph also reveals that 20% of this class would have no damage; no family would suffer losses that exceeded 78% of its property's pre-disaster value. The reader is cautioned that these percentages are merely 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 might have been quite different from those depicted here.

One way of measuring the impact of the flood disaster on victims' ability to recover is to determine the damage/income ratio for different socioeconomic 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 V-7 illustrates this ratio for uninsured victims in different age and income groups affected by a 22 foot flood. As the figure indicates, 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 $12,500 had, on the average, damage which was 2.8 times their annual income. The high income uninsured group, on the other hand, suffered losses which were only slightly above their annual income. If this is a typical post-disaster phenomenon, then individuals most in need of disaster relief

FIGURE V-7

AVERAGE DAMAGE/INCOME RATIO FOR UNINSURED RESIDENTS SUFFERING DAMAGE FROM A 22-FOOT FLOOD



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.

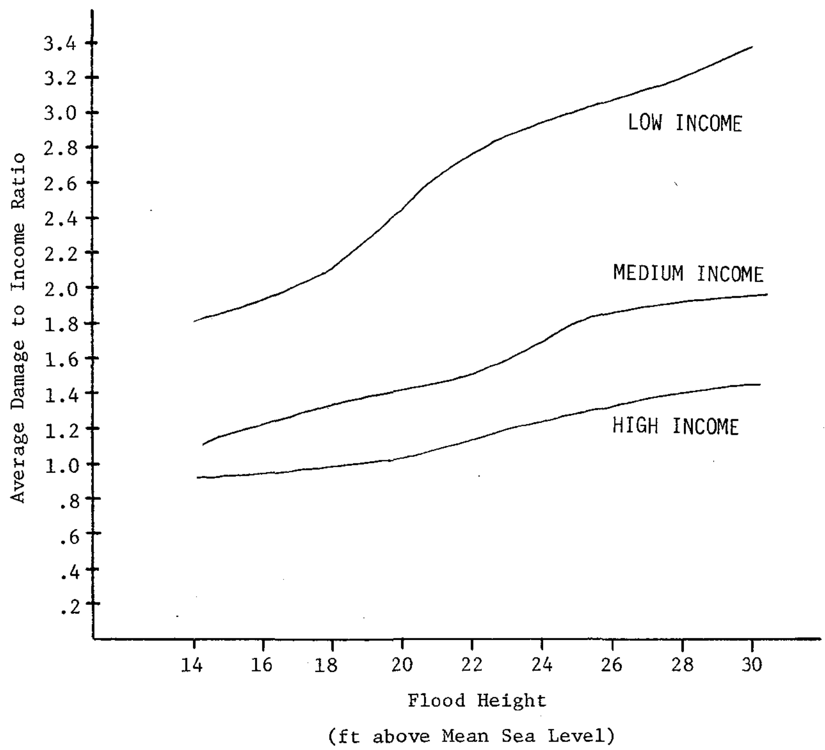
The damage/income ratio taken by itself has no causal significance, since we are not able to predict whether individuals who have high incomes will also have high damage. On the other hand, this descriptive statistic can be used in combination with other financial ratios discussed in Chapter IV to determine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

Figure V-8 indicates how the damage/income ratio changes as the severity of flooding varies. This type of analysis depicts for the user the impact that changes in the magnitude of flooding have on the homeowner's financial status. Low income uninsured victims have much higher values than either of the other two groups whether there is minor flooding (14-18 feet), medium flooding (20-24 feet), or very severe flooding (26-30 feet). For relatively minor floods none of the income groups has 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 30 feet the average ratio for those with incomes under $12,500 is over 3.4 compared to 1.9 (medium income group) and 1.4 (high income group).

FIGURE V-8

AVERAGE DAMAGE/INCOME RATIOS* FOR
RIVER CITY INCOME CLASSES AS A
FUNCTION OF FLOOD HEIGHT

*(for Uninsured Residents suffering some damage)



Specifying A Recovery Submodel (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 purchased by victims, the type of recovery funds available, and the behavior of different victims with respect to different sources of relief.

In our example we assume SBA loans are available at 3% to cover any uninsured damage. Many homeowners eligible for low interest loans have not taken advantage of this opportunity, particularly if their losses were below $10,000. Table V-4 details the percentage of insured and uninsured victims in the field survey who availed themselves of SBA 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 V-4. For those who qualified for SBA relief, an "amount received" subroutine specified the dollar amount by first determining the ratio of SBA loan to total damage and then by 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 V-4 in which some victims used SBA loans for recovery purposes. We assumed then that the victims of River City utilized SBA funding in approximately the same manner as did homeowners interviewed in the field survey.

TABLE V-4

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 (Stage III)

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 finance his entire recovery through insurance, then the value of his house and contents are restored to their pre-disaster condition. 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 different socioeconomic groups in River City, we have compared in Table V-5 the ratio of total debt to total assets at three points in time: the pre-flood period (Stage I), the immediate post-flood period (Stage II), and the period after recovery funds have been provided (Stage III). Table V-5 considers differences between the three insurance programs (i.e., 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 and the time after recovery funds were provided for all income and age groups (e.g., for the low income group the ratio dropped from .30 to .21).

TABLE V-5

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

Furthermore, in all income and age groups the value of this ratio after recovery funds were provided 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)[8]. As one would expect, a voluntary program produces debt/asset ratios falling between those resulting from Programs 1 and 3 in the post-recovery period (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 V-6. The first portion of the table shows that 76% of the homeowners in the community suffered some damage from a 22 foot flood with the per capita total loss for these victims averaging $28,200. As one would expect, the nature of recovery differs greatly under each of the three programs. Only 24% of the victims had insurance when it was voluntary, so that many of them relied on the SBA (56%) for relief through an average loan of $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 increased slightly to $14,800[9]. When insurance was mandatory, insurance claims naturally dominated the recovery picture. Only one-fourth of the victims supplemented their insurance coverage with SBA funds; under this program the average loan amounted to less than $9,000.

TABLE V-6

COMPARISONS OF RECOVERY PROCESS FOR RIVER CITY RESIDENTS
UNDER ALTERNATIVE INSURANCE ARRANGEMENTS

	Effect of Disaster		Sources of Recovery (for those Suffering Damage)			
	Damage due to 22 ft flood		Insurance Claims		SBA Loans	
	Per Capita Damage for Victims	Percentage of Houses Damaged	Per Capita*	Percentage Using Source	Per Capita*	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 V-6 also shows the magnitude of recovery by giving the ratio of recovery 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% of the victims did not obtain enough funds from their coverage and SBA loans to restore their property to at least 75% of its pre-disaster value. On the other hand one finds that if no insurance was available, approximately 30% of the disaster victims did not utilize the SBA for any disaster relief and hence have a recovery funds/total damage ratio equaling 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 V-7 for low income residents of River City. The per capita damage figures for this group are lower than for the community as a whole as is 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% of its pre-disaster value. Under a program of no insurance 35% do not utilize the SBA for any relief, a higher percentage than for the community as a whole.

Summary and Conclusions

The types of analyses described in this chapter illustrate the opportunities users have to examine the impacts of alternative hazard mitigation and recovery

TABLE V-7

COMPARISONS OF RECOVERY PROCESS FOR LOW INCOME RIVER CITY RESIDENTS UNDER ALTERNATIVE INSURANCE ARRANGEMENTS

	Effect of Disaster		Sources of Recovery (for those Suffering Damage)			
	Damage due to 22 ft flood		Insurance Claims		SBA Loans	
	Per Capita Damage for Victims	Percentage of Houses Damaged	Per Capita*	Percentage Using Source	Per Capita*	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	.75-1.00	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.

programs. In this example we constructed River City using actual field survey data collected from an earlier study. Future studies of communities could utilize available information assembled by groups such as the National League of Cities, the Council of State Governments and federal agencies such as the Federal Insurance Administration and the U.S. Corps of Engineers. One can always supplement this information with U.S. Census Bureau data. The principal purpose of the chapter was to depict in graphic terms the capabilities of the CDMS. We chose to investigate alternative insurance programs, as considerable data had been collected on this subject from the field survey. The modeling system is sufficiently flexible that users are encouraged to propose other programs which can be investigated with existing data bases.

FOOTNOTES

1. Specifically, the field survey was designed to identify the decision processes utilized by homeowners in determining whether to purchase insurance. Multivariate statistical analyses were employed to estimate the relative importance of different factors on the probability that an individual would have flood or earthquake coverage. The field survey also provides quantitative data on the impact of alternative disaster programs on the recovery process of disaster victims.

2. See U.S. Water Resources Council Report (1976) and Executive Order (11988) on Flood Plain Management (1977).

3. See Kunreuther (1973), D.R. Anderson (1974), Brown and Lind (1976), and Platt (1976) for a detailed evaluation of the National Flood Insurance Program as it relates to flood plain management.

4. As described in Chapter III, the damage submodels do allow the user to study the impact of protective works on damage.

5. We arbitrarily located 42% of these households in subzone U and 58% in subzone W.

6. For this illustration we arbitrarily chose a critical value of .88. This cutoff point resulted in approximately 28% of the homeowners in River City having coverage.

7. The limits on coverage were set at $70,000 for the structure and $20,000 for contents.

8. 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 (1977) 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 for the immediate post-flood and post-recovery periods than those found by Vinso due to the lesser damage incurred by River City. However, the relative magnitudes of the ratios are similar.

9. This is consistent with values found in the Vinso (1977) Wilkes-Barre study. He found that 62% of the victims took out SBA loans for recovery purposes. Interestingly Vinso also found that the average SBA

loan amount was roughly half the average damage, which is consistent with River City's recovery under Program 3.

CHAPTER VI

IMPLICATIONS FOR POLICY AND FUTURE RESEARCH

Evaluating Private And Social Risks

The Community Disaster Modeling System enables one to compare the impacts of alternative 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 a social risk if the federal government were to pay for all flood losses to private property.

Most actions involve both types of risks[1]. The relative magnitudes of the private and social costs will depend upon the nature of the public policies in force and the time horizon under consideration. Should a flood occur tomorrow, for example, 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, however, contains 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. Recall Mr. Glenn who has suffered $12,000 damage to his house and $6,000 to the contents from a 22 foot flood in River City. If the Glenn family had purchased sufficient flood insurance to cover its entire loss (except for the deductible), then the social costs associated with the claim will be determined by the proportion of the insurance loss paid by the federal government[2]. Suppose that at the time of the River City flood 55 cents out of every dollar in insurance claims was subsidized by the federal government through the Federal Insurance Administration. Then the social cost would be .55 multiplied by the insurance claim payment. The remaining 45% would be treated as a private cost.

The same analysis could be applied to all victims in River City who have insurance coverage. Indeed for any given flood, the social cost of the flood insurance program will increase as the percentage of the government subsidy increases 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, under Program 3 (no flood insurance available) the only source of relief was SBA disaster loans. The social cost of each dollar in SBA relief will be directly proportional to the difference between the subsidized interest rate and the market rate of interest. If, as in the illustration, the interest rate were

3% on loans of any size and the market rate of interest were 9% then the general taxpayer would be subsidizing the recovery by 6% for every dollar loaned to disaster victims. Naturally, if the SBA disaster relief program included forgiveness grants, the social costs of this recovery measure would be increased.

The CDMS is not intended to determine directly which set of adjustments is the most desirable from the standpoint 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. In the above discussion on the recovery problems in River City, Program 1 (required insurance) and Program 3 (no insurance available) 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[3]. These stark figures produced by the modeling system highlight critical problems and choices facing federal, state and local governments as well as the insurance industry in designing disaster programs.

Extensions Of The System

The River City example and the discussion of private and social costs are designed to stimulate further suggestions by users and decision-makers as to how this tool can be improved for policy purposes. Future work on the system might include: (1) construction of alternative scenarios, (2) additions to the damage submodel, (3) additions to the financial submodel, (4) analysis of alternative adjustments, (5) extensions to the software package, and (6) developing data sources. Each of these areas is discussed below.

(1) Construction Of Alternative Scenarios

By constructing different communities using either field survey data or characteristics generated through 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 socioeconomic 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 floodproofed) to determine the effects such changes will have on physical damage and the financial status of different socioeconomic groups[4].

One could in this way 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 as well as 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 system has been designed so that the user can undertake these types of sensitivity analyses with relative ease.

(2) Future Research On The Damage Submodel

The studies undertaken to date have been concerned with a single type of natural disaster, namely floods. Yet analysis of additional disasters may be incorporated within the existing framework of the CDMS, and requires only development and modification of existing routines.

To varying degrees, every portion of the United States is vulnerable to natural disasters. In particular, most of the nation is exposed to some risk from seismic disturbances. The CDMS could naturally be extended to include earthquake modeling, since it is probably the next level of complexity from a damage point of view.

This logical outgrowth could provide an interactive computer model that would evaluate possible damages in a community exposed to a certain level of seismic risk. These damages would of course reflect the nature and frequency of such events.

(3) Future Research On The Financial Submodel

While the submodel as it now exists is useful for studying the financial impact of disasters, several avenues are open for future research.

Income statement. The present submodel analyzes in detail how disasters and subsequent recovery programs affect what a household owns and what it owes. This information is valuable in designing suitable recovery programs. The balance sheet, however, is not the entire story. Disasters will also influence what proportion of a household's income goes to which claimants. If the loans are used for recovery, less discretionary income is available to sustain economic activity. If insurance is used, premiums must be paid from current income. It is, therefore, quite important to analyze the impact on the income statement as well as the balance sheet.

Recovery phase. Currently the recovery phase consists of estimations relying on the results of the Kunreuther et al (1978) survey. This survey investigated what households would do when recovering from a disaster assuming a fixed set of alternatives. An important question has not yet been answered, though: to what extent will a household prefer to accept reduced livability to reduce the level of indebtedness of the household? Kunreuther et al determined that households did not fully utilize SBA loans; hence, it would be interesting to determine to what extent a household will substitute private sources such as bank loans and savings for SBA loans and to what extent a household might prefer not to replace all its furniture and contents lost in the flood in order to reduce the funds needed for recovery. In any case, investigating this element of household decisionmaking should be a critical requirement in studying the recovery phase.

Community relationships. Finally, it would be helpful to determine the impact of the disaster and recovery on the community as a whole. Simply summing households is not sufficient. Disasters will impact on business, financial institutions, local governments and other elements in the community. It would be useful to obtain an indication of the role each component of the community has in the economic recovery of a region following a disaster.

(4) Analysis Of Alternative Adjustments

The CDMS 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 (1975) critical assessment of the flood hazard provides a meaningful foundation for this analysis by indicating which adjustments are closely linked, which ones have only weak interrelationships, and which appear to be unrelated. After recognizing the limits of our understanding as to how these adjustments relate to each other, users should undertake future analyses of hazard mitigation and recovery measures of the sort outlined below.

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, 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 either to "modify the insurance provisions or eliminate land-use planning and accompanying insurance guarantees in the community" (White and Haas, 1975, 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 that users may want to incorporate into the CDMS. We caution the reader 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.

Floodproofing. Preliminary analyses of the costs and potential benefits of floodproofing have been undertaken by Wilson, Lepore and Duffy (1977) in presenting their findings on the damage submodel. Their analyses have concentrated on the impact that specific floodproofing requirements will have on reducing losses to residential structures from floods of different magnitudes. A user could also incorporate the floodproofing adjustment into a more extensive disaster program. For example, he could analyze the costs of adopting specific floodproofing 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 floodproofing techniques: the CDMS could analyze balance sheet effects following specific floods, should specific groups of homeowners choose to adopt or not utilize available floodproofing 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 CDMS could enable the user to evaluate the effectiveness of different warning systems if data are available on the impact of such messages on behavior of selected groups in population. W. 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. Limited 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 (Leik, 1977).

To evaluate the relative merits of a warning system, one would need to have the cost data associated with the installation and implementation of a warning system for different communities threatened by floods. Given this information, 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 either to protect some of their possessions or move them to the basement should they prefer to replace used items by a claim. Their actions will undoubtedly be influenced by the size of the deductible on the flood policy.

Analysis of flood-prone land acquisition. The National Flood Insurance Act (1968) 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 CDMS 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, on the community as a whole, as well as on state and federal governmental agencies responsible for providing mitigation and recovery funds for natural hazards.

To determine the relative effectiveness of 1362 when compared to other relief programs, one should consider 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 should the government not reimburse them for substantially damaged property. This type of analysis then suggests that one must integrate other adjustments (e.g., insurance purchasing decisions, degree of floodproofing, decisions to obtain loans) explicitly into the relief program comparisons.

Analysis of 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 obtain forgiveness grants of up to $5,000 and loans to cover the remaining portion of their loss at an annual interest rate of 1%. In April 1973 legislation was passed (PL 93-24) rescinding the $5,000 forgiveness grants authorized after Tropical Storm Agnes and increasing the annual interest rate from 1% to 5%. The interest rate was raised even further to 6 5/8% 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 $10,000 of uninsured damage, 3% loans on the next $30,000, and 6 5/8% loans for that portion of a loan covering uninsured losses exceeding $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 CDMS can examine how changes in the terms of this program will affect the recovery process under different assumptions about victims' behavior following a disaster. For example, 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, and what are the private and social costs associated with these programs.

(5) Extensions To The Software Package

Throughout this monograph a single entity in a community, the homeowner, has been analyzed. However, if the CDMS is to prove a useful tool for public policy analysis, the remaining sectors of a community (i.e., business and governmental) must also be studied. Such a capability has been added to the software package, though too late to be included in the examples in previous chapters. Coupled with this addition is the ability of sectors to interact with one another. Thus the following type of analysis becomes possible:

> Subject a community made up of homeowner, business, and governmental sectors to a flood. Then, based on the budgetary constraints of relief agencies and the severity of damage to homeowners and business, allocate disaster relief to individuals and businesses on some predetermined basis.

(6) Developing Data Sources

In this project we utilized field survey data of homeowners in flood-prone areas throughout the United States collected as part of an earlier NSF-RANN study. An NSF-supported project is currently underway (Miller and Vinso, 1978) to determine the appropriate sources of data from such agencies as the Corps of Engineers, Soil Conservation Service, U.S. Census Bureau, Federal Insurance Administration and other ongoing studies. In fact, a principal purpose of the interactive modeling system is to serve as a focal point for data collection efforts in this regard.

Conclusion

To be considered successful for policy purposes, the Community Disaster Modeling System must meet the needs of users who are interested in investigating the effects of different mitigation and recovery policies. As Katz and Miller (1977) have shown, the modeling system is designed to provide a high degree of flexibility so that it is possible to make substantial modifications without having to invest large amounts of time and skill or risk confusion in reprogramming. This study has been an attempt to introduce the system to potential users and to highlight the advantages of its interactive construction. The next step is for users to make the initial commitment to experiment with the system. Only then can we determine whether the Community Disaster Modeling System is a truly valuable instrument for policy analysis.

FOOTNOTES

1. For an interesting discussion of private and social risks see Lave (1971).

2. In recent years this percentage subsidy borne by taxpayers has been reduced from 90% to slightly above 50% so that the social cost of flood insurance has decreased.

3. Vinso (1977) 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.

4. For a detailed description of how to use the model see Katz and Miller (1977).

APPENDIX A

AN ANALYSIS USING PROTECTIVE MEASURES

In a separate analysis using the homeowners in River City, we studied the impact of protective measures on damage. Figure A-1 presents the effects of floodproofing on the ratio of total damage (house plus contents) to pre-flood house and contents value in the two high hazard subzones. The table is further broken down by type of house. For this particular analysis we arbitrarily specified that all houses without basements in the high hazard subzones were floodproofed by being raised on three feet of fill and that all homes with basements were protected by a three foot wall.

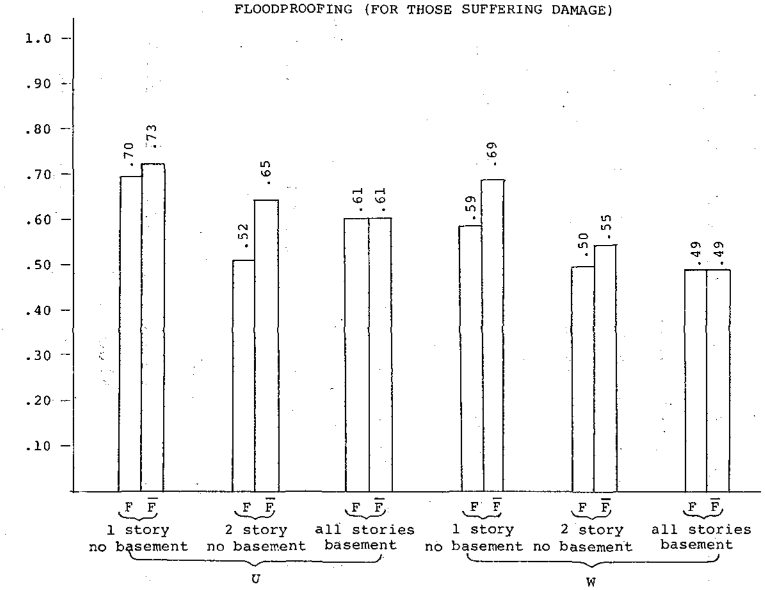
After a 22 foot flood*, homes raised on fill suffered less damage than when they were not raised on fill, but the three foot wall served as no protection for the houses with basements. It is worth noting that for the one story homes without basements and without floodproofing in subzone W, the house and contents damage/value ratio for those suffering damage was 0.69. This figure dropped to 0.59 when the houses were floodproofed. Furthermore, though not directly reflected in these figures, two of the houses of this type in W that had incurred damage without floodproofing suffered no damage when raised on fill.

---

* - For this analysis only we accounted for water velocities. Water velocity was arbitrarily specified at 8,7,5,3,1 feet per second for subzones U,W,X,Y,Z respectively.

FIGURE A-1

RATIO OF HOUSE AND CONTENTS DAMAGE TO HOUSE AND CONTENTS VALUE BROKEN DOWN BY SUBZONE, HOUSE TYPE AND FLOODPROOFING (FOR THOSE SUFFERING DAMAGE)



All houses were subjected to a 22 foot flood

Water velocities were taken into account for this analysis

F { All homes without basements in subzones U and W were raised on three feet of fill
All homes with basements in subzones U and W were protected by a three foot levee

F̄ No homes in subzones U and W were floodproofed

APPENDIX B

DETERMINATION OF FINANCIAL CHARACTERISTICS

To analyze the impact of natural disasters on households one needs a systematic way to present their financial status. While a uniform format has not been developed for households, we can borrow the methodology used for determining the financial position of business firms.

Balance Sheet Construction

The standard form for presenting the financial status of a firm at a given point in time is the balance sheet. This statement lists what is owned (assets) and what is owed (liabilities). Since what is owned must be equal to what is owed, assets must equal liabilities (hence a "balance sheet"). However, assets can be differentiated according to ease of conversion to cash. Those assets which are easily converted to cash are classified as "current assets" while those whose cash value is not easily realized are defined as "fixed assets". Likewise, liabilities can be classified according to the relative proximity of claims on funds. Claims which will come due within a prescribed period (generally one year) are termed "current liabilities". Claims which come due past one year (generally paying a fixed return for their life) are classified as "long term liabilities". The residual belongs to the owners (or stockholders) and is termed "equity". A typical balance sheet for a firm is shown in Table B-1a.

TABLE B-1

TYPICAL BALANCE SHEETS

Assets		Liabilities
a. For a Firm		
Current Assets		Current Liabilities
Cash		Notes Payable
Marketable Securities		Accounts payable
Inventory		Wages Payable
Accounts Receivable		Other Current Payables
Other Current Assets		
Fixed Assets		Long-Term Liabilities
Plant & Equipment		Long-Term Debt
Less: Depreciation		
Equity in other firms		Equity
Goodwill		
Total Assets	=	Total Liabilities & Equity
b. For a Household		
Financial (Current) Assets		Current Liabilities
Cash & Demand Deposits		Notes Payable
Securities		Unsecured Credit
Savings Accounts		
Savings Bonds		
Cash Value of Life Insurance		
Real (Long-term) Assets		Long-Term Liabilities
Automobiles		Bank Loans
Market Value of Home		Mortgages
Market Value of Contents		SBA Loans
Other Assets		Other Loans
		Equity (Net Worth)
Total Assets	=	Total Liabilities & Net Worth

In a similar fashion, the financial position of the household can be determined at a given point in time by preparing a personal balance sheet. A typical household balance sheet is shown in Table B-1b. The forms these financial statements take are slightly different from those of the firm. Looking more closely at the accounts, we see that they can be broken down into two classifications: financial and real assets.

Financial Assets

"Financial assets" are claims which the household has on others, are not physical or tangible assets, and can be converted into cash relatively easily. While we could group all of these assets together, some information would be lost as each financial asset has different characteristics.

There are three basic types of financial assets, each included in the household's portfolio for a different reason. Cash and demand deposits are used primarily for transaction purposes; since these deposits are non-interest bearing, most households attempt to minimize the amount they have tied up in these funds. The second type of financial asset may be broadly defined as savings and is composed of savings accounts and savings bonds. These assets are kept primarily to provide a source of funds quickly if expenditures exceed income, but, unlike cash, savings accumulate interest. These savings are not only readily available but can also be converted to cash with no loss of capital because they do not decline in value below the price at which they were obtained.

On the other hand, securities, including stocks and bonds, generally provide a higher return than savings but are far more speculative; while the cash returns may be greater, capital loss is possible if one is forced to sell at less than cost. Hence, there will be more reluctance to liquidate these securities than savings as a source of recovery funds. Finally, the cash value of life insurance is also a source of funds but would only be used as a last resort since most individuals buy insurance for protection rather than for its potential cash value.

Real Assets

Generally, the most important investment for a household is a home. Its second single most important investment is automobiles. The contents of the house are treated separately from the property itself since insurance and disaster recovery programs separate the contents of the house from the structure itself. Finally, any other assets such a boats, furs, etc., are grouped without further disaggregation.

Liability Accounts

In a similar fashion, liabilities are disaggregated. Those debts which come due in full within a short period of time such as charge accounts, medical and dental bills we designate current liabilities. Short term loans such as bank or finance company loans due within a year are also included in this category. Since current liabilities are claims on assets which must be satisfied in the very near future, not only is there a limit to the extent that this type of debt can be used for disaster recovery but it also effects the amount of other debt such as SBA loans which can be obtained.

Long term liabilities do not come due in the near future but generally have periodic fixed payments and require some form of collateral. Bank loans are intermediate loans (1-10 years) used primarily for home improvements. Mortgages, on the other hand, are used to purchase homes and generally extend for twenty to thirty years with interest rates lower than bank loans. SBA disaster loans are the primary form of relief provided by the federal government for recovery. They are frequently long term (up to thirty years) at interest rates much lower than the prevailing rates. This form of relief is separated in Table B-1b from other loans which include financing for such assets as automobiles or appliances. The sum of the current and long-term liabilities represents the total liability of the household unit as viewed by outside creditors.

As with the firm, total liabilities are subtracted from total assets and the residual reflects the equity, net worth, or wealth of the household. If all assets were liquidated for cash and all liabilities paid off, equity is the remainder left for the household.

Determination Of Account Levels

Finally, the dollar values of the accounts must be determined. Because of various statutes, regulation by the Internal Revenue Service, Securities and Exchange Commission, and the states of incorporation, the assets and liability accounts in a business balance sheet are expressed in book values (costs at the time of acquisition). Financial decision-making is not based on original costs, however, but rather on market or replacement values. If a firm must replace a machine that today costs one million dollars, it is immaterial that the same machine cost five hundred thousand dollars ten years ago. Likewise, if a bond issue must be replaced, it is irrelevant that the interest rate twenty years ago was three percent. Since interest rates are higher now, the firm must either pay more of its income in the form of interest payments or else issue less debt for the same amount of interest.

Similarly, we expect that the decisions made by the household would also be based on a market or replacement value as opposed to original cost. Assume, for example, that a household owned a refrigerator which it purchased ten years ago for one hundred dollars. It still performs the same service, cooling food to prevent spoilage, but what is the value of that refrigerator? If the household has to sell it to satisfy a debt, it might bring fifty dollars. On the other hand, if the refrigerator had to be replaced, a unit performing the same service might cost three hundred dollars. What then is the value of the refrigerator? In analyzing the financial decision-making process, the value is either fifty or three hundred dollars depending on whether it is currently available or must be replaced. In any case, the one hundred dollar cost is obviously irrelevant. The value of each asset owned by the household then will be determined by the current market value of that asset.

Ratio Analysis Of The Balance Sheet

We can analyze the financial impact of a disaster on households by investigating changes in the market values of the various accounts. While we might compare individual components of the balance sheet, such comparisons in general are inappropriate. Since some households have larger amounts of assets than others, a twenty percent reduction in assets may mean tens of thousands of dollars for one household while for another it may mean only a few thousand. The usual method for comparing financial characteristics among units of different magnitudes is to construct financial ratios.

Analysis of these ratios involves three types of comparisons. First, the present ratio can be compared to past ratios. When these ratios are displayed over time, we can study the types of changes and determine whether there has been an improvement or deterioration in the financial condition of the household. The second involves comparing the ratios of one household with either other households or some average household at the same point in time. The third is the most important. Since most households acquire assets slowly over time and adjust their financial statements to the variability of income and preferred levels of cash, savings, etc., the preflood levels of a ratio for a given household provide information on the preferred composition of financial assets, debt, etc. Seen this way, the preflood ratios provide benchmarks which define how far the disaster moved the household away from the preferred financial condition as well as estimates as to how debt and personal funds can be used to return the household to its preflood financial position.

As an example of this type of analysis consider the following ratio:

$$\frac{\text{Financial Assets}}{\text{Total Assets}}$$

This ratio describes what percentage of the assets owned by the household are in the form of financial assets. It gives an indication of the level of financial assets as opposed to real assets. The first type of comparison might look at how the ratio or percentage after the flood (but before recovery) differs from that before the flood. Since financial assets in general cannot be destroyed by a natural disaster while real assets can, this ratio should increase. After the recovery phase has progressed for some time, the ratio can indicate to what extent financial assets have been liquidated to provide real assets.

Second, the ratios can be compared to those of other similar households. Projector and Weiss (1966) found that older residents with high incomes had a higher proportion of financial assets to total assets than younger and lower income households. Thus, the preferred level of financial assets for a given household will differ depending on the income and age of the household. A standard of reference can be established as a function of these variables when designing disaster relief policies.

Finally, we can determine to what extent the recovery process has been completed by comparing the ratio at a given point in time to the preflood ratio of that household and of similar households. Although no definitions currently exist to suggest how close to the preflood condition one must come to justify the assumption that recovery is complete, analysis of ratios can help provide such a definition.

Choosing The Relevant Ratios

Now that the form of the analysis has been developed, which ratios are to be used here? Many ratios are possible. Some describe the relationship among components of the balance sheet, some look at the relationship between income and expenses, while still others relate balance sheet items to income and expenses. In this paper, we are concerned only with the relationships among the elements of the balance sheet.

To analyze the financial condition of the disaster victim, four additional ratios are reviewed: the current ratio, the quick ratio, the debt-to-total-assets and the debt-equity ratios. We emphasize again that there is no absolute level for any of these ratios for all households but only with respect to the comparisons previously discussed.

The "current ratio" is the ratio of financial assets to liabilities and is used to determine the ability of the household to meet outside obligations with cash on hand or easily obtained cash. Looking at this ratio, we gain insight into the ability of the household to remain solvent in adversity. The more variable current income, the higher this ratio should be. Abstracting from income, the higher this ratio, the greater should be the ability of the household to pay its bills.

The current ratio, however, is a crude measure since it does not take into account the ease of converting the individual components of financial assets into cash. Reviewing the components of financial assets, we see that all are convertible easily and quickly to cash without loss of capital except for marketable securities. Since these securities can lead to capital loss if converted to cash at a price less than cost, the household will be much less eager to utilize securities as a source of cash.

One way to compensate for the shortcomings of the current ratio is to use the "quick ratio". This ratio is the same as the current ratio except that it excludes marketable securities from the numerator. Of course, if the household were faced with a situation where financial assets had to be liquidated to pay its debts and there was no possibility of further borrowing, the household would certainly sell these securities, even at a loss, rather than sell real assets or go bankrupt. This would, however, be a last resort, so the quick ratio provides a more penetrating measure of the liquid position of the household.

Finally, we obtain an indication of the household's desire and ability to take on debt obligations by using "total-debt to net-worth" (equity) and "debt-as-a-percent-of-total-assets". As a household increases the proportion of debt, fixed claims on income increase. All other things being the same, the probability that the household will be unable to meet these fixed charges also increases. These ratios will vary then with the variability of income.

There is another aspect to debt besides fixed charges, however. Debt also represents a claim on assets. If the head of the household dies, debts musts be satisfied before anything goes to the heirs. The larger the debt carried, the more assets which must be liquidated to satisfy these debts. Younger households generally use debt to acquire assets like homes because it takes far too long to save enough to pay cash. To overcome this problem of a claim on assets, life insurance is purchased, and relatively cheaply because the probability of death is low. If the head of the household dies, the insurance pays off the bulk if not all of the debts. As a household ages, however, the probability of death increases. Insurance becomes a very expensive way to guard against the possibility that assets may have to be liquidated to satisfy debts. As a result, households tend to reduce the amount of debt they carry as they get older. Therefore, the debt-net-worth (equity) and debt-to-total-assets ratios will be a function not only of variability of income but also of the age of the household. It is important then to compare debt ratios among similar households since a comfortable amount of debt for a young household can be a crushing burden for an elderly household.

REFERENCES

Anderson, D.R.
1974 "The National Flood Insurance Program -- Problems and Potential," Journal of Risk and Insurance, 41:579-599.

Anderson, W.
1970 "Tsunami Warning in Crescent City, California and Hilo, Hawaii," in The Great Alaska Earthquake of 1964: Human Ecology, Washington, D.C.: National Academy of Sciences, pp. 116-124.

Ando, A. and F. Modigliani
1963 "The 'Life Cycle' Hypothesis of Saving: Aggregated Implications and Tests," American Economic Review, 53:55-83.

Brown, J. and R. Lind
1976 "An Economic Impact Analysis of the National Flood Insurance Program," Washington, D.C.: Federal Insurance Administration.

Cochrane, H.C.
1975 Natural Hazards and their Distributive Effects, Boulder, Colorado: University of Colorado, Institute of Behavioral Science.

1976 "Flood Hazard Simulation: Reviewing the State of the Art," (mimeo).

Dacy, D. and H. Kunreuther
1969 The Economics of Natural Hazards: Implications for Federal Policy, New York: Free Press.

Day, J.C.
1970 "A Recursive Programming Model for Non-Structural Flood Damage Control," Water Resources Research, 6:1262-1271.

Design Cost File
1976 New York: Construction Publishing Co.

Dunkelberg, W.C. and F.P. Stafford
1971 "Debt in the Consumer Portfolio: Evidence from a Panel Study," American Economic Review, 51:598-613.

Friedman, D.G.
1975 Computer Simulation in Natural Hazard Assessment, Boulder, Colorado: University of Colorado, Institute of Behavioral Science.

Friend, I. and M. Blume
1975 "The Demand for Risky Assets by Households and Other Investors," American Economic Review, 65:900-922.

Friend, I. and C. Lieberman
1975 "Short-Run Asset Effects on Household Saving and Consumption," American Economic Review, 65:624-633.

Grigg, N.S. and O.J. Helweg
1975 "State of the Art of Estimating Flood Damage in Urban Areas," AWRA Water Resources Bulletin, pp. 379-390.

Institute for Water Resources
1972 A Computer Simulation Model for Flood Plain Development, Washington, D.C.: U.S. Army Corps of Engineers.

James, L.D.
1964 A Time Dependent Planning Process for Combining Structural Measures, Land-Use and Flood Proofing to Minimize the Economic Cost of Floods, Palo Alto: Stanford University, Institute of Engineering-Economic Systems.

Johnson, W.K.
1977 "Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures," Davis, California: U.S. Army Corps of Engineers, Hydrologic Engineering Center.

Jones, D.E.
1977 "The Economics of Water-Resistant Construction," Proceedings of the Conference on Flood-Plain Management, Asilomar, California: ASCE.

Katz, N. and L. Miller
1977 "An Interactive Modeling System," Decision Sciences Working Paper #77-09-02, Philadelphia: The Wharton School, University of Pennsylvania.

Kunreuther, H.
1973 Recovery from Natural Disasters: Insurance or Federal Aid? Washington, D.C.: American Enterprise Institute.

Kunreuther, H., R. Ginsberg, L. Miller, P. Sagi, P. Slovic, B. Borkan and N. Katz
1978 Disaster Insurance Protection: Public Policy Lessons, New York: Wiley-Interscience.

Lardieri, A.C.
1975 "Flood Proofing Regulations for Building Codes," ASCE, Hydraulics Division, 101, pp. 1155-1169.

Lave, L.
1971 "Risk, Safety and the Role of Government," in Perspectives on Benefit-Risk Decision Making, Report of a Colloquium Conducted by the Committee on Public Engineering Policy, Washington, D.C.: National Academy of Engineering.

Lee, L.T. and J.D. Collins
1976 "Engineering Risk Management of Natural and Man-Made Hazards," ASCE Annual Convention Preprint 2757, Philadelphia.

Leik, R.K.
1977 "Community Response to Natural Hazard Warnings," NSF Research Proposal, University of Minnesota.

Mileti, D.
1975 Natural Hazards Warning Systems in the United States: A Research Assessment, Boulder, Colorado: University of Colorado, Institute of Behavioral Science.

Miller, L. and J. Vinso
1978 "Extensions and Utilization of the Community Flood Model", National Science Foundation grant to University of Pennsylvania.

National Flood Insurers Association
1974 "Insurance Claims Tapes," New York.

Owen, H.J.
1977 "Annotations of Selected Literature on Nonstructural Flood Plain Management Measures," Davis, California: U.S. Army Corps of Engineers, Hydrologic Engineering Center.

Platt, R.
1976 "The National Flood Insurance Program: Some Midstream Perspectives," American Institute of Planners Journal, 42:303-313.

Projector, D.S.
1968 Survey of Changes in Family Finances, Washington, D.C.: Board of Governors of the Federal Reserve System.

Projector, D.S. and G.S. Weiss
1966 Survey of Financial Characteristics of Consumers, Washington, D.C.: Board of Governors of the Federal Reserve System.

Sheaffer, J.R.
1967 "Introduction to Flood Proofing," Chicago: University of Chicago, Center for Urban Studies.

1977 "Economic Justification of Flood Proofing: Analysis of a New Commercial Structure," Chicago: Sheaffer and Roland, Inc.

U.S. Army Corps of Engineers
1969 "Flood Damages -- Susquehanna River Basin Study," (unpublished) Baltimore.

1971 "Flood Insurance Study," Philadelphia.

1972 "Flood Proofing Regulations," Washington, D.C.

1976 "Flood Fighting Measures," (unpublished) Baltimore.

1977 "Technical Report on Representative Flood Damage to Residential Properties," (draft report) Huntington, West Virginia.

U.S. Congress
1966 _A Unified National Program for Managing Flood Losses_, Report of the National Task Force for Flood Control, HD 465, 89th Congress, 2nd Session, Washington, D.C.: U.S. Government Printing Office.

U.S. Department of Agriculture, Soil Conservation Service
1970 "Flood Damage Estimates, Residential and Commercial Property," WEP Technical Guide 21, Supplement 1, Fort Worth, Texas, pp. 1-127.

U.S. Department of Housing and Urban Development, Federal Insurance Administration
1970 "Flood Hazard Factors, Depth-Damage Curves, Elevation Frequency Curves, Standard Rate Tables," Washington, D.C.

U.S. Water Resources Council
1976 _A Unified National Program for Flood Plain Management_, Washington, D.C.: U.S. Water Resources Council.

Vinso, J.D.
1977 "Financial Implications of Natural Disasters: Some Preliminary Indications," _Mass Emergencies_, 2:205-217.

1978 "Financial Consequences of Natural Disasters: A Discussion of the Financial Sector of the Community Disaster Model," Rodney L. White Center for Financial Research Working Paper, Philadelphia: The Wharton School, University of Pennsylvania.

White, G.F.
1964 "Choice of Adjustment to Floods," Chicago: University of Chicago Press.

1966 "Optimal Flood Damage Management: Retrospect and Prospect," in A.V. Kneese and S.C. Smith (eds.), Water Research, Baltimore: John Hopkins Press.

White, G.F., et al
1973 Flood Hazard in the United States: A Research Assessment, Boulder, Colorado: University of Colorado, Institute of Behavioral Science.

White, G.F. and J.E. Haas
1975 Assessment of Research on Natural Hazards, Cambridge: Massachusetts Institute of Technology Press.

Whitman, R.V., et al
1975 "Seismic Design Decision Analysis," ASCE Journal, Structural Division, 101:1067-1084.

Wiggins, J.H.
1976 "Waterborne Hazard Analysis, An Expected Loss Assessment of Riverine Flooding, Storm Surge and Tsunami," Redondo Beach, California: J.H. Wiggins Co.

Wilkes-Barre Redevelopment Authority
1974 "Flood Proofing Requirements," Wilkes-Barre, Pennsylvania.

Wilson, J., J. Lepore and B. Duffy
1977 "The Community Disaster Model: The Damage Sector," Department of Civil and Urban Engineering Working Paper, Philadelphia: University of Pennsylvania.

Monograph Series
Program on Technology, Environment and Man
Institute of Behavioral Science 6
University of Colorado
Boulder, CO 80309

The following monograph papers may be obtained from the Natural Hazards Information Center, located at the above address.

#004 Warrick, Richard A., et al. *Drought Hazard in the United States: A Research Assessment.* 1975, 199 pp.

#005 Ayre, Robert S., et al. *Earthquake and Tsunami Hazards in the United States: A Research Assessment.* 1975, 150 pp.

#006 White, Gilbert F., et al. *Flood Hazard in the United States: A Research Assessment.* 1975, 143 pp.

#008 Baker, Earl J. and Joe Gordon-Feldman McPhee. *Land Use Management and Regulation in Hazardous Areas: A Research Assessment.* 1975, 124 pp.

#021 Mileti, Dennis S., Thomas E. Drabek and J. Eugene Haas. *Human Systems In Extreme Environments: A Sociological Perspective.* 1975, 165 pp.

#022 Lord, William B., Susan K. Tubbesing and Craig Althen. *Fish and Wildlife Implications of Upper Missouri Basin Water Allocation: A Research Assessment.* 1975, 114 pp.

#024 Farhar, Barbara C., Ed. *Hail Suppression: Society and Environment.* 1977, 293 pp.

#025 Kates, Robert, Ed. *Managing Technological Hazard: Research Needs and Opportunities.* 1978, 175 pp.

#026 Kunreuther, Howard, et al. *An Interactive Modeling System for Disaster Policy Analysis.* 1978, 140 pp.

The monograph series distributed by the Institute of Behavioral Science may be purchased on a subscription or announcement basis.

The following publications in the monograph series may be obtained from National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161. When ordering from NTIS, be sure to include the PB number and prepayment for the order.

#002 Friedman, Don G. *Computer Simulation in Natural Hazard Assessment.* 1975, 194 pp. PB 261 755; $7.75.

#003 Cochrane, Harold C. *Natural Hazards and Their Distributive Effects.* 1975, 135 pp. PB 262 021; $6.00.

#007 Brinkmann, Waltraud, A.R., et al. *Hurricane Hazard in the United States: A Research Assessment.* 1975, 98 pp. PB 261 757; $5.50.

#009 Mileti, Dennis S. *Disaster Relief and Rehabilitation in the United States: A Research Assessment.* PB 242 976; $4.75.

#010 Ericksen, Neil J. *Scenario Methodology in Natural Hazards Research.* 1975, 170 pp. PB 262 024; $7.50.

#011 Brinkmann, Waltraud A.R., et al. *Severe Local Storm Hazard in the United States: A Research Assessment.* 1975, 154 pp. PB 262 025; $6.75.

#012 Warrick, Richard A. *Volcano Hazard in the United States: A Research Assessment.* 1975, 144 pp. PB 262 026; $6.75.

#013 Mileti, Dennis S. *Natural Hazard Warning Systems in the United States: A Research Assessment.* 1975, 99 pp. PB 261 547; $6.50.

#014 Sorensen, John H. with J. Kenneth Mitchell. *Coastal Erosion Hazard in the United States: A Research Assessment.* PB 242 974; $4.75.

#015 Huszar, Paul C. *Frost and Freezing Hazard in the United States: A Research Assessment.* PB 242 978; $4.25.

#016 Sorensen, John H., Neil J. Ericksen and Dennis S. Mileti. *Landslide Hazard in the United States: A Research Assessment.* PB 242 979; $4.75.

#017 Assessment of Research on Natural Hazards staff. *Snow Avalanche Hazard in the United States: A Research Assessment.* PB 242 980; $5.25.

#018 Cochrane, Harold C. and Brian A. Knowles. *Urban Snow Hazard in the United States: A Research Assessment.* PB 242 977; $4.75.

#019 Brinkmann, Waltraud A.R. *Local Windstorm Hazard in the United States: A Research Assessment.* PB 242 975; $5.00

#020 Ayre, Robert S. *Technological Adjustments to Natural Hazards.* PB 252 691; $4.50.