DISASTER PREVENTION FOR SUSTAINABLE DEVELOPMENT

ECONOMIC AND POLICY ISSUES

Edited by
Mohan Munasinghe
and
Caroline Clarke

The International Decade for
Natural Disaster Reduction
(IDNDR)
and
The World Bank

Disaster Prevention for Sustainable Development: Economic and Policy Issues

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A Report from the Yokohama World Conference
on Natural Disaster Reduction
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UN General Assembly Resolution 236 of 1989 launched the International Decade for Natural Disaster Reduction (IDNDR, 1990–2000) to "reduce through concerted international action, especially in developing countries, the loss of life, property damage, and social and economic disruption caused by natural disasters." IDNDR focuses on natural disasters such as earthquakes, tsunamis, volcanic eruptions, landslides, avalanches, cyclones, floods, drought, and locust infestations.

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Foreword

The World Conference on Natural Disaster Reduction, which took place at Yokohama, Japan, from 23 to 27 May 1994, provided a unique opportunity to review the economic effects of disasters. Caroline Clarke of the U.S. National Academy of Sciences and Mohan Munasinghe of the World Bank organized and coordinated the technical session on this subject. We are grateful for the generous contribution by the Bank and the Academy to the success of the conference.

Reason tells us that it is cost effective to protect our investments in development through disaster reduction and that prevention is better than cure. Evidence from case studies points to increasingly adverse socioeconomic effects of disasters. Particularly in developing countries, socioeconomic losses may seriously affect and set back development for years to come.

Disaster reduction involves a combination of measures ranging from hazard, risk, and vulnerability analysis to policies, regulations, management plans, standards, insurance, and furtherance of education, training, and public information. Disaster reduction should be based on sound analysis of the costs and benefits of past experiences. Some of this basis exists, but more work is still required to bring cost-benefit analysis to government policymakers and key industry executives in a form they can translate into policy decisions and action.

As a step in this direction, after the Yokohama World Conference the World Bank and the IDNDR Secretariat initiated a review of case studies on the economics of disasters. A major objective of this exercise is to demonstrate the value of practical disaster reduction—that is, it does pay to prepare for and prevent disasters. A second example of the post-Yokohama cooperation is the session on "economics of disasters" at the Sixth Regular Session of the Scientific and Technical Committee for IDNDR, February 27 to March 3, 1995, which brought the World Bank and the U.S. National Academy of Sciences together again with IDNDR, to plan for the future of disaster reduction.

Finally, this joint publication of the World Bank and IDNDR is a concise review of the economic and policy issues relating to disaster prevention for sustainable development. Drs. Clarke and Munasinghe have provided an excellent basis for further studies by editing the report, which contains articles written by some of the most prominent researchers and policymakers looking at the economic aspects of disasters. We extend our gratitude to all of them.

Olavi Elo
Director
International Decade for
Natural Disaster Reduction

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1

Economic Aspects of Disasters and Sustainable Development: An Introduction

Caroline L. Clarke and Mohan Munasinghe

Natural disasters threaten sustainable economic development worldwide, representing a considerable challenge for the global community. In the past twenty years, earthquakes, volcanic eruptions, landslides, floods, tropical storms, drought, locust invasions, and other natural calamities have killed 3 million people, inflicted injury, disease, homelessness, and misery on 1 billion others, and caused billions of dollars of material damage—more than $100 billion in 1991 and 1992 alone.[1] Natural disasters destroy decades of human effort and investments, thereby placing new demands on society for reconstruction and rehabilitation. This halts and, in some cases, reverses economic progress. Large-scale natural disasters can have profound, negative impacts on long-term development, causing distress and increasing dependency.

The developing countries, where two-thirds of the world's population live, suffer the most debilitating consequences due to natural disasters: 90 percent of the natural disasters and 95 percent of the total disaster-related deaths worldwide occur in the developing countries. The per capita losses in the gross national product (GNP) are estimated to be twenty times greater than in industrial countries. Since the 1960s, economic losses have increased at least fivefold. Losses in the industrial countries are also on the rise. In the United States, for example, insurance payouts from natural disasters during 1990–94 are already more than quadruple those accumulated for all of the 1980s, which themselves were quadruple those of the previous decade. These losses are growing largely due to the increasing concentra-

tion of population and investments in vulnerable locations and to inadequate investment in measures to reduce risk (UNCRD 1994).

On May 26, 1994, as a part of the World Conference on Natural Disaster Reduction, held in Yokohama, Japan, the World Bank and the U.S. National Academy of Sciences sponsored a technical session on the economic aspects of disaster prevention for sustainable development (see appendix 2 for the session program). Its purpose was twofold: (1) to explore the relationship between disasters and sustainable development, focusing on the economic aspects, and (2) to begin a dialogue between economic experts and decisionmakers from around the world on the economic tools for reducing vulnerability and managing potential losses in the context of development.

The contributions in this volume seek to provide a better understanding of the economic impacts of disasters in order to promote development that is resilient to the effects of natural disasters and to guide judgments about ex ante expenditures for prevention and mitigation. The chapters introduce the economic aspects of vulnerability and disaster impact on levels ranging from the household to the nation; they also examine two principal ways in which societies cope with potential economic losses and threats to sustainable development before an event occurs: by incorporating disaster risk into decisions on development investment and by sharing disaster risks and costs through insurance arrangements (both formal and informal).

Disasters and sustainable development

Disasters continue to strike with greater frequency, magnitude, and complexity. In most cases, the natural phenomena triggering the disasters are beyond human control. However, vulnerability to such disasters is a result of our own actions. Earthquakes, for example, are naturally occurring extreme events, but the amount of damage they cause is largely a function of decisions made in the course of development. The uncontrolled growth of cities and the expansion of slums into marginal areas; poor design, building techniques, and supervision of construction; and lack of enforcement of land-use regulations are some of the development decisions that result in significant losses when an earthquake strikes a city. Thus, vulnerability concerns the predisposition of a society to experience substantial damage as a result of natural hazards. Large-scale urbanization, natural resources degradation, poverty, population pressure, and certain patterns of consumption, production, and development are some of the human actions that increase the vulnerability.

Environmental vulnerability and poverty are mutually reinforcing: 80 percent of the poor in Latin America, 60 percent of the poor in Asia, and 50 percent of the poor in Africa live on marginal lands that are characterized by poor productivity and high vulnerability to environmental degradation and natural disasters. Developing countries, which necessarily place high priority on food production and industrial activity, have fewer resources left to reduce disaster risk. Rising economic losses in the industrial countries also suggest that, even there, mitigation efforts are not keeping pace with the factors that are increasing vulnerability.

Many developing countries are also experiencing rapid population growth, accompanied by increasing concentration of their population and investments in vulnerable locations. These trends increase pressures on natural resources and

the environment and raise the consequent risks associated with human activity. In rural areas, rangelands are heavily overgrazed and forestlands are severely degraded by overexploitation and neglect. Acute shortages of firewood have accelerated deforestation, which, together with destruction of the vegetative cover on natural pastures, has increased the threat of floods and the deterioration and desertification of previously fertile land.

The accelerating pace of urbanization and the growing scale of urban-industrial activity is exacerbating environmental stresses in developing-country cities and increasing the vulnerability of urban dwellers to both natural and technological disasters (Kreimer and Munasinghe 1991). The demand for more urban space has pushed the poor onto marginal, environmentally vulnerable terrain. More than half of the world's population now lives within 60 kilometers of the ocean. At the same time, greater demands are being placed on forest resources. The resulting deforestation increases the vulnerability of urban areas to droughts, fires, floods, runoff, landslides, sedimentation of dams and reservoirs, pollutants, and diseases. In many developing countries, overcrowding, congestion, poverty, unemployment, and inadequate infrastructure and services further weaken urban resistance to natural hazards.

Accelerated changes in demographic and economic trends have disturbed the balance between ecosystems. There is some evidence of causal links between environmental degradation and vulnerability to disaster. The same kind of tampering with the natural environment that concerns ecologists, such as deforestation, can also exacerbate the impact of natural disasters on the environment. It is hard to ignore the apparent correlation between the frequency and severity of natural disasters and growing local and global environmental degradation, especially in the second half of the twentieth century. Environmental degradation intensifies disasters, thereby increasing the potential for secondary disasters: high windstorms are followed by floods and landslides, floods by drought, and drought by pest epidemics and famines. The damage to the environment caused by extreme weather events has escalated, increasing faster than population growth. It is also clear that developing countries are far more vulnerable than industrial countries to both catastrophic events and deterioration of the environment.

As greater vulnerability is linked with poverty, it stands to reason that development helps to diminish the effect of natural disasters. The difference in losses between developing and industrial countries supports this view. Nevertheless, although evidence indicates that development helps to diminish the effects of natural disasters (at least in the aggregate), some of the tenets of development—such as greater use of resources, urbanization, and the use of environmentally harmful technologies—have increased vulnerability. To counter this, sustainable development paths are needed that place emphasis on productive use of natural and other resources to meet the needs of the present while ensuring adequate or enhanced resources to meet the needs of future generations (WCED 1987). Disaster prevention and mitigation are, in this sense, important elements of environmental management and planning for sustainable development.

Policymakers around the world are recognizing that the ability to achieve sustainable development can be increased by reducing the impact of natural disasters. Yet we are lagging in integrating disaster reduction measures into development ac-

tivities. This volume explores some of the ways of improving the cost-effectiveness of investments in mitigation and of making the reduction of vulnerability a routine, explicit objective for development.

Overview of the volume

The contributions in this volume are organized, as was the technical session in Yokohama, to provide an overview of the implications for sustainable development of losses from natural disasters (highlighting the economic aspects), to discuss methods for development investment decisions to take disasters into account, and to highlight issues related to sharing the disaster risks and costs through insurance arrangements.

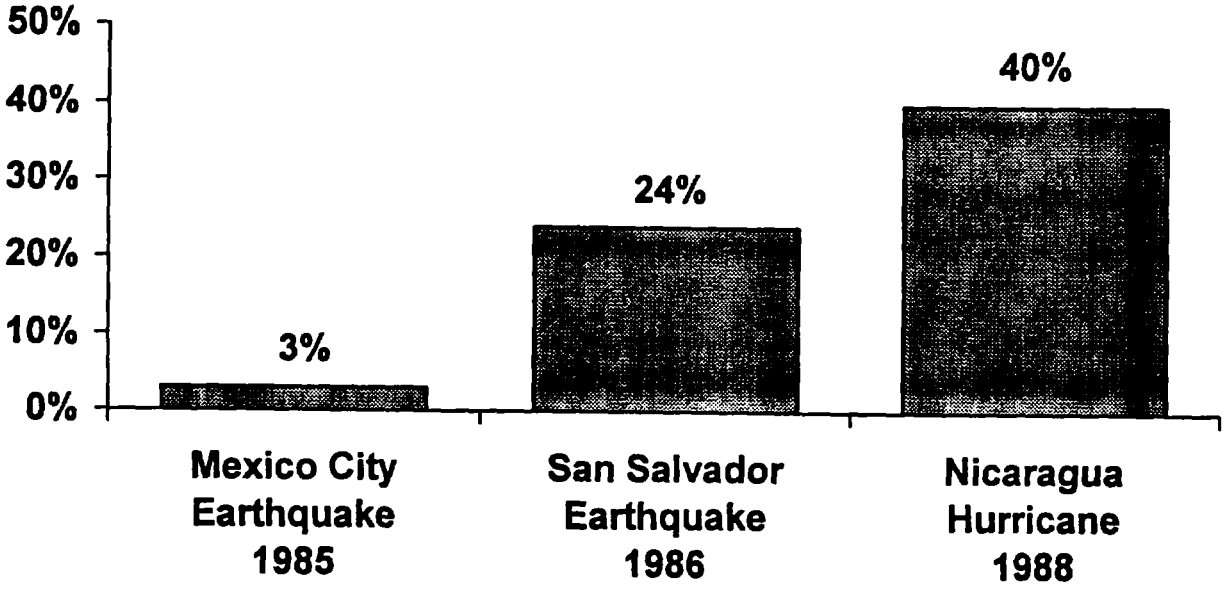
The consequences of natural disasters and the efforts needed to recover from them are country specific and depend on many factors, such as the proportion of the economy affected and the prevailing economic and social conditions, in addition to the nature and severity of the disaster itself. Using the experience of the Latin American and Caribbean countries, Romulo Caballeros Otero and Ricardo Zapata Martí in chapter 2 outline the impacts of disasters on national economies, such as the disruption of production; increase in foreign debt; the loss of employment, income, and tax revenue; damage to the natural resource base and environment; and the slowing of economic growth and development that results (see figure 1-1).

Caballeros Otero and Zapata Martí note that although immediate and short-term impacts of natural disasters may be relatively easy to evaluate in economic dimension, long-term consequences—social impacts in particular—are difficult to assess. They observe that the larger the disaster and the smaller the economy, the more severe are the long-term impacts, and vice versa. Finally, for the international community to provide assistance, an authentic assessment of the situation is vital, including determination of the most affected sectors and areas; identification of post-emergency projects that require financial and technical assistance; and strengthening of the country's ability to meet the needs following a disaster.

Poorer countries face special challenges when adopting disaster mitigation in the process of sustainable development. Atiq Rahman in box 2–1 of chapter 2 notes that developing countries have a high percentage of poor who are the most vulnerable to natural disasters, weak institutional capacity for confronting disasters, and inadequate market mechanisms that may help to buffer against disasters and spread risks. He notes that reinforcing indigenous coping strategies and self-reliance at the community and national levels is important to improving resiliency to natural disasters.

The international community—the development banks, in particular—should support disaster prevention and mitigation as a means to improve sustainable development. For investment decisions to take disasters into account, risk has to be considered in economic analyses. In chapter 3, Mary Anderson reviews the ways in which our understanding of vulnerability has developed over time. She discusses the trends associated with development that have increased vulnerability and prompted the current focus on sustainable development. Human actions have undermined and continue to undermine the environment, and current government-sponsored development efforts in many countries reinforce the tendencies toward future environmental depletion in an attempt to meet citizens' basic needs such as food, jobs, and housing.

Figure 1-1: Costs of Disasters as a Percentage of Yearly GDP in Mexico, San Salvador, and Nicaragua, Various Years, 1980s



Source: Gavidia 1990.

Vulnerability is complex, dynamic, self-compounding, and cumulative. It is sometimes irreversible and is frequently borderless and uncontainable. Anderson presents a useful framework for assessing vulnerability that can be used by communities and educators to improve the public's understanding of disaster proneness and prevention and by governmental and international bodies to assess risk and to decide which courses of action to take to reduce disaster vulnerability.

By incorporating information about natural disasters and possible mitigation strategies into the planning process, the prospects can be enhanced for a satisfactory outcome from public investments in development projects. According to Randall Kramer, donor agencies and development banks seldom include disaster potential in economic analyses that support project design and lending decisions. In chapter 4, he outlines the benefits and limitations of benefit-cost analysis for evaluating investments in mitigation within the project planning cycle. He notes that analysts are constrained by lack of systematic information on the impact of natural disasters and outlines approaches under two scenarios. The limited-information scenario adopts approaches that are not data intensive and may be particularly relevant at the prefeasibility stage of project analysis. The adequate-information scenario that links probability distributions of natural disasters to economic variables may be suitable for more sophisticated feasibility studies of projects.

Kramer discusses several methods for incorporating disaster risk information into benefit-cost analysis, including those used when information is limited. These methods can identify the impacts of disasters on project feasibility. The use of risk-modified, benefit-cost methods can alter investment decisions and suggest means to modify project design.

The Asian Development Bank (ADB) has estimated that the disaster mitigation component of recent recovery projects do generate an economic rate of return that is high enough to warrant investment. In chapter 5, Günter Hecker observes that benefits of disaster management projects are not properly assessed. This is due to the paucity of data, both ex ante and ex post. Moreover, the absence of predisaster and up-to-date social and economic benchmark indicators impedes attempts to assess the benefits of the project. He observes that project analyses have tended to focus on easily measurable costs and benefits, whereas to assess all economic benefits, it would be necessary to take into account social and environmental concerns as well as those readily measurable in monetary terms.

Hecker highlights the ADB's increasing role in disaster-related projects, emphasizing mitigation, the fostering of self-reliance, and strengthening of institutions. He notes that disasters require very rapid responses to reduce the delays. Implementing disaster recovery projects in two phases—a repair phase and a rehabilitation phase—may allow afflicted communities to recover faster.

The other principal way that societies cope with potential economic losses and threats to sustainable development is by sharing the risks and costs of disasters through insurance arrangements. In market economies, formal insurance mechanisms are well developed for dealing with a variety of hazards. However, some insurance elements for natural disasters ought to be developed to reduce risk further. Howard Kunreuther in chapter 6 explains how improved insurance mechanisms can provide better incentives for disaster reduction. For example, insurance may be tied to seals of approval for better construction, or differential rates can be applied to reflect different levels of risk in such a way as to encourage homeowners to adopt mitigation measures.

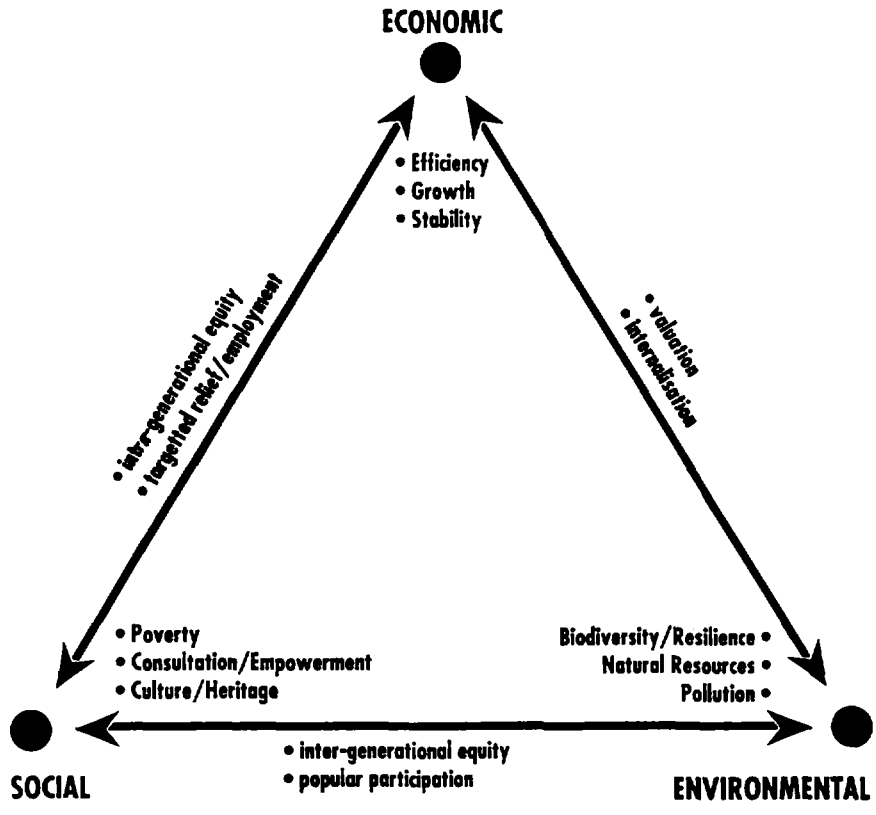
Some conclusions

The general consensus emerging from the papers and discussions in Yokohama is that disaster prevention and mitigation are essential components of the three main elements of sustainable development: economic, social, and environmental (see figure 1-2).[2]

The economic approach to sustainability is based on preserving the stock of capital (or assets) that yields the maximum amount that a person or community can consume over some time period and still be as well off at the end of the period as at the beginning. Such assets include natural resources and the capacity of the environment to absorb shocks, both technologically induced and natural. Natural and man-made capital may be more complements than substitutes, and natural capital, or the loss of ecological resilience, often plays a crucial role in limiting development. Of course, the degree of loss of productivity that occurs as a result of natural disasters is determined also by the capacity of human societies to adapt and continue functioning in the face of stress and shocks.

Because urbanization, poverty, and environmental deterioration are closely interrelated, the economic approach requires cost-effective methods of preventing and mitigating en-

Figure 1–2: Approaches to Sustainable Development



Source: Munasinghe 1993.

vironmental catastrophes. Improving regulatory measures, market-based control mechanisms (such as pricing and taxation), and urban management are critical. In addition to providing more comprehensive environmental protection and basic services, this would alleviate constraints on productivity and economic growth.

In order to determine the level and types of such policies, some awareness of the costs of impacts and the internalization of environmental externalities into benefit-cost analysis are essential. When informa-

Box 1–1: The Role of Benefit-Cost Analysis

Stephen Bender, while moderating the sessions in Yokohama, stated:

"The decisions affecting the creation and continuance of vulnerability are certainly complex but may often be outside of formal project financial transactions and certainly beyond rigorous benefit-cost analysis. Yet it seems fair to assume that all vulnerable populations make, one way or another, some kind of benefit-cost analysis of their situation."

tion is scarce, benefit-cost analysis should be used in conjunction with multi-criteria analysis (which integrates economic, social, and environmental aspects in a balanced way) to reduce those types of impacts that should be addressed and to identify which measures are the most cost-effective.

Box 1–2: The Increasing Importance of Disaster Insurance

At the Yokohama sessions, Gianfranco de Giusti outlined some recent and innovative proposals aimed at improving the Italian insurance market's capacity to manage disaster risk. Another speaker, Wang Fushan, noted that in China, insurance spending will play a growing role in disaster relief. Approximately 600,000 institutions and 13 million families are participating in insurance schemes. This coverage only represents around 10 percent of the population. Compensation from insurance has never exceeded 5 percent of economic losses in recent disasters. There is great potential for developing and expanding the insurance sector in China.

As the impacts of natural disasters fall disproportionately heavily on the poor, the social view of sustainable development stresses the participation of at-risk communities in devising and implementing effective strategies to reduce vulnerability. The communities must have a voice in identifying site-specific solutions and assessing the efficacy of proposed measures. The implementation of disaster planning is best performed jointly by local communities, the government, and industry. Better community awareness is essential. There is a need to identify and understand people's perception of risk, to develop better channels of communication and popular consultation, and to rely on local resources. In many cases, the profound changes brought by urbanization have undermined the traditional support system for coping with crisis. Decentralization of decisionmaking is important in the strengthening of organization for disaster preparedness prevention and mitigation, particularly given the need for rapid and localized responses in the face of swiftly occurring catastrophes.

Box 1–3: The Sociocultural Context

At the Yokohama sessions Omar Dario Cardona stated that:

"A reading on the topic of vulnerability and risk presented by geophysicists, hydrologists, engineers, and planners can be quite different from the reading or 'imagery' available to the exposed communities and people. For this reason, it is necessary to seek in-depth knowledge about individual and collective perception of development and risk and to investigate the cultural characteristics and organization of societies, as well as their behavior and relationship with the physical and natural environment, which favor or impede prevention and mitigation and which also favor or restrict preservation of the environment for the development of future generations."

The environmental view of sustainable development emphasizes preserving the resilience and dynamic ability of biological and physical systems to adapt to change. The failure to limit environmental degradation resulting from human intervention increases the vulnerability to risks posed by natural hazards. Manila, Rio de Janeiro, and Jakarta are examples of uncontrolled urban development, combined with deforestation and dumping of wastes into rivers and canals, which have

led to increased runoff and heavy flooding. Many of the same actions that preserve the ability of systems to adapt to change also increase resiliency to external shocks or extremes in the environment such as natural disasters. This interconnection between natural resource degradation and increased vulnerability to natural catastrophe emphasizes the need for preventive measures.

The dialogue that these papers generated among economic experts and decisionmakers gathered in Yokohama in May 1994 highlighted a few additional points of general agreement. Reducing vulnerability, especially of the poor, is a key element of disaster prevention strategy. International assistance dedicated to preventing and mitigating disasters, which has never been great, should be increased. Disaster reduction strategies should also be integrated into the full range of sustainable development projects and policies, especially macroeconomic policies.[3] Many insurance techniques should be adapted more systematically in the developing world. However, because of the large number of poor and the absence of well-functioning markets, nonformal insurance mechanisms should also be strengthened, drawing upon knowledge based on ways in which societies traditionally have coped with risk. Finally, to address the need for capacity building, training, and resource mobilization for disaster prevention and mitigation in the context of sustainable development, regional centers should be developed and strengthened, and their ties improved.

Notes

1. A billion is 1,000 million.
2. For further details of the three key aspects of sustainable development (social, environmental, and economic), see Munasinghe (1993).
3. For further details of the links between macroeconomic policies and the environment, see Munasinghe and Cruz (1994).

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2

The Impacts of Natural Disasters on Developing Economies: Implications for the International Development and Disaster Community

Romulo Caballeros Otero and Ricardo Zapata Martí

Natural disasters have numerous impacts on national economies that can bear on the conduct of economic policy, on the sustainability of long-term development strategies, and on productive performance. These impacts are particularly relevant in the countries of Latin America and the Caribbean, which frequently experience natural disasters of various origin and intensity, with the sequel of human lives lost and grave economic and social impact.

During the past three decades, the frequency and severity of disasters and adverse natural cycles have been compounded by the emergence of new, quasi-natural and unpredictable events. A nation's or a society's capacity to respond to and face these unscheduled happenings and the nature of the actions necessary to do so are in an important measure affected by the ability to measure, appraise, and evaluate the damages caused.

The complex matrix of such events comprises both natural disasters, such as earthquakes, tsunamis, hurricanes, floods, volcanic eruptions, and plagues, and relatively new phenomena that can be man-made or induced by human conduct, such as ecological disasters, desertification, mega-accidents, urban disasters, or civil wars. Their impact can be seen in the loss, first, of human capital and, second, of productive capital. In the vast majority of cases, emergency actions tend to alter the conduct of current policies, and the reconstruction efforts tend to induce serious changes in economic policies in the medium term. In some cases, effects impinge on national priorities and lead to modifications of development policy that are felt in the longer term and cause irre-

versible adverse effects. Furthermore, depending on its economic position prior to the disaster, a country may find itself unable to undertake the required program and projects for rehabilitation and reconstruction and may require international cooperation—both technical and financial—to implement them.

Some intrinsic elements of the nation, society, or economy affected have, in general, implications for the efforts needed to face the emergency, undertake the reconstruction, and, finally, surmount the consequences of the disaster. Relative size of the economy affected, the magnitude and depth of the event, and the economic and sociopolitical conditions of the country at the time are some of these elements. Given the persistence and growing diversity of these phenomena and the magnitude of their socioeconomic consequences, it is natural for the international community to give more attention and support to the development of means to prevent or, at least, mitigate their more severe negative effects.

The international community—via multilateral lending and technical cooperation organizations as well as bilateral assistance programs of donor countries—is willing to support these undertakings and requires detailed and reliable information concerning the magnitude of the damages. Potential donors expect a precise determination of the most affected sectors and areas, identification of the post-emergency projects and plans that require financial and technical cooperation, and determination of the country's capacity to handle its share of the burden in the rehabilitation and reconstruction efforts. Most recently, at the twenty-fifth session of the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) member countries approved a resolution requesting systematic research and analysis of the economic effects of disasters in countries in the region as well as of possible undertakings to prevent and mitigate disasters and reduce their effects (Cartagena de Indias, Colombia, April 20–27, 1994; the text of this resolution is presented in appendix 2-1).

This chapter provides some elements that may help to prevent, mitigate, and reduce the effects of disasters by synthesizing experiences accumulated in the last twenty years through observing and appraising natural disasters in Latin America. It does not make exhaustive reference to the events themselves but rather highlights the immediate, medium, and long-term effects and actions to be undertaken. Since 1972, ECLAC has been assisting member states to assess damages caused by natural disasters. A damage assessment methodology has been developed and tested to estimate the extent of the damages, their economic impacts, and the requirements for rehabilitation and reconstruction, based on the country's capacity to execute programs after a disaster occurs (see ECLAC 1991). The ECLAC methodology facilitates the systematic definition of the requirements for international cooperation in a period of time that does not exceed one to two months; it requires information that can be collected in the days immediately after the disaster strikes and that can be compared to macroeconomic data and forecasts available before the disaster. The methodology is applied to estimate the economic impact of the events rather than to appraise effects of a different nature, such as social short- or long-term impact or ecological and environmental damages.

The first part of the chapter offers general remarks on the typology and salient characteristics of an event, successive phases that take place after it, as well as some methodological insights into dam-

age appraisal. Some conceptual remarks are made on the links between the nature of the country affected, the dimension of the event, and its socioeconomic consequences. From these are derived concepts that will be used in the rest of the chapter as well as some working hypothesis.

The following section presents an analytical description of the components of the methodology for appraising different types of disasters as well as for measuring their effects in the national economy and society. An effort is made to summarize in systematic form the experience of such tasks and to present the implications that disasters may have for a country's institutions, depending on the political or economic situation when the disaster occurred.

This is followed by a synthesis of the different types of consequences that disasters have in the long term, both for development and for economic performance, such as the balance of payments, production, income growth, public finance, and so forth. Special attention is paid to damage control and reconstruction and how they affect they country's national priorities and capability to return to its development path. In this last context, the role of the international donor community and the need for external resources are specifically addressed.

Finally, the last section discusses international efforts needed to prevent disasters. Preventing disasters and reducing their impact must be part of a systematic approach that goes beyond emergency assistance or reconstruction and links development potential and sustainability to these actions.

General considerations

The cycle following a disaster is usually divided into three phases: emergency, rehabilitation and immediate recovery or transition, and reconstruction. The emergency phase refers to the most immediate period after the disaster strikes, when actions to save human lives or to provide first aid are undertaken. It may include actions such as search and rescue, emergency first aid, temporary shelter, provisional restoration of transportation and communication links, emergency repairs to essential utilities and services, and the first efforts to assess the number of persons affected and to estimate damages suffered by public and private property. The rehabilitation or transition phase covers a time frame in which efforts are made to restore the most pressing services and most essential social infrastructure. It includes building temporary shelters as well as repairing transport infrastructure and public utilities and services. The return to normal work, the creation of new jobs, the offering of credit and financial resources, and the initiation of projects to address the immediate consequences of the disaster are among the rehabilitation measures needed to assist the population and communities affected. The reconstruction phase refers to the period required to restore the physical infrastructure and services damaged or destroyed by the disaster.

Types and main characteristics of disasters

Different types of disasters may occur. A broad definition includes dramatic, sudden, unscheduled events that are often accompanied by large losses of human life, suffering and affliction to a society or a significant part of it, and a temporary breakdown of prevailing lifelines and systems. Such events cause considerable material damages and interrupt the normal functioning of an economy and of society in general (other types of natural events, such as droughts, take a long time

to develop into a major disaster and may cause devastating effects in society as well). Disasters so defined can be classified as either natural or man-made.

The most important natural phenomena, according to the frequency of their occurrence worldwide in the last twenty years, are the following: floods, typhoons, hurricanes and cyclones, earthquakes, tornados, whirlwinds and thunderstorms, snowstorms and blizzards, heat waves, cold spells, volcanic eruptions, landslides and landslips, avalanches, tidal waves and tsunamis, and blasting mildew, frost, droughts, sand, or dust storms. The most common man-made disasters are caused by explosions, firestorms, airplane crashes and collisions, movements of the earth or water, and the collapse of dams, embankments, and water reservoirs. A growing list of quasi-natural disasters can be added to these, including processes such as air, water, or land pollution and the reduction and destruction of forests. Also to be considered are social disasters, such as epidemics, famine, riots and pogroms, massacres, terrorist acts, and wars.

Most of the remarks made in this chapter relate to the major natural disasters that have caused the most damage in Latin America and the Caribbean; they have either a meteorological or a geological origin. Tables 2-1 and 2-2 summarize the economic and social effects most commonly associated with natural disasters, grouped by major categories. An especially interesting and devastating natural phenomenon in Latin America is the modification of sea currents and wind patterns that has caused major floods and affected the climate, water quality, and fishing patterns near the Pacific shores of South America. The Latin American and Caribbean region is particularly prone to natural phenomena, especially in the Caribbean, which lies in the path of major tropical storms and hurricanes. The region is also part of the so-called Fire Ring that encompasses the Pacific Ocean and delineates the contact zones of the major tectonic plates where many earthquakes and volcanic eruptions occur (a partial list of the major disasters that have affected Latin America and the Caribbean in the last

Table 2-1: Immediate Economic and Social Effects of Natural Disasters

Type of effect	*Earthquake*	*Cyclone*	*Flood*	*Tsunami*	*Volcanic eruption*	*Fire*	*Drought & famine*
Temporary migration							x
Permanent migration							x
Loss of housing	x	x	x	x	x	x	
Loss of industrial production	x	x	x	x		x	
Loss of commerce	x	x	x	x		x	
Loss of agricultural production (plant crops and harvest)		x	x	x	x	x	x
Damage to infrastructure	x	x	x	x		x	
Disordered markets & distribution	x	x			x		
Interrupted transportation systems	x		x				
Breakdown of communication	x	x	x	x		x	
Panic						x	
Social disruption	x	x				x	

Source: Adapted from Cuny 1983.

Table 2–2: Effects of Natural Disasters on the Earth's Surface, Infrastructure, and Agriculture

Type of disaster	*Effects on the earth's surface*	*Effects on infrastructure*	*Effects on agriculture*
Earthquake	Tremors and fissures	Damage to construction, roads, ditches, and bridges	None
	Landslips	Covered and buried structures; embankments on rivers that cause local flooding	Some local losses to affected area
	Liquefaction of the earth	Damage to buildings that sink	None
	Collapses underground	Damage to underground construction, conduits, and cables; change in the course of underground water	Temporary loss of irrigation
	Avalanches	Damage to buildings, roads,	Local losses of plants and forests ditches, and bridges
Hurricane, typhoon, and	Strong, gusty winds	Damage to buildings and distribution and high-tension lines	Loss of trees; damage to plants, especially grains
cyclone	Flooding (through rainfall)	Damage to bridges and buildings; landslides and landslips	Loss of plants, especially roots and tubers; erosion
	Flooding (through storms)	Damage to bridges, roads, and buildings	Extension damage to plants and irrigation systems; saline deposits: contamination and erosion of earth
Drought	Dryness of earth	No major damage	Destruction of crops and forests
	Wind gusts	Minor damage	Erosion and minor damage to forests
	Desertification	No major damages	Land covered with sand; type and time of crops altered; trees ruined; dry-resistent thorny, bushy vegetation increased
Flood	Erosion	Softening of building's foundations	Destruction of crops; alteration of the type and time of harvest
	Water-saturation and landslides	Buried buildings; damage to other structures	Localized damage to fields of crops and forests
	Sedimentation	No major effects	Improvement in the quality of terrain
Tsunami	Floods	Destruction of or damage to buildings, bridges, irrigation systems; pollution of waters	Localized destruction of crops; saline deposits and destruction of coastal forest and vegetation and water wells
Volcanic eruption	Eruption and deposit of debris on surface	Destroyed, damaged, or buried buildings and other structures; fires	Extensive defoliation, forest damage, and losses near eruption site
		Damage to buildings, ditches, and bridges	Buried crops and destroyed earth and forests; forest fires; temporary damage to earth; pollution

Note: Effects on other productive sectors such as industry and services are mostly reflected in damage to infrastructure.
Source: Adapted from Cuny 1983.

Table 2-3: Major Disasters in Latin America and the Caribbean Since 1972

Date	*Place*	*Event*
1972	Managua, Nicaragua	Earthquake
1974	Honduras	Hurricane (Fifi)
1975	Grenada	Tropical storm
1975	Antigua and Barbuda	Earthquake
1976	Guatemala	Earthquake
1979	Dominica	Hurricane (David)
1979	Dominican Republic	Hurricanes (David and Frederick)
1979	Nicaragua	Civil war consequences
1982	Nicaragua	Floods
1982	El Salvador	Several natural disasters
1982	Guatemala	Meteorological phenomena
1982	Nicaragua	Meteorological phenomena
1983	Bolivia, Ecuador, and Peru	Meteorological phenomena (change of path of sea currents)
1985	Mexico	Earthquake in Mexico City
1985	Colombia	Volcanic eruption of Nevado del Ruiz and mudslide in the city of Armero
1986	El Salvador	Earthquake in San Salvador
1987	Ecuador	Natural disaster (earthquake and landslides)
1988	Nicaragua	Hurricane (Joan)
1989	Mexico	Gas explosion (San Juanico)
1990	Mexico	Hurricane (Gilbert)
1992	Mexico	Gas explosion (Guadalajara)
1992	Nicaragua	Volcanic activity (Cerro Negro)
1992	Nicaragua	Tsunami (Pacific coast)
1992	El Salvador	Civil war
1993	Florida	Hurricane (Andrew)
1994	Los Angeles	Earthquake

Note: Specific disasters are referred to in the text. For additional information, see the specific studies on each case, which are included in the references.

thirty years is given in table 2-3; the references provide a list of the documents prepared by ECLAC since 1972 to appraise the economic effects of natural disasters.

Damage assessment methodology

To facilitate understanding of the methodology, it is necessary to define terms that relate to direct and indirect damages and to secondary effects. Direct damage refers to all damage to fixed assets, capital, and inventories of finished and semifinished goods, raw materials, and spare parts. It includes total or partial destruction of physical infrastructure, buildings, machinery, and equipment, transport and storage facilities, and furniture as well as damage to farmland and soils, irrigation and drainage works, dams, and so forth. In the particular case of agriculture, the destruction of crops ready to harvest is considered direct damage. Essentially, direct damage refers to physical destruction, whether complete or partial, that occurs simultaneously with or immediately after the disaster.

Indirect damage refers to damage to the flow of goods that will not be produced

and of services that will not be provided after the disaster strikes. The period of time covered begins immediately after the disaster and may last several months or years, depending on the type and characteristics of the disaster. Indirect damages are measured in monetary—not physical—terms and may include, among others, the following:

- Increased operational expenditures in a given sector due to the destruction of physical infrastructure or inventories and increased costs for the provision of services.
- Additional costs incurred in a given sector or activity due to the need to use alternative means of production or increased costs of providing services, such as the cost of providing transportation when alternate routes are longer than normal routes.
- Loss of corporate income as a result of the inability to provide services, such as utilities, and loss of personal income as a result of total or partial loss of an individual's means of livelihood.
- Unexpected expenditures related to meeting new needs arising from the disaster, such as the costs of vaccination campaigns to avoid epidemics.
- Loss of production or income in activities located either downstream or upstream of activities directly affected by the disaster, such as when, after an industry is destroyed, suppliers cut back their activities because they have no alternative markets or customers reduce their purchases because they have no other supplier.
- Investments incurred because fixed assets or activities must be moved to safer areas after a disaster.

The sum of direct and indirect damages represents the total—material and monetary—damage inflicted by a disaster. Care must be exercised when assessing both types of damage: the amount of indirect damages often exceeds that of direct damages and may cripple a weak economy and render it unable to meet the rehabilitation and reconstruction required.

Secondary effects refer to the impact of the disaster on the overall economic performance of a country as measured by the most significant macroeconomic variables. The estimated changes in these variables due to the disaster complement the estimated direct and indirect damages, although they cannot be mathematically added to express the total amount of damage inflicted.

A disaster's main secondary effects have an impact on the following:

- Overall and sectoral gross domestic product (GDP);
- Balance of trade and the balance of payments;
- Level of indebtedness and of monetary reserves;
- State of public finances; and
- Amount of gross capital investment.

Depending on the nature of the disaster, the secondary effects of inflation on employment and household income may also be relevant.

Gross domestic product can decline when the output of sectors that have sustained direct and indirect damages declines; it can grow, however, when the construction sector surges as a result of rehabilitation and reconstruction activities. The balance of trade and the balance of payments can be affected when exports shrink because output diminishes and imports grow to satisfy unmet internal demands and the requirements of rehabilitation and reconstruction. Public sector spending grows to meet the needs of

the emergency and rehabilitation phases, and tax revenues shrink because output and exports diminish, which may combine to create or increase fiscal budget deficits. Reconstruction efforts may involve acquiring or increasing foreign or local indebtedness. Simultaneously, prices may go up because of shortages or speculation, thus creating or worsening inflationary pressures on the economy. Moreover, depending on the economic position of the country prior to the disaster and the size of the secondary effects, the country's international reserves and ability to meet external commitments may be jeopardized.

In order to assess the secondary effects of a natural disaster, it is assumed that all direct and indirect sectoral damages have been evaluated beforehand, taking stock of the information needed to assess sectoral damages when appropriate. ECLAC's damage assessment manual provides details on the sectoral assessment methodology. Nevertheless, it is important to note here that, to be able to assess secondary effects, sectoral evaluations of damages must include estimates of foreseeable losses in output (of goods and services) during the period required to rehabilitate farmlands, industrial production, and physical and social infrastructure. They must also include estimates of indirect effects on household employment and income, exports and imports, gross investment, taxation, and so forth for each sector affected. In addition, an estimation must be made of the period of recovery for each sector or activity during which the indirect effects are present.

Estimation of Macroeconomic Effects

The estimation of the effects of natural disasters on the economic position of a country is based on a comparison of the economic performance anticipated before the disaster struck and a modified projected performance estimated after the damage assessment has been completed. In that respect, the ECLAC damage assessment methodology requires, as an essential base for comparison, the macroeconomic performance prospects for the year during which the disaster strikes. The methodology involves estimating how much such projections will be altered as a result of the direct and indirect damages sustained during and after the disaster. The basic macroeconomic information required for this work includes the following:

- Projections of overall and sectoral economic growth for the year during which the disaster takes place and, ideally, for the two subsequent years.
- Trends in the main balance of payments aggregates of exports and imports, levels of external financing, international reserves and foreign indebtedness, international prices and demand for the country's main export products, and debt servicing agreements.
- The approved fiscal budget, including estimates of fiscal deficit if any, for the year during which the disaster strikes and estimates of fiscal income and expenditures for the months preceding the disaster.
- Other sectoral and macroeconomic statistics such as crop growth index, trends in manufacturing sector output as well as monthly consumer and producer price index, urban and rural unemployment survey data, and so forth.

Effects on Economic Activity

The macroeconomic aggregate that best expresses variations in the overall level of economic activity is the GDP. Constant prices—preferably current prices at the

time of the assessment—should be used to illustrate the disaster's real effects on economic growth rates. However, expressing the main aggregates that make up domestic supply (gross output for each branch of economic activity) and demand (expenditures for public and private consumption and capital formation) in current values for the year or period in which the disaster occurs frequently poses a statistical problem. In many countries, this information is available only in constant prices for a given year, usually a census year.

To solve that methodological problem, an appropriate and reliable price index, such as the GDP deflator, the wholesale price index, or the cost-of-living index, must be adopted to convert these figures into current values for the year in which the disaster occurs. After completing such adjustments, projected economic data for the year(s) following the disaster should be expressed in constant prices of the year of the disaster to eliminate the effects of inflation and enable a valid determination of the disaster's effects on real growth rates.

The sectoral damage or losses to be used in the macroeconomic assessment include the following:

- Products and services that, owing to the destruction of infrastructure and machinery, will no longer be produced.
- Income that will no longer be received, estimated on the basis of salaries, wages, and profits that will not be forthcoming while production plants are being rehabilitated (for small businesses in which a wide variety of goods and services is produced, this method of estimation is more feasible and reliable than the previous one).
- In the special case of the housing rental sector—included in the national accounts—losses that are the result of multiplying the number of houses destroyed or damaged by the average monthly rent during the estimated rehabilitation and reconstruction period.

In each sector, indirect losses include both the volume (or units) of losses in future production of goods and services until the previous productive capacity and the price of these goods and services expressed in terms of producer prices or, in the case of services, consumer prices recover fully.

The gross amounts thus estimated are converted into value added before being incorporated into the projected GDP. To this effect, national account information relating gross values to value added for leading economic sectors and branches of activity are used. Usually, a recent input/output matrix relating these values is available.

As indicated previously, the anticipated expansion of the construction sector as a result of the rehabilitation and reconstruction plan and activities will have a positive bearing on GDP and must be estimated. In this respect, the annual growth of the sector is calculated on the basis of the known capacity of the sector and the expected amounts of investment for rehabilitation and reconstruction.

Data on sectoral-loss value added and expansion of the construction sector are superimposed on the anticipated sectoral estimates of GDP for the year in which the disaster occurs, and for subsequent years if the data are available and the type and magnitude of the disaster so warrant their inclusion.

GDP after the disaster is thus estimated. Global and sectoral economic setbacks due to the effects of the disaster can be identified easily by comparing the new

estimation of GDP and the projection made before the disaster for the same year. Trends in economic growth can be determined by comparing the newly estimated GDP and real GDP figures for previous years.

EFFECTS ON THE EXTERNAL SECTOR

The external sector of a country is affected by a natural disaster through the balance of payments current account and, in some cases, the external financial requirements of reconstruction. These effects are felt not only in the year during which the disaster occurs but also in a longer time frame that lasts until the country's productive capacity is fully restored.

The assessment process must obtain the most reliable and up-to-date information concerning the balance of payments situation for the whole economy and its projection for the year in which the disaster occurs and the following years if possible. This should be complemented with other basic data on external indebtedness, debt servicing levels, and international monetary reserves before the disaster.

The resulting current account of the balance of payments during the year of the disaster is estimated on the basis of both the envisaged account before the disaster and the following calculations based on the indirect damages for each sector affected:

- Reductions in the export of goods and services, whether due to the destruction of their means of production or their reorientation toward internal markets; losses in services occur when a country has been affected in its capacity to receive tourists, its shipping fleet, or its capacity to export engineering services.
- Increases in imports of goods required for the rehabilitation phase, including fuel and food to replace insufficient internal production as well as to supply the construction materials needed to reconstruct destroyed assets.
- Donations in kind and in cash received to attend the emergency phase.
- Insurance and reinsurance payments from abroad to cover damages and destruction of assets.
- Possible reductions in interest payments to foreign creditors that may be agreed upon as a result of the disaster; possible increases in payments related to new short-term loans requested to attend the emergency or to rehabilitate essential services immediately.

Projecting these factors allows us to determine the possible occurrence of or increase in a current account deficit in the balance of payments in the year of the disaster. Should the requirements for imports or the reduced level of exports remain for a longer time period, a chronic deficit may occur as a result of the disaster.

The resulting capital account of the balance of payments may be estimated by superimposing on the pre-disaster projection the information related to the medium- and long-term foreign financing requirements for the priority investment projects that are to be included in the reconstruction plans that will follow in the, say, five years following the disaster. It should also include the additional foreign financing required to compensate for the possibility that deterioration of the current account balance will be chronic. These additional foreign financing requirements will have to be made compatible with prior foreign debt commitments and with the country's level of international reserves. A change in the conditions governing foreign financing and debt servicing may have to be negotiated.

EFFECTS ON PUBLIC FINANCES

Using the pre-disaster fiscal budget as a base, the following secondary effects are superimposed to determine the disaster's effects on public finances:

- Reductions in tax revenue due to decreases in the production of goods and services, household income, and consumption expenditures.
- Increased current expenditures to attend the emergency phase of the disaster.
- Increased capital investments for the rehabilitation and reconstruction program.

The first two types of secondary effects are usually felt during the calendar or fiscal year of the disaster, while the increased capital investment is usually spread over a number of years.

The reductions in tax revenues are estimated as part of the sectoral evaluation of indirect damages, based on the projected production of goods and services. Further reductions in tax revenues should be estimated based on the expected reductions in household income and consumption expenditures. In some cases, governments may decide to reduce the level of taxes on exports in order to foster or expedite the recovery of production levels; these reduced tax revenues should also be entered into the equation. A similar case occurs when national or local governments cannot collect property taxes on destroyed housing and business buildings. Expenditures incurred by national governments to meet the unforeseen needs immediately following the disaster, including the provision of temporary shelter and the most immediate rehabilitation needs, should be determined during the assessment. The result is a revised current account of the fiscal budget that shows the effects of the disaster. From it, resulting fiscal deficits and the possible noncompliance with agreed upon fiscal restraint targets may be identified.

In regard to the capital investment expenditures for rehabilitation and reconstruction, a preliminary program is prepared during the damage assessment mission. The following items must be taken into consideration:

- Estimates of total investment required to rehabilitate and reconstruct infrastructure and to restore production.
- The known delivery capacity of the construction sector in the affected country or region.

An annual capital investment program for rehabilitation and reconstruction is thus prepared and then superimposed on the program envisaged before the disaster occurred. Should the new requirements constitute a sizable percentage of the capital investment envisaged under normal conditions, the country's overall investment program should be revised. Some already programmed development projects may have to be postponed or discarded, unless additional financing can be obtained. Furthermore, if the additional financing is to come from foreign sources, an additional analysis should be made concerning the balance of payments and the country's ability to maintain a higher level of debt servicing.

EFFECTS ON INFLATION

Contrary to other macroeconomic effects, the resulting impact on consumer prices cannot be quantitatively measured or estimated immediately after the disaster. A qualitative assessment can be made, however, based on the disaster-imposed short-term constraints on the local supply of manufactured goods and agricultural products, including the effect on marketing channels and transport systems. It must be borne in mind that consumer

prices may decline whenever imported products are cheaper than domestic supplies.

EFFECTS ON EMPLOYMENT

A disaster has both short- and medium-term effects on employment and household income. The short-term effects can be estimated on the basis of available data on the relations between employment and sectoral production, once the decline in sectoral production has been estimated. Work-months to be generated in the medium term by the rehabilitation and reconstruction activities can be estimated based on the existing ratio of labor requirements to level of construction investment. Both estimates must be combined to show the total effect of the disaster on this important social and economic variable.

Some conceptual considerations

Some conceptual remarks are presented here in order to examine the impact that different types of disasters have on different economies. Examples are given to portray the complex matrix that comprises the magnitude of the events, the main economic characteristics of the potentially affected country, and the alternative contexts and time frames in which a disaster may occur.

CLASSIFYING DISASTER IMPACTS

In general and on the basis of experience accumulated in the Latin American and Caribbean region, there is no predetermined pattern as to the consequences of different disasters. The resulting pattern of effects is determined by the combination of many factors, including the economic situation prevailing in the country before the event, the productive structure of the country and the extent of damages sustained, the severity of the disaster's consequences, the time of the occurrence, the very nature of the phenomenon, and, even, the way in which national authorities face the problem and relate to the international community.

Some disasters may be concentrated in a relatively limited area, affecting one specific geographical territory, massively affecting one population group, and devastating specific productive areas (see ECLAC 1973). In these cases, even though the economic and social costs may be very significant, the disaster may affect a limited number of activities and, although complete recovery tends to be a long and difficult process, reconstruction may stimulate economic growth.

Other events may affect a wider geographical area (see, for example, ECLAC 1974, 1975a, 1975b, 1976), where—at least initially—their effects and costs tend to be less evident, making it harder to rally international cooperation. An exception is where, as in Guatemala in 1976, timely damage assessment and appeal for international cooperation obtained the full backing of donors (see ECLAC 1976). In cases such as this, the disruption to economic activity is widespread, but its macroeconomic impact is less obvious. Depending on the prevailing economic and financial situation prior to the disaster, recovery from the negative impact of such a disaster can also imply a high cost and sacrifice for the country as a whole.

Major differences in impact can be observed when comparing the size and characteristics of damages with the size and complexity of the national economy affected by a disaster. A given disaster may involve very high costs in absolute terms—such as the $4.1 billion of the Mexico City earthquake—but, given the economic size of the country, reconstruction may have only modest macroeconomic effects (the

same was true in Florida in 1993 and Los Angeles in 1994).[1] By contrast, other disasters may have very high global effects on the economy even though the relative size of the damages, compared with those of other disasters, may be very small. In this respect, consider that the 1972 Managua earthquake, which in absolute terms was only a fraction of the cost of the 1985 Mexico City quake, affected 46 percent of the country's entire industrial sector. On the other side, some disasters whose total impact in dollar terms was only a fraction of that of the 1985 Mexico quake (Grenada and Antigua and Barbuda in 1975 and Guatemala in 1976) required a long time for the affected economies to recover (four years for Antigua and Barbuda, ten for Grenada, and three for Guatemala; see ECLAC 1975a, 1975b, 1976).

The damage appraisal of the Antigua and Barbuda disaster pointed out that the nature and magnitude of the damages had to be put in the context of the economic size of the country, the nature and scale of its economic functions, and the limits of its financial capabilities both in the public and private sector. At the time of the disaster, the country had a population of 70,000 inhabitants (some 17,000 households), a public sector with an annual budget of some $38 million, a productive capacity oriented mainly toward the export sector, and an economy highly dependent on tourism. The magnitude of the impact and the cost of rehabilitation and reconstruction were clearly small in absolute terms, but they represented a devastating burden for the country (ECLAC 1975b).

SOME WORKING HYPOTHESES

From another point of view, even though all major disasters have significant negative impacts, it is necessary to differentiate between disasters that have mainly economic effects and those that involve more important social consequences. For instance, Hurricane Fifi (Honduras in 1974) and other disasters (such as Grenada in 1975 and Nicaragua in 1988) had basically economic consequences but did not have major social impact such as the disruption of ample population groups; their effects were less evident in sociological terms (ECLAC 1974, 1975a, 1988). When the consequences are mostly economic, the cost of recovery may be estimated more accurately, and it is easier to prepare rapidly a portfolio of reconstruction projects that will receive attention and resources from the international donor community.

In contrast, other disasters may have more serious negative impacts on social groups than what the quantitative economic assessment would indicate (ECLAC 1979a, 1979b, 1987, 1992a, 1992b, 1993). In Nicaragua in 1979 and 1992, Ecuador in 1987, and El Salvador in 1993, assessment of the effects on macroeconomic variables did not show the full extent of social consequences. Furthermore, the relatively small absolute size of the damage also generated limited interest among both national authorities and the international community. There are many recent instances where, unfortunately, the estimated overall damage was small compared with the size of the country's economy but represented very high losses for the population affected by family disruption, loss of assets, and the virtual impossibility of recovering productive capacity on their own. Frequently these events cause dramatic damage to individuals that goes unnoticed, particularly when the population affected is concentrated in rural areas and has low income and few possibilities of presenting their plight to the authorities or potential donors.

The time frame in which a disaster occurs as well as its nature are also important. For instance, in the case of predominantly agricultural economies, the location in time when a disaster occurs within the productive cycle or season has a bearing on the amount of damages. Hurricanes, floods, and intense rainstorms that coincide with the harvest cycle (as occurred, for example, in Honduras in 1974) thus have a larger immediate impact than in cases where most of the harvest activities have been completed.

In a broader sense, the impact of a disaster depends on the country's economic trends prior to the disaster. In San Salvador in 1986, emergency and reconstruction activities were hampered by the extremely fragile financial position of the country and even more so by the costs of the prevailing military conflict. In this case, the urgency to face the crisis conflicted with other social development plans. The relatively large amount of destruction, the urgent need for reconstruction, the weakened productive capacity, and the growing financial imbalances posed serious dilemmas for economic policymakers seeking to maintain the adequate order of priorities. These dilemmas occurred, inevitably, within the small space provided by a costly armed conflict, both in social and economic terms (ECLAC 1986b).

In less dramatic although no less important cases, the urgent need to reconstruct competes at a disadvantage with stabilization and structural adjustment programs that, when coupled with financial support from international financial institutions, have strict conditionalities and macroeconomic goals. In these cases, the purely economic alternative might be to risk overheating the economy in order to respond to the economic and social demands arising from the disaster, which often have a national dimension.

Assessment of selected disasters using the ECLAC methodology

When a large-scale disaster destroys many assets in a relatively small national economy, reconstruction efforts may induce important changes in the medium- and long-term priorities of the nation and may even modify the route to development. When closely linked with the possibility of obtaining financial resources, reconstruction is limited by the country's internal productive capacity and the operational capability of its economic system. San Salvador's earthquake reconstruction program was limited by the shortage of specialized construction workers, many of whom had left the country during the internal war that preceded the disaster (see ECLAC 1986b). On the other extreme, in Guatemala following the 1976 earthquake, practically the whole country's capacity to build infrastructure was devoted to the reconstruction program, channeling all the sector's resources for more than two years into the provision of housing for the affected population (ECLAC 1976). This led to the deferment of important construction projects, including those intended to reduce the housing deficit that existed even before the disaster. In other cases, even though the total impact was not extraordinary, changes in priorities resulting from the reconstruction program induced social tensions and conflict between the need to attend to persons affected by the disaster and the need of persons who lacked the minimum living conditions even before the disaster (as occurred in Mexico in 1985; ECLAC 1985).

Analysis of selected major disasters

The following discussion summarizes the macroeconomic effects of three major disasters in the Latin American and Caribbean region, as estimated using the

ECLAC methodology and data obtained immediately after the disasters (because the type and material extent of losses can be found in other reports, only macroeconomic effects are discussed here). Some information is also summarized for other events that have affected the region since the 1970s (see tables 2-3 and 2-4).

THE 1985 MEXICO CITY EARTHQUAKE

This earthquake caused an estimated $4.3 billion in losses, of which $3.8 billion referred to direct damage and destruction to physical infrastructure and inventories and $545 million to losses in production and income (ECLAC 1985). The growth of GDP was not expected to slow as a result of indirect losses. However, the position of the external sector was expected to suffer considerably, generating a trade imbalance of $8.6 billion. This expected deterioration derived from a reduction in exports, including especially the tourism services sector, and an increase in imports of goods and services for the rehabilitation and reconstruction program and projects, in spite of an inflow of reinsurance payments. The deficit in the balance of payments was thus expected to increase more than 5 percent in the three years immediately after the disaster.

In addition, the position of public sector finances was expected to decline an estimated $1.9 billion as a result of the $2 billion in increased expenditures connected with the emergency phase, including the demolition of partially damaged structures, the removal of rubble, and the rehabilitation and reconstruction of damaged and destroyed assets. On the plus side, a net increase of $125 million in tax revenues was expected to be collected as a result of increased construction activity. The public sector deficit was thus expected, in the three years following the disaster, to increase by an average 10 percent over the previous year.

In spite of the deficit, it was thought that the required reconstruction effort could be borne without major difficulty, particularly if the expenditures involved were spread over a period of several years. Even though the loss of $4 billion in absolute terms was considerable—and of course the losses of life were irreplaceable—the value of the losses represented only 2.7 percent of the forecasted GDP for Mexico in 1985, 13.5 percent of the expected gross capital formation for the year, or 11 percent of total expenditures of the Mexican federal government.

Difficulties were nevertheless foreseen for the reconstruction efforts since the effects of the disaster could not be considered an isolated phenomenon. The earthquake occurred at a time when the Mexican economy was struggling against a particularly difficult set of circumstances: public expenditure austerity was being applied, banks were short of liquidity, and external financing restrictions were looming.

The analysis of the macroeconomic effects of the disaster was instrumental in revealing to the authorities that the cost of reconstruction, which could not be postponed, required a revision of some of the most sensitive areas of economic policy, such as public expenditure, credit policies, the price structure, and the balance of payments. Thanks to this analysis, discussions could be started to define how to face the new financial requirements while trying to maintain a stabilization program and continue servicing the public external debt.

THE 1986 SAN SALVADOR EARTHQUAKE

This disaster inflicted an estimated $940 million in damages; direct losses of capital and inventories amounted to $710 million and indirect losses to $230 million (ECLAC 1986b). Although these losses are only one-fourth of those calculated for

Table 2-4: Effects of Selected Disasters in Latin America and the Caribbean

Event	*Economic performance*	*Fiscal effects*	*Balance of payments effects*	*Infrastructure and capital losses*
Managua, 1972	GDP fell 15% overall and 46% in industrial and productive activity in Managua	Tax revenue fell 39%	Sixfold increase in current account deficit: reduction of almost 20% in exports and increase of almost 20% in imports due to extraordinary needs	Capital losses and lost production amounted to a sevenfold increase in investment requirements in fixed capital, both private and public
Honduras, 1974	GDP fell 6%overall and 23%in agriculture	Fiscal deficit grew 79% due to a decrease in current tax revenues of 15% and an increase in expenditures of 65%	Threefold increase in the current account deficit; imports grew 61%, and exports fell 66%	Loss of national assets and decrease in production represented almost twice the average annual investment
Antigua and Barbuda, 1974	GDP fell 12%, especially in oil refining, which fell 30%, tourism, basic services, and housing	Fiscal deficit increased 3 times	Balance of payments deficit increased 4 times	Damages to infrastructure represented around 4 times the average national investment
Grenada, 1975	GDP fell more than 20%; 10 years are needed to reach full agricultural production in plantations	Fiscal deficit increased more than 60%	External imbalance grew 4 times	Capital losses and damage to infrastructure amounted to 5 times the average annual investment
Dominican Republic, 1979	GDP fell 8%	Fiscal deficit increased 8 times	External deficit increased 27%	Capital assets lost twice the average of yearly investment
El Salvador, 1982	GDP fell 2%	Fiscal deficit increased 30%	External deficit grew 25%	Losses of capital and infrastructure equivalent to average investment in one year
Ecuador, 1982–83[a]	GDP fell almost 3%	Fiscal deficit increased 20%	Balance of payments deficit increased 22%	Capital and infrastructure losses equivalent to 3 years of domestic investment
Bolivia, 1982–83[a]	GDP fell 10%, 55% in agricultural sector	Fiscal deficit increased more than 275%	External sector imbalance grew 30%	Total losses were estimated at $836.5 million
Peru, 1982–83[a]	GDP fell 5%	Fiscal deficit increased 33%	Current account deficit in balance of payments increased 30%	Total losses were estimated at $2.0 billion
Mexico, 1985	GDP fell 2.7%	Fiscal deficit increased 7%	Balance of payments effect was negligible	Total losses were estimated at $4.1 billion
Nicaragua, 1988	GDP fell 2%, 17% in the agricultural sector	Fiscal deficit increased 20%	Balance of payments deficit increased 10%	Total damages estimated at $839 million
Nicaragua, 1992 Cerro Negro (volcanic activity)	GDP fell less than 1%	Less than 10% increase in fiscal deficit	Balance of payments deficit increased 2%	Total damages estimated at $19 million
Ttsunami	GDP fell almost 1%	Fiscal deficit increased an additional 5%	Balance of payments deficit increased 24%	Total losses estimated at $25 million

a. Estimated for 1983.
Source: ECLAC, on the basis of studies conducted in the field in each case.

the Mexican case, they had a much larger economic impact because they represented nearly 24 percent of GDP and about 40 percent of the national foreign debt at the time. Furthermore, the secondary effects on the macroeconomic aggregates were expected to be felt for several years after the disaster. The expected growth rate of GDP was expected to fall 2 percent in the year of the disaster due to decreased production in the sectors of commerce and industry. Public sector finances were foreseen to be severely affected by an estimated $935 million in the five years following the disaster, including an increase of $975 million in public outlays to face the requirements of the emergency, rehabilitation, and reconstruction phases, despite a net increase of $40 million in tax revenues. This meant a net increase of 24 percent in the public sector deficit.

For that five-year period, the external sector position was expected to deteriorate by $350 million as a result of increased imports for rehabilitation and reconstruction ($450 million), despite disaster-related reinsurance payments and relief assistance. The net anticipated result was to nearly double the current account balance of payments deficit. Shortages in construction materials combined with the increased demand for rehabilitation and reconstruction were anticipated to affect consumer prices, resulting in annual inflation rates above values for the previous years.

The San Salvador earthquake had a very negative effect on the main macroeconomic aggregates of the country, which lacked the capacity to face the challenges of reconstruction while facing the preexisting social problems, such as housing shortages and high unemployment rates. In view of that, the El Salvadoran government decided to elicit international cooperation—both financial and technical—to support the rehabilitation and reconstruction program.

THE 1987 EARTHQUAKE IN ECUADOR

This earthquake imposed an estimated $1 billion in damages. Direct losses represented $185 million; indirect losses represented $815 million (ECLAC 1987). The total estimated losses were significant, constituting approximately one-tenth of GDP at that time. However, indirect damages were more important, since anticipated production losses amounted to 7 percent of GDP and 33 percent of expected exports for 1987. GDP in 1987 was expected to decrease 2.7 percent—instead of growing 2.8 percent as estimated prior to the disaster—as a result of a 37 percent decline in value added due almost exclusively to declines in the oil-production sector. Minor reductions in the agricultural and domestic trade sectors were also foreseen.

The economy's external sector was expected to suffer an important negative impact. The balance of payments was expected to experience a drop of $554 million in the export of crude oil and by-products and an increase in imported goods worth $135 million to meet internal demand for fuel and to initiate the reconstruction of damaged infrastructure. A further $20 million were required to transport foreign crude oil acquired or borrowed from friendly nations in order to comply with sales contracted in the international market.

Furthermore, the position of public sector finances was expected to worsen. Public expenditures to meet rehabilitation and reconstruction requirements were expected to increase, and current income from the export of oil products and tax revenues from decreased economic activities were expected to decline. Before the quake, the fiscal deficit was expected to decrease, when compared with 1986;

after the disaster, it was predicted to increase nearly 40 percent.

The analysis conducted revealed the vulnerability of the oil-producing and export activities of Ecuador's economy, at a time when the government was making important but still not totally successful efforts to stabilize it. The analysis also revealed that the country's capacity to undertake by itself the investment needed for reconstruction was seriously compromised by the earthquake's anticipated effects on both the finances of the public sector and the position of the external sector. It could be foreseen, however, that due to the nature and relatively limited amount of damage done to infrastructure, reconstruction and restoration of the country's production and export capacities could be achieved with relative ease, if international cooperation could be obtained on a timely basis.

The long-term impact of disasters

Disasters significantly and negatively affect the prospects of long-term development of most of the Latin American and Caribbean countries. Countries having relatively small economies suffer those effects for a particularly long period of time. The speed with which the international community assists countries affected by natural disasters also has a bearing on the duration of the recovery period.

Impact on development prospects

A first consequence of a disaster is the immediate decline in national average living conditions; this effect is naturally more concentrated on the population living in the area directly affected by the disaster. In addition to losses due to damaged infrastructure and to the provision of public services, personal and family assets are also destroyed. Such is the case of housing and household and personal effects, which may not be replaced for several years. In the interim, the allocation of private and public resources may have a positive—albeit temporary—effect on the growth of GDP. The increased investment, insofar as it is destined for reconstruction, merely replaces a portion of lost capital. Replacement often reduces well-being from the level prevailing prior to the disaster.

Twenty years after, the effects of the Managua earthquake can still be seen in the precarious urban conformation of the destroyed capital city (see ECLAC 1973). Due to the nature of that earthquake, its effects were felt by the total population of Managua, the capital. Some low- and middle-income groups were affected particularly severely because their housing units were not built to resist earthquakes.

In other cases, the manner in which reconstruction programs were designed and undertaken further aggravated the already unequal distribution of wealth and did not permit the well-being of the population most directly affected to be restored (see ECLAC 1976). Still in other cases, disasters modified the very pattern of development because they affected key sectors of the economy. Consider the case of Peru, which in both the 1972–73 and the 1982–83 occurrences of the El Niño phenomenon suffered important setbacks in its fishing and related industries, when some of the fish varieties virtually disappeared from the Pacific coastal areas. The direct impact on the fishermen and the negative consequences for the export sector were very high (see ECLAC 1983b).

Impact on economic performance

Long-term macroeconomic effects are expressed in terms of a number of significant variables that signify a reduction of

per capita income. The Latin American and Caribbean experience confirms the hypothesis developed by researcher Ken Sudo, who has drawn an interesting correlation between GDP per capita and the number of disasters a year (see Sudo 1994). The absolute dimension of a disaster and the context in which it occurs (size and characteristics of the economy affected) also have a bearing on its long-term impact. The 1985 earthquake in Mexico did not have noticeable long-term negative effects on the country's macroeconomic variables—in part due to timely corrections of economic policy—even though eight years after its occurrence, a small number of the affected population still lacks permanent housing. On the other hand, the long-term effects of the disasters in Nicaragua in 1972, Guatemala in 1976, and El Salvador in 1986 are still being felt.

In addition to the macroeconomic impacts mentioned above, some specific long-term effects can be seen and measured over the years. These specific areas include the destruction of economic infrastructure, imbalances in the external sector, extraordinary fiscal imbalances, and inflation.

Destruction of Economic Infrastructure

Even though damage to and destruction of infrastructure occur immediately after a disaster and have a short-term impact, full replacement of these losses requires a relatively long period of time in most cases. During that time, the economy—and the most affected sectors especially—functions in a distorted fashion. Reconstruction of lost infrastructure thus tends to slow the rate of growth and development. Some concrete examples of the long-term impact of the destruction of infrastructure include highways and agriculture, in the case of Hurricane Fifi in Honduras, electricity services in San Salvador, and marine resources in Nicaragua and Peru.

External Sector Imbalances

Although these imbalances occur in the short term, they increase the economy's indebtedness and place an additional burden on its service profile, which affects the future capacity of the government to assign resources to investment and social expenditure in the long term. In this case, the experience of Latin America and the Caribbean confirms Sudo's analysis (for example, Guatemala in 1976, El Salvador in 1986, and Peru, Bolivia, and Ecuador in 1982).

Extraordinary Fiscal Imbalances

Short-term fiscal imbalances occur because special budgetary allocations are needed to undertake unexpected emergency and immediate rehabilitation following a disaster. These imbalances may persist in the medium term because direct and indirect economic effects of the disaster cause fiscal revenues to fall. Over time and gradually, these imbalances affect the government's capacity to sustain or improve its specific activities and to provide quality public services. This is evident particularly in social services such as education and health. Furthermore, a worsening of an existing fiscal imbalance may have repercussions for existing financial adjustment arrangements with international lending institutions that involve conditionalities.

Inflationary Processes

The immediate effects on prices that are the result of market disorders due to a disaster are compounded by the monetary effects associated with the reconstruction expenses undertaken with donated resources or external financing. In addition, fiscal deficits tend to have an inflationary effect in cases where fiscal

and monetary policies and controls do not address these matters. Added to this short- and medium-term inflation, insofar as damages to infrastructure cause an increase in production costs, further price increases occur that affect the functioning of the economy as a whole. Thus, reconstruction—when of significant size in relation to the economy—may overheat the overall economy. In some instances, this effect may be incompatible with the country's stabilization and structural adjustment efforts. These inflationary processes weaken the country's capacity to grow and invest, further deteriorate income distribution profiles, and exacerbate poverty.

Effects on institutional arrangements

Major disasters may affect the institutional arrangements in the affected country. To facilitate responses to the event, emergency committees are normally established to identify the most pressing needs and to channel aid. At a later stage, institutions may be set up—usually in the form of special reconstruction committees—as parallel structures to existing public administration ministries or bodies in the field. These new institutions are intended to expedite action, uninhibited by certain administrative and bureaucratic rigidities in the "normal" public apparatus, in matters such as purchasing and allocation of resources. Such institutions—created to attend a specific reconstruction program—tend to perpetuate themselves (the case of Guatemala comes to mind), duplicating functions and tapping scarce resources. Such institutions, however, sometimes develop an effective capacity for identifying and executing projects and improve the government's ability to channel and use international cooperation fruitfully. This is particularly true in countries with weak organizational structures. These institutions also help to assure donors that their resources are used adequately and without bias. Although in many cases this may not lead to the establishment of a national or regional institution for the prevention of disasters, these institutional arrangements for tackling reconstruction after disasters help some countries to face new disasters.

Because of the frequent occurrence of disasters in Latin America and the Caribbean and the repetition of errors and mistakes in reacting to them, temporary institutional arrangements set up in the wake of one disaster sometimes become permanent structures that conduct risk analysis and define plans on how to react to potential disasters. They may also disseminate experiences and educate the population about measures that can be taken, on a preventive basis, to reduce risks and, once a disaster occurs, to react in an orderly and coordinated way when reconstruction begins. This implies a sustained education effort that includes educational and training programs, modified zoning and construction codes, and so forth.

Implications for the international donor community

In the Latin American and Caribbean region, ECLAC frequently undertakes, immediately following a major disaster and at the request of the affected country, a comprehensive damage assessment. This assessment evaluates the direct and indirect costs involved, identifies the sectors that require priority attention in the rehabilitation and reconstruction phase, and analyzes the macroeconomic effects of the disaster. The assessment is prepared in a relatively short period of time—usually within four to six weeks of the disaster—and provides the means with which

to determine the ability of the affected country to face by itself the requirements of rehabilitation and reconstruction. The document is also a tool with which the international donor community can orient its technical and financial cooperation, specifically the substantive contents of aid and the conditions concerning interest rates and repayment periods (recently, the ECLAC member states issued a mandate to the Secretariat to undertake this type of damage assessment on a systematic basis; see the resolution adopted by ECLAC during its twenty-fifth period of sessions—Cartagena, April 20–27, 1994—which is presented in appendix 2-1).

Although resources to attend the most pressing needs of the emergency phase are usually available through internal budgetary reallocations and the generous and timely assistance of the international community (both international organizations and donor governments), the rehabilitation and reconstruction programs following major disasters require sizable fresh resources under soft terms. The urgency with which these new resources are needed requires that the international donor community make special efforts. Important steps have been taken in recent years as a result of major disasters in Latin America, the Caribbean, and elsewhere. They include the ability to reorient existing development loans, more flexible requirements for formulating projects, and quicker processing of requests for loans. However, further work may be necessary if the international donor community is to help developing countries face reconstruction and tackle prevention and mitigation activities.

In this respect, the international donor community should bear in mind that cooperation on rehabilitation and reconstruction should be in addition to the normal development cooperation already approved or earmarked for the affected country. Only in this fashion can developing countries seek to solve long-standing social problems that are aggravated by a major disaster. The flexibility to reorient existing loans certainly allows countries to address promptly the unexpected problems generated by a disaster but may also postpone or even cancel the execution of other much needed development programs and projects. International lending organizations and even donor governments through their bilateral cooperation programs may wish to consider establishing special programs designed exclusively to provide fresh, additional resources to finance unexpected rehabilitation and reconstruction plans after major disasters.

The international community may also wish to relax its normal institutional counterpart requirements for development assistance, by accepting—in the case of disasters—that the rehabilitation and reconstruction loans or grants be channeled through national institutions—including nongovernmental organizations—specifically set up for this task, instead of through the ministry or other public sector organization that would usually execute development loans and projects. This flexibility would ensure a faster response and still provide adequate assurances. A prerequisite may be that these resources be kept apart from the public administration's regular budget to ensure direct accountability.

In cases where the disaster is of significant magnitude but its impact is minor in relation to the size of the national economy, the government may wish to make full use of available domestic credit and financial resources before requesting external cooperation. The international donor community should be prepared to reinforce these domestic efforts.

The international donor community should also consider carefully the situation of a country seeking cooperation for rehabilitation and reconstruction following a disaster whose financial position is limited by an adjustment and stabilization program. Such a country may have accepted conditionalities related to its monetary, fiscal, and external financing policies, and these may block the need to expand liquidity and thus mobilize the resources needed to face emergency, rehabilitation, and reconstruction. In these cases, international lending institutions should be prepared to accept the affected government's request for flexibility in the fulfillment of those goals and conditionalities. Failure to do so may mean that sufficient fiscal resources are not assigned to the most pressing needs of the population during the emergency phase and, worse still, that social unrest emerges when reconstruction needs are not met.

Given the experience in the Latin American and Caribbean region and the frequency and intensity of disasters that affect it, the international donor community should provide more flexible mechanisms to facilitate the flow of cooperation for financing emergency and reconstruction. Lack of such mechanisms will result in greater medium- and long-term social and economic costs for the countries affected by disasters. Their unmet needs and damaged infrastructure will affect the functioning of the economy, slow economic growth, compromise the achievement of goals set forth in stabilization programs, and hinder overall development.

Summary and conclusions

The experience of Latin America and the Caribbean shows a significant increase in the frequency and complexity of disasters, with a growing incidence of quasi-natural and social disasters. The pattern of disasters is unpredictable, making it difficult to measure the long-term consequences of a disaster, because several variables related to the event itself interact in complex ways, affecting the economy, the country's relations with the international community, and the conditions prevailing when the disaster strikes.

Advances have been made in the ability to assess damages and organize actions for the emergency, rehabilitation, and reconstruction phases. In the experience accumulated by ECLAC, the diverse variables and a methodology have been developed and made systematic and can be applied in general to all disasters. Unfortunately, no major advances nor sustained efforts have been made to develop the capacity to predict and prevent disasters, even those caused by phenomena that are cyclical or repetitive in nature.

In most disasters, the economic evaluation of their immediate and short-term impact, although complex, may be feasible. The consequences, particularly the social impact over a long time frame, are harder to measure and project. Regarding the effect of a disaster on a country's long-term prospects for economic and social development, the nature and size of the phenomenon tend to be in inverse relation to the size of the affected economy: the larger the disaster and the smaller the economy, the more significant the impact.

The economic effects of disasters include, among others,

- A negative impact on development prospects that not only immediately downgrades living conditions, especially of the population most directly affected, and temporarily defers or

cancels development plans that seek to address long-standing social needs, but that also modifies the very production patterns of developing economies when key productive sectors are affected.

- A deterioration of economic performance, which can be measured in terms of short-term reductions in the growth of GDP and per capita income; when productive activities are affected, the result is both short- and long-term imbalances in the external sector.
- Imbalances in the fiscal budget, because fiscal resources are reallocated to meet the urgent and unexpected emergency requirements, fiscal revenues decline, and conflicts arise in the need to fulfill commitments the country may have made to adjustment loan conditionality.
- Immediate and medium-term inflationary pressures stemming both from market disorders that occur right after the disaster and from the monetary effects associated with reconstruction expenditures undertaken with external financing and donations.

These consequences of disasters for developing economies also have implications for the international community, which is called to assist affected countries in the following ways:

- Continuing to offer international assistance to developing countries whose domestic fiscal resources are insufficient to meet the urgent requirements of the emergency stage immediately following a disaster.
- Assigning priority to disaster prevention and mitigation cooperation plans and projects from developing countries that result in diminished rehabilitation and reconstruction needs when future disasters occur.
- Making the already accepted scheme of reorienting existing sectoral loans and loan application requirements more flexible to attend unexpected needs.
- Making additional fresh resources—perhaps through the creation of a special fund—available to meet rehabilitation and reconstruction needs arising from disasters and to avoid the deferment or cancellation of other much-needed development projects; this special fund would involve soft terms for interest rates and repayment periods to avoid compromising the developing country's limited capacity to repay.
- Accepting temporary noncompliance by developing countries of adjustment and stabilization loan conditionalities related to fiscal austerity, when outlays required by rehabilitation and reconstruction modify their fiscal budget situation.
- Reinforcing rehabilitation and reconstruction financing when affected governments—following disasters having limited macroeconomic effects—elect to resort to domestic credit and financial resources.
- Making institutional counterpart requirements more flexible for rehabilitation and reconstruction financing by accepting that resources may be channeled through national institutions—including nongovernmental organizations—especially established for the purpose, as opposed to the normally accepted government ministries or decentralized institutions.

Note

1. A billion is 1,000 million.

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Appendix 2-1. Resolution on Economics and Natural Disasters: Twenty-Fifth Session, Cartagena de Indias, Colombia, April 20–27, 1994

The Economic Commission for Latin America and the Caribbean

Considering that the Latin American and Caribbean region is frequently affected by natural disasters of diverse origin and intensity, adversely affecting the economic development of the countries and the living conditions of the population,

Taking into account that preliminary estimates made by ECLAC show that annual losses caused by natural disasters in the countries of Latin America and the Caribbean exceeded 1.5 billion dollars,

Considering also that it is possible to reduce these losses to less significant amounts through the identification and implementation of preventive measures and mitigation actions that require important investment resources which, nevertheless, are at only a fraction of the level of losses estimated at present,

Further taking into account that although ECLAC has developed methodologies to estimate the economic effects of disasters, the region does not account with the necessary quantitative arguments to enable competent authorities the prompt adoption of investment policies geared to the prevention and mitigation of disasters.

1. *Decide* to request that the ECLAC Secretariat:

a) Undertakes the systematic research and pertinent quantitative analysis to determine, as soon as possible, the total economic effects of disasters in the countries of the region as well as their reduction to smaller levels through the undertaking of actions to prevent and mitigate them;

b) Presents the governments of the region concrete proposals for the introduction of the issue of disaster prevention and mitigation in national development plans, as part of the efforts being carried out during the International Decade for the Reduction of Natural Disasters; and

2. *Recommends* that the Secretariat seeks and obtains additional extra-budgetary resources in order to carry out these tasks.

Appendix 2-2: Map Showing the Location of Selected Disasters

The Context of Disasters and Sustainable Development: Case Studies of a Growing City and Urban-Rural Linkages in Bangladesh

Atiq Rahman

Natural disasters threaten sustainable development worldwide, and the need for integrating natural disaster into the conventional development process is paramount. Natural disasters often destabilize communities, ecosystems, and production bases and make them more vulnerable to additional shocks such as other disasters and economic or political instability. The response of poor societies to natural disasters is often complex. It depends on many factors, including the type and intensity of the disaster, disaster preparedness, and the institutional support system—both formal and informal. Poorer societies, even if initially resilient, are often destablized by natural disasters to the extent that their sustainability is completely undermined.

More detailed case studies would be helpful in improving countries' efforts to make disaster reduction an integral part of development planning. Presently, there is only a relatively small body of knowledge about the complex interplay between disasters and sustainable development. New case studies are needed to explore and analyze the linkages between natural disasters and sustainable development in two settings: a megacity with rapid population growth, like Dhaka City, which is one of the fastest growing cities in South Asia; and a metropolis in a more regional setting, such as the coastal city of Chittagong and its adjoining areas, which were badly affected by a major cyclone in April 1991. Outlined below are the issues that such studies would help to illuminate.

Bangladesh: The setting and the disaster

Bangladesh is faced with rampant poverty, high population density, increasing population, recurring natural disasters, and a dwindling base of natural resources. Furthermore, there are geomorphological and political instabilities, a high level of dependence on external aid in the economy, and democracies and democratic institutions in the early stages of formation.

More than 5 percent of the gross domestic product (GDP) is lost annually to recurrent natural disasters. Recurrent floods cover large areas, often up to 30 percent of the country. They affect and damage crops, seeds, trees, livestock, housing, infrastructure, and the economic and productive units in the formal and informal sector both in urban and rural regions. Floods can enhance erosion by rivers, with a consequent loss of valuable arable lands and increased vulnerability of affected communities. Areas hit by cyclones are not very large, but the devastation can be enormous: the cyclone of April 1991 killed more than 130,000 people. In the recent cyclone of May 1994, casualties fortunately were limited to 200, but calculated damages exceed hundreds of million of dollars, which the country can ill afford.

The northwest part of Bangladesh is vulnerable to drought and the northeast to flash floods. The country is on a zone of low-scale tectonic activity. Exogenous factors such as changes in global climate and the consequential rise in sea level threaten the coastal communities, home to more than 15 percent of 120 million people. A recent study on the vulnerability to climate change and rise in sea level predicted that coastal inundation of the south and increasing drought in the northwest will have devastating economic and environmental impacts. The stark conclusion is that if the predicted impacts of changes in global climate are true, and if neighbors refuse to cooperate on making water from common rivers available (for example, the sharing of the Ganges water with India), then all the development efforts for the next thirty years will be totally negated by exogenous factors for which the people of Bangladesh are not responsible. Sustainable economic development will continue to be a farfetched goal. Furthermore, the greatest disaster is the existing poverty, which undermines the basis for sustainable development.

A proposed study on these issues would analyze historic disasters and their economic costs, different disaster scenarios, disaster management concepts, and institutionalized responses. This study would also analyze the different phases of disasters and their comparative costs and benefits and demonstrate the linkages between economic activities and natural disasters and their relevance to sustainable development.

Case studies

As mentioned above, two detailed case studies—one looking at a mega-city and the other at urban-rural linkages—would provide a more accurate view of the country's vulnerability to disasters and sustainability. Although urban centers are focal points of enhanced economic activity, particularly in the industrial and formal sectors, disaster analysis should not treat them in isolation because urban-rural linkages are multifaceted and intense.

The urban case study: Dhaka City

Dhaka, the capital of Bangladesh, is one of the fastest growing Asian cities, with an annual population growth rate of more than 6 percent. Dhaka had a population of 6.1 million in 1991, which will have increased to 11.2 million by the year 2000. The average background population growth rate is around 2.2 percent, migration from rural areas accounts for the rest. The dominant push factors are landlessness and poverty, and the major pull factors are some, albeit precarious, employment opportunities and the potential to form slums with little or no sanitary and infrastructure support. The lowest strata in society, as in most mega-cities, live on the wastes of the affluent.

The major recent natural disasters were floods in 1987 and 1988. Part of the reason for the massive economic devastation and impact was excess water from outside, but the dominant reason was waterlogging caused by poor planning and by so-called protection plans for the construction of embankments. These embankments, and the choking of drains by rampant and ill-conceived construction, make the city and its dwellers more vulnerable to flooding.

Other disasters are typhoons—short, sharp events—which can be devastating, particularly if they hit infrastructure of economic importance such as industries, power plants, and bridges. Fire hazards also remain a major threat because of the population congestion and poor housing. Again, the poor are the most vulnerable.

The proposed case study would analyze in detail the economic effect of disasters and their preferential impact on different economic sectors such as industry, transport and roads, buildings, waterways, health and sanitation, power, and institutions. The study would also explore the impacts of disasters on different social classes and their responses, illustrating the vulnerability of the poor to natural disasters and the ways in which the elite distort planning priorities and influence decisions that are ultimately socioeconomically suboptimal for the city and the country.

Urban-rural linkages: Cyclone of April 1991

The coastal areas of Bangladesh were devastated by a cyclone in April 1991. The victims of the cyclone and associated water surge were not only the 130,000 who lost their lives and the millions marooned and disabled, but all components of the economy—human beings, animals, trees, soil, bodies of water, infrastructure, and commercial products such as shrimp, salt, and textiles. A recent study has shown that the Port of Chittagong alone sustained a loss of Tk1,616 million ($400 million). Some twenty-two vessels sank, including a port dredger and a floating crane. The airport was severely damaged, as were forty-three major industries in the Export Promotion Zone. An estimated Tk10 billion ($2.4 billion) of plant was damaged in the export sector alone. This is equivalent to the nation's total annual development budget. Several offshore islands were totally devastated: 75 percent of the houses and 65 percent of the schools in Sandwip Island were wiped away.

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A case study of this experience would systematically analyze peoples' reaction to disasters, economic losses, and management strategies: what has worked, what has not, and how people cope with such disasters. However, the dominant conclusion remains that the more effective participation of the people is the best approach to improving disaster management and mitigation. Preparedness is the essence of reducing the impact of disasters and achieving economic development overall. While disasters themselves inflict great harm, the greatest killers are underdevelopment and poverty.

Conclusions

Floods, cyclones, tidal bores, and earthquakes are not the only disasters: poverty and illiteracy are more deadly, and they also are barriers to better disaster management. Forward planning to cope with exogenous and extended phenomena such as global warming and a rise in sea level tend to be embedded in economic activities in an intricate and interconnected world, where often the poor states, and even poorer communities, are most vulnerable. The poor are pushed toward the disaster-prone and environmentally degraded areas, making them even more vulnerable, and locking them into an economic and ecological downward spiral.

Development is the greatest antidote to disaster. Proper economic growth offers the best opportunities, and only effective participation of the populace in this decisionmaking can make economic-ecological sustainability possible. The deadly triad of population growth, natural disasters, and environmental degradation can only be addressed with the emerging tools of sustainable development and economic opportunities for the people, particularly the poor.

3

Vulnerability to Disaster and Sustainable Development: A General Framework for Assessing Vulnerability

Mary B. Anderson

Vulnerability has to do with future jeopardy and potential harm. To be vulnerable is to exist with a likelihood that some kind of crisis may occur that will damage one's health, life, or the property and resources on which health and life depend. Everyone is, to some degree, vulnerable. Any of us can suffer a catastrophic personal loss that affects our health, life, or property. We all could be affected by a nuclear accident that spills across geographical borders or by the depletion of essential resources, such as the ozone layer, on which we depend. Many people live in zones that are subject to natural hazards such as earthquakes, windstorms, or floods, and, increasingly, these natural phenomena even affect those of us who live at a distance because they have adverse impacts on the environment, world resources, and markets on which we all depend.

Vulnerability is the subject of this paper. Over recent years, even as progress is made in understanding nature and controlling some of its negative effects, vulnerability appears to be rising. The numbers of disasters have risen, as have the numbers of people affected and the value of property destroyed (many authors assemble data to show these trends; for an overview, see International Federation of Red Cross and Red Crescent Societies 1993b, pp. 33ff). The inauguration of the International Decade for Natural Disaster Reduction (IDNDR) reflects world concern with the suffering and setbacks thus experienced. In its opening session in late 1991, the Special High-Level Council of the IDNDR noted that "Reducing vulnerability to natural disasters is a major goal requiring concerted and coordinated efforts of government, UN-system organizations, the world's scientific and techni-

cal community, volunteer organizations, schools and educational institutions, the private sector, the media, and individuals at risk. Vulnerability assessment . . . [is] essential" (United Nations IDNDR 1992). The council thus alerted the international community to the fact that, if we are ever to control and limit the damage from disasters, we must be able to identify and assess vulnerabilities in different places and times in order to design timely, affordable, and effective strategies for reducing the negative impacts of disasters.

Though essential, assessment of vulnerability has proven to be a complex undertaking. As we have gained more and more experience responding to disasters, we have improved our understanding of vulnerability. But we have also been forced to recognize its complexity and to acknowledge that numerous interconnected, mutually reinforcing, and dynamic factors are involved. In addition, disagreement about which factors are most important has emerged. Different disciplines have developed indexes of vulnerability that incorporate the factors of primary concern within their own fields but overlook or omit factors that other disciplines consider essential for full understanding.

This chapter begins by reviewing the way in which our understanding of vulnerability has shifted and enlarged over time, followed by a discussion of the interrelationships among economic development efforts of the past, trends in vulnerability, and the current concern with defining and achieving sustainable development. This is followed by a section outlining five critical characteristics of vulnerability and, finally, by a framework for vulnerability assessment that reflects the characteristics, factors, and relationships discussed. The purpose of this effort is to suggest a comprehensive, yet usable, framework for understanding vulnerability that can be used by communities to assess their own risk and to decide which courses of action to take to reduce their vulnerability, by planners to mitigate and prevent disasters, by educators to improve the public's understanding of disaster proneness and prevention, and by government and international bodies to discuss and agree on joint responsibilities and cooperative efforts to reduce vulnerability.

Before beginning, however, we must specify something more about the vulnerability we are attempting to assess. Everyone is in some ways and to some degree vulnerable. The purpose of assessing vulnerability is to be able to take appropriate actions to reduce vulnerability before the potential for damage becomes actual. We are, however, interested in understanding more than the simple vulnerability each of us faces as a part of living. We are also interested in recognizing and responding to levels of vulnerability where the potential for damage to health, life, or resources and property is significant—that is, where it is so large that the communities experiencing losses cannot handle them alone and need outside assistance to sustain life and health and to recover resources and property. We are interested in vulnerability that threatens to put people "over the edge" of self-sufficiency where they become dependent, at least for a while, on outside support. This is, in fact, the working definition of a disaster, namely, a crisis event that surpasses the ability of an individual, community, or society to control or survive its consequences (Kreimer and Munasinghe 1990). We are, then, interested in developing a framework to aid in assessing vulnerability to disaster in this sense.

An historical overview: How understanding of vulnerability has shifted and enlarged

The literature on disaster vulnerability and how to assess it is large and growing. Other scholars have reviewed this literature in useful and interesting ways (for an excellent review, see Winchester 1992, especially chapter 2). For our purposes here, we will group the vulnerability literature into three categories that also, to some extent, reflect progress toward the emergence over time of a fuller and more realistic understanding of the concept.

Nature as cause: Scientists, technologists, and engineers respond

Early disaster studies identified natural hazards as the cause of vulnerability. People who lived in zones of seismic activity, along coastlines subject to typhoons or tsunamis, on slopes of active volcanoes, or in areas prone to extensive drought or flood were, by the fact that they lived in these areas, vulnerable. Where the frequency or magnitude of the hazards was great, vulnerability was great. Where such events were infrequent, vulnerability was considered to be low. By avoiding living or working in these areas, humans could, it was thought, avoid vulnerability. The 1979 working understanding of the Office of the United Nations Disaster Relief Coordinator (UNDRO) reflects this definition: vulnerability represented the relationship between hazards (natural events, including their strength, magnitude, and duration) and risk (exposure to the events, measured essentially in terms of proximity; see, for example, UNDRO 1979).

With this understanding of vulnerability, scientists, technologists, and engineers have attempted to predict natural hazard events and to develop technologies that enable human structures and systems to withstand their impacts. The assumption has been that such events, as acts of nature, cannot be prevented. However, vulnerability could be reduced, these researchers believe, if we could more accurately predict where and when and in what magnitude these events will occur and if we could, also, develop technologies that mitigate their negative effects.

The efforts of this group of disaster vulnerability researchers have had significant success over time. Technologies and materials for constructing buildings have been developed that can withstand strong winds, storms, flames, and seismic activity. Water control systems have greatly reduced seasonal damage from flooding in many areas, and some communities have invested in elaborate and expensive control systems to limit damage from even the rare and unusual 50-year or 100-year crises (one example is the massive flood control system built to protect London and its surrounds from floods that occur perhaps every 2,000 years at a cost of £730 million; see Anderson 1990, p. 10). Systems for predicting and tracking storms that originate at sea have greatly improved so that, in most parts of the world, residents of coastal regions now have hours (or even days) of warning to prepare their property and to evacuate for personal safety. Technologies for mapping hazard proneness, down to small specific micro-zones, provide precise scientific assessments of the likelihood of disaster vulnerability that local communities can use to decide whether and how to reduce their risks (see, for example, International Geological Congress 1984; "Welcome to the Future" 1993, to name only a few of the sources of scientific and technological approaches to vulnerability assessment).

Costs as cause: Economists assess how much vulnerability reduction is rational

In spite of the many gains in our scientific and technological capacity to limit vulnerability to natural hazards, people continue to be injured and die, and property and resources continue to be destroyed, in disasters every year. One reason for this is that many of the prediction and mitigation technologies are costly, and individuals and communities are unwilling or unable to afford them. A second body of literature about disaster vulnerability and mitigation focuses on these costs and attempts to develop economically rational criteria for deciding which vulnerability-reduction technologies should be used under what circumstances.

These researchers note that although vulnerability has its costs in terms of losses of life, health, and property, vulnerability reduction entails costs as well. If the elimination of vulnerability were free, then societies would reduce all risks to zero. However, when faced with the actual (often high) costs of the vulnerability-reduction technologies, individuals and societies must make rational choices between buying these technologies or buying something else instead. The fact that hazards are largely unpredictable makes this calculus all the more important and difficult. The choice is whether to invest today to prevent some future, uncertain event or to invest today to produce some certain, needed good.

Economists have developed increasingly sophisticated systems for assessing the value of reducing vulnerability over time. Systems for measuring the cost-benefit ratios of using the various technologies available for reducing vulnerability now recognize indirect and secondary costs as well as the direct costs involved in immediate losses (Anderson 1990). Probability theory has been merged with economic calculations to arrive at appropriate discount rates for comparing current forgone consumption and future reduced losses. Increasingly, researchers are improving their methods for collecting data on losses from disasters and their models for incorporating external and resource-loss costs into their calculations of whether, when, how, and where reducing vulnerability is viable. To be accurate, each of these cost measurement techniques requires, however, an accurate assessment of vulnerability—that is, the ability to know with the highest possible degree of certainty exactly what vulnerability entails in order to put an accurate price on preventing it. If knowing this is not possible, then pricing has to reflect uncertainty itself—a much less satisfactory solution to the problem of economic choice. Thus, as economists have contributed to the literature on vulnerability assessment, they have recognized that the understanding of vulnerability must be expanded to incorporate an increasing number of variables.

Humans as cause: Social scientists, policy reformers, advocates for the poor, and environmentalists enter the scene

Even as the technological/engineering and economic/accounting approaches to assessing and dealing with vulnerability have developed, others who are concerned with the impacts of disasters have criticized these two approaches as too narrow (see, for example, Bruce 1992; Maloney 1990–91; Schramm and Warford 1989; Suhrke 1993). The critics observe that disasters have differential impacts on peoples who live in hazard-prone areas. They note that vulnerability to loss of life, health, and property varies widely among

people who experience the same disaster and among people who experience disasters of the same size and scope at different times and in different parts of the world. They conclude that more than just hazard and exposure must be considered in any accurate assessment of vulnerability.

Considering the economists' approaches to establishing rational criteria for deciding on vulnerability reduction, these critics also note that different people appraise the danger of hazards differently. Because people acknowledge and interpret their vulnerability differently—even though they experience the same exposure to the same hazard—they make different decisions about how much vulnerability reduction is worth to them. That is, the benefits side of the cost-benefit ratio varies widely according to factors that go beyond simply avoiding the measurable losses that are captured in the hazard/exposure definition of vulnerability. Thus, this group of critics sees that the price that people are willing to pay, or not willing to pay, to reduce vulnerability to uncertain events incorporates many additional—and some not readily quantifiable—factors (notable for being the first to include these issues in his analysis is White 1973; see Winchester 1992).

Accompanying the growing awareness of the complexity of factors that affect vulnerability assessment is awareness of the role that humans play in creating vulnerability. Whereas previous assessments focused on the acts of nature that come from outside human agency, later assessments acknowledged that it is largely human actions, decisions, and choices that result in people's vulnerability to natural events. Choices about where to live (or, in some cases, the lack of choice due to political, economic, or social position), decisions about where to locate a chemical plant, and acts of cutting forests, farming marginal lands, or evading building codes are examples of how humans cause a "natural" hazard to become a disaster. Humans make themselves—or, quite often, others—vulnerable.

The third category of literature on vulnerability assessment, therefore, includes the criticisms and expanded definitions of the social scientists, policy reformers, advocates for the poor, environmentalists, and others who, having identified the differential character of vulnerability and the central role of humans in creating vulnerability, have incorporated additional variables into their definitions of vulnerability. Included are economic poverty, social and political marginalization, lack of options as well as lack of resources, and other social, political, and economic indicators that, in any given setting, cause people to live in circumstances that put them at high risk from any natural, market, political, social, or other perturbation.

It is now widely recognized, then, that people are vulnerable to a natural event not because of proximity per se, but because of proximity coupled with low economic or social status. For example, poor people often live in weaker houses on less desirable and less stable lands, have fewer income or resource reserves, and are less healthy than people who are better off. People who are socially or politically marginalized usually have restricted employment opportunities, low access to education, or generally few options that would enable them to withstand or recover from a disaster. The coincidence of high death and injury rates in disasters with low national income levels reveals how poverty at the national level also makes some nations more vulnerable to disasters than others. It follows that when personal, community, or national wealth is inadequate even for basic, daily security, few investments are made in the

technologies that can help to ensure survival in the face of a hazard event.

However, having acknowledged the important relationship of poverty to vulnerability, it is also apparent that poverty is not a sufficient proxy for vulnerability. One need only consider the upper-class homes built on the hills of California or on the shores of the eastern seaboard in the United States to know that it is not only the poor who reside in risky, hazard-prone places, nor is it only they who lose their homes or lives when hazards strike.

Vulnerability assessment requires far more contextual analysis of complex and multifaceted factors that cause people to make the decisions and choices and to undertake the actions that increase vulnerability. Increasingly we see that the factors influencing human choices and actions arise from sociopolitical systems, reflect people's status and position within their economies and societies, and are shaped by habits and expectations related to past experience.

The third body of vulnerability investigation, while complicating the analysis immensely, has made two very important contributions to our understanding of vulnerability. First, by lodging responsibility for vulnerability squarely inside human systems, it has removed any justification for the claims that disasters cannot be predicted or prevented. While acknowledging that the exact time, place, or magnitude of an earthquake, for example, cannot be foretold, this group of writers notes that current scientific knowledge can and has identified zones of seismic activity and that this, coupled with awareness of the social and economic factors that cause human habitats to be vulnerable to earthquakes, allows us to predict with a high degree of certainty where seismic activity will result in a disaster.

Second, this group notes that, if human agency is involved in creating or increasing vulnerability, then humans can also make different choices that prevent (or reduce) vulnerability. We can decide not to do the things that increase vulnerability and to do the things that reduce it. We *cannot* overgraze the lands we now deplete, we *cannot* denude hillsides of their forests, we *cannot* build properties that are below code for predictable wind or earth force. To reverse past risk-increasing mistakes, we can replant unstable hillsides, we can retrofit old buildings, we can relocate chemical industries to zones of relative safety. Although, in the extremes, certain disasters will remain unpredictable and unpreventable, the growing awareness of human responsibility for vulnerability opens up a vast range of choices and actions that can be undertaken to reduce vulnerability.

How, then, does this recognition help us to move toward a useful and usable framework for assessing vulnerability? To answer this, we shall next examine in some detail how vulnerability has risen because of past human actions and how this history influences the choices to be made in the future.

Past economic development, increasing disaster vulnerability, and future sustainable development

Given the strong link between poverty and vulnerability, we might assume that economic development is one central strategy for reducing vulnerability. The historical record, however, presents mixed evidence about this relationship. The processes by which human societies pursue economic security and wealth have, very often, increased the vulnerability both for those who have gained and for others as well. Recognition of the negative relation-

ship between development and vulnerability, especially as it is mediated through the environment, has produced a strong and growing concern with defining and pursuing sustainable development, that is, development that meets the needs of the present without compromising the ability of future generations to meet their own needs (this definition was put forth by the World Commission on Environment and Development, created by Resolution 38/161 of the General Assembly of the United Nations in 1983).

To plan and work for sustainable development, however, we have to know what has gone wrong in past development efforts. Why have these efforts to improve welfare also increased the vulnerability of large numbers of people?

Trends associated with development that have increased vulnerability

Ten distinct, though related, trends that are associated with the progress of economic development have also increased vulnerability. They are the transformation of resources, the production of effluents, the production of dangerous substances and invention of dangerous techniques, population growth, use of marginal lands, urbanization, rise in expectations, the attitude that everything can be done and all problems solved, the attitude that rationality can be achieved through pricing, and the widening gap between rich and poor. Many of these are by now familiar and well documented. It is not necessary for us to prove, here, that these trends have occurred since others have done so. Rather, this list of trends in development and vulnerability serves to focus attention on the realities with which we must deal in future development approaches if we are to reduce vulnerability and achieve sustainable development.

TRANSFORMATION OF RESOURCES

Underlying the dominant development paradigm of Europe and North America in the nineteenth and twentieth centuries (and adopted by many of the countries of the East and South) has been the belief, articulated by Sir Frances Bacon, that nature is to be understood in order to be controlled and dominated by mankind. The possibility for humans to transform natural resources into things that provide increasing levels of security and comfort has provoked immense ingenuity and inventiveness on the part of many people. The outcomes have been impressive, and many people live healthier and more secure lives as a result of these efforts. By the late twentieth century, however, we are all aware of the limitations of natural resources and of the negative consequences of their depletion through overuse both for the present and for the future. Even so, the trends of resource use are up, and the rates of use are rising.

As nonrenewable resources are consumed, three types of vulnerability increase. First, human societies face the possibility of scarcities in the things now considered necessary for the good life and of many things that truly are essential for any life, such as food. Second, as some societies exert their power over the limited resources that remain, others suffer shortages and thus become increasingly vulnerable. This may, in turn, produce political challenges that increase the vulnerability of even those who still have control over scarce resources. And third, the loss of some resources poses environmental consequences for all of us. For example, depletion of forests has been linked to loss of ozone, possible global warming, and rising sea levels, with the resultant loss of productive land, reduction in food

availability, and increasing health dangers. There are many other examples of resources whose loss would increase the threat to us all, including nonrenewable sources of energy and certain plant and animal species.

Furthermore, production techniques and the good life associated with economic development of the past have resulted in the destruction of "naturally occurring [disaster] mitigation elements in the ecosystems" (Bender 1993). For example, ocean reefs absorbed wave energy from sea storms, and mangrove stands protected coastal lands from winds and waves. Unrecognized as natural preventers of disasters, these resources have often been destroyed, leaving areas vulnerable now where no vulnerability existed before. Thus the rates of resource use associated with vast economic progress continue to rise, increasing vulnerability.

EFFLUENT PRODUCTION

Production techniques associated with resource use have also resulted in increasingly dangerous levels of effluents being released into the air, waters, and soils on which present and future production and welfare depend. The so-called free goods of air and water are not free at all because our levels of effluent production outstrip the capacity of nature to cleanse itself and replenish its freshness. And, as is true for the use of resources, the rates of effluent production are, for the most part, rising (see Anderson 1992; Parker 1992; Quarantelli 1992).

Immediate vulnerability from effluents arises from impacts on the health of humans, animals, and plants. Future vulnerability involves also the inability to produce needed things that rely on the resources destroyed through poisons, such as cultivable land or water, which are necessary to sustain life.

PRODUCTION OF DANGEROUS SUBSTANCES AND INVENTION OF DANGEROUS TECHNIQUES

Economic development has involved the production of substances and the invention of techniques that both serve human ends and, at the same time, present new dangers. For example, central to economic development has been the production and use of a variety of chemicals and chemical processes. The manufacture of these chemicals uses some resources and produces waste materials, but the substances themselves also pose direct dangers to health. Chemical fires, explosions, or leakages represent new hazards to which humans are vulnerable. Similarly, gas storage tanks, nuclear reactors, large dam systems, and other technologies of modern industrial societies, while increasing wealth, also pose new and immediate hazards. When threatened by the natural hazards of storms and earthquakes, these hazards, by their very existence, raise the threat of dangers beyond those produced by the natural events themselves.

POPULATION GROWTH

Development has resulted in improved public health, cleaner water (up to a point), the discovery of vaccines, and the creation of health care systems and technologies; it has also resulted in improved life expectancy and higher fertility for both humans and animals. These gains represent a reduction in vulnerability in the immediate sense.

Yet, the cumulative impact of these gains has been to increase population, which increases demand on the scarce and depleting resource base, adds to the wastes that are returned to the environment, and forces the overuse of land, water, and energy. Increasing animal herds have resulted in expanding desertification in some regions with concomitant lowering of the water table and rising proneness to

drought. As human and animal populations expand, tensions sometimes increase and, with them, the potential for political conflict, another source of human vulnerability.

USE OF MARGINAL LANDS

Improvements in scientific capacity and technological developments, coupled with population growth, have encouraged societies to move into and rely on lands that, previously, were considered unsafe or unproductive. For example, floodplains have been made "safe" with dams, ditches, and dikes and hillsides have been "stabilized" with reinforcement technologies and, therefore, developed as lands for agriculture, industry, and habitation.

As marginal lands are increasingly used by humans, however, the margin of safety of life and production in these areas is inevitably low. That is, people now are encouraged, by developmental progress, to live in areas that are inevitably more prone to hazards than other lands. The damage caused by the extensive and disastrous flooding in the Midwest of the United States in the summer of 1993 was, to a very large extent, the result of people's decisions to live and work in zones that would never have been settled if "development" had not brought the series of technologies that made these areas appear to be safe. With a false sense of security, many people experienced increased vulnerability. In areas where population pressures are also great, this trend toward settlement of unsafe areas—with the aid of technologies associated with development—proceeds apace.

URBANIZATION

Trends toward urbanization have always been associated with economic and social development. Much progress has been made in science, industry, the arts, and politics as a result of this trend. Developments of science and technology have also made it possible for more and more people to live in cities. Increases in agricultural productivity enable more people to live off the food grown by fewer people. Communication, transport, sewage, electricity, and other complex systems, as well as highly advanced building techniques, enable people to live under conditions of population density that were previously impossible. Population pressures and depletion of rural resources encourage more and more people to move to urban centers in search of employment, security, and lifestyles associated with modernity.

As cities become mega-cities, with populations over 20 million people, however, they become highly vulnerable to a number of hazards and failures: available resources can be inadequate to sustain the number of people, and harmful wastes are produced in numbers that cannot be absorbed in the given space, increasing the potential for hunger and disease (see Kreimer and Munasinghe 1992; Pan American Health Organization 1993). They also include accidents such as explosions of fuel stocks (located for convenience near the population that needs them), leakages of chemical and other toxic wastes used in industrial production, and fire. System failures and breakdowns can also bring extraordinary dangers. When vast numbers of people are linked through telecommunications systems on which they depend for their work, health, or information, a loss of such a system can threaten survival. Urban dwellers are vulnerable to a whole new set of hazards that accompany the very processes that make city life attractive and possible. This vulnerability seems to rise in correlation with the numbers of people accommodated within fixed geographic space.

Three of the ten trends that are associated with economic and social development are trends in attitudes. They represent changes in the ways that people think, and they exacerbate the vulnerabilities just discussed. They are rising expectations, the attitude that everything is possible, and the attitude that rationing can be accomplished through pricing.

RISING EXPECTATIONS

Worldwide, aspirants to development identify it with increasing access to consumer goods. The Western model of consumer-oriented economics has come to be, by the vast majority of people, synonymous with development. So long as no alternative model of development is equally compelling and appealing, the rising expectations among those who are now poor put strong pressure on all of the above trends.

THE ATTITUDE THAT EVERYTHING IS POSSIBLE

Historically, progress in achieving economic surplus through the industrial revolution in Western Europe and North America was linked to (and, in part an outcome of) the scientific revolution, which had occurred one century earlier. The way of knowing of the scientific revolution—empirical, pragmatic, experimental—drove and reinforced the technological discoveries on which abundance was gained. Steady progress was apparently made in the economic sphere by drawing on the expanding knowledge available from science and technology for three consecutive centuries.

With the experience of such apparent success, people came to believe that all problems that have to do with the material of science—specifically nature and matter—are solvable. All that is necessary is further scientific or technological discovery. Every problem is viewed as a challenge or a frontier to be conquered, as all the past ones have been, by the application of increasing knowledge. In fact, as we come to the twenty-first century, more and more problems are not susceptible to the scientific solutions we have come to expect. We can, indeed, analyze and understand some of the new problems we face—such as depletion of nonrenewable resources—but the easy discovery of ways to reproduce these resources, or of alternatives that can substitute for what has been lost, eludes us. Believing that such solutions exist and can be found with sufficient effort has, however, seduced human societies into pursuing costly, irreversible patterns of resource use and effluent production. Unless solutions are found, these patterns, as we know, increase vulnerability on a broad scale.[1]

THE ATTITUDE THAT RATIONALITY CAN BE ACHIEVED THROUGH PRICING

Concomitant with the attitude that all problems can be solved, the attitude that rationing of scarce resources can be rationally handled though the pricing mechanism of the free market system has also been widely accepted through the experience of the past two to three centuries. According to this view, even though we cannot always replace overused resources, we can apply a price to their use that accurately reflects not only their use but also the loss of their future availability. Thus, even though some resources are depleted, we can make rational (hence, good) decisions about when, how, and where to use them and thus safeguard ourselves from wasting, or in a fundamental sense, misusing, scarce resources.

Increasingly, this belief is under attack. Many now note that systems of pricing and of applying discount rates do not adequately incorporate the loss of resources. Criticisms center on the impossibility of putting a reasonable price on

irreversible losses, on the fact that future generations are not present to negotiate the price that they pay for current misuse of resources, and on the fact that, even in the present, those who pay for the misuse of resources often do not benefit from their use.

So long as decisionmakers believe that all things can be accurately priced as a way of making rational choices among alternatives, however, the pace of resource use and of effluent discharges will not fundamentally alter. Thus, this attitude reinforces the other trends that are now increasing our vulnerability to disaster.

Finally, a tenth trend and an attendant coda to all the trends remains to be discussed: the widening gap between rich and poor.

The widening gap between rich and poor

Worldwide, and within countries as well, a significant gap persists between those who are well off and those who are or are becoming poor. Previously it was believed that development would inevitably produce an enlarged middle class and that gains at the top would trickle down, finally benefiting everyone and reducing the gap between rich and poor. This did, in fact, occur in some places over some decades. However, the gap between income and welfare is not only persisting but widening as an adjunct to the patterns of development currently being pursued. For example, the consumption of resources is distributed extremely unevenly across the world. While the 16 percent of the world's population that lives in India has less than 2 percent of the world's income, the fewer than 5 percent of the world's population that lives in the United States has about 36 percent of the income. Almost 1 billion people or almost one-fifth of all humans live in absolute poverty and hunger today (Ministry of Environment, Norway 1988–89).[2]

Given the trends of resource depletion, environmental degradation, population growth, and urbanization, the tendency is for the gap between rich and poor to grow and for the absolute numbers of those who are counted among the poor to grow. Some people are becoming more vulnerable, and their vulnerability will have greater impacts worldwide. These may show up in the form of costs of humanitarian assistance to those who are unable to sustain their own lives or in the form of social and political tensions that erupt in localized violence or expanding conflicts.

Attendant to the trends toward increasing vulnerability that have arisen from and been furthered by the very processes of development is another tendency related to people's capacities to recover from crises. Even as people move from their traditional life patterns toward modern lifestyles, which expose them to new and greater hazards, they leave behind a number of the social, familial, economic production, and moral/ethical structures and modes that helped them to cope with crises in the past. The processes of development they seek and continue to pursue increase their exposure to hazard and erode their capacity for resistance and recovery.

If these ten trends and one coda toward increasing vulnerability have accompanied the very processes of development—previously viewed by human societies as central to any strategy for reducing vulnerability—then what does this tell us about assessing vulnerability? And how does this relate to current efforts to find a new approach to development that corrects these trends and is sustainable over the long run?

Vulnerability assessment and sustainable development

Recognition of the trends discussed above has focused attention on sustainable development. In particular, growing awareness of the negative and irreversible impacts of past development gains on the world's ecosystems has raised the specter of spiraling and expanding vulnerability that can be neither controlled nor contained. As a recent publication of the World Bank puts it, "Accelerated changes in demographic and economic trends have disturbed the balance between ecosystems, increasing the risk of human suffering, death, and destruction" (Kreimer and Munasinghe 1990, p. 3). Not only has the number of disasters risen over recent decades (that is, events with negative consequences on humans), but even more striking is the fact that the number of extreme weather events (whether or not they have had an impact on human societies) has also risen "about 50 percent on average each decade between 1900 and 1990, accelerating significantly since 1950" (Kreimer and Munasinghe 1990, p. 3).

The evidence of perturbations in the environment and ecosystems is strong. While debates continue within the scientific community regarding the actual changes that have occurred or are occurring in nature, most who study these issues agree that human-caused environmental degradation *probably* has had significant long-term impacts. As the leadership of the Scientific and Technical Committee of the IDNDR notes, "The increasingly realistic mathematical models of global climate tend to suggest a more hazardous world in the future" (Bruce 1993, p. 3). And, the point is widely accepted that sustainable development strategies must directly address the ways in which economic progress affects vulnerability.

Important, also, of course, are the effects of vulnerability on economic progress and, particularly, on the sustainability of that progress. One point of interaction discussed above is that human actions continue to undermine the environment. Significant damaging actions are undertaken by vulnerable populations who see no options for survival except to continue their (harmful to the environment) practices. Patterns of marginal living—in agriculture, in herding, in fishing, in forestry, that is, in the range of human activities undertaken to derive a livelihood directly from nature—often deplete the resources on which survival depends. This is increasingly true as population pressures mount.

Two additional points about the impact of vulnerability on the prospects for sustainable development should be made. Cumulatively, environmental degradation has produced a group of environmental refugees who comprise "the single largest class of displaced persons in the world" (Jacobson 1988, p. 37). These trends are likely to worsen over the next few decades and will, themselves, add to the pressures exerted on the environment of the regions to which they flee and undermine the chances of achieving sustainable development in those regions. Finally, current government-sponsored development efforts in many countries reinforce the tendencies toward future environmental depletion in an attempt to meet citizens' immediate needs for food, jobs, housing sites, and so forth. Short-term strategies undertaken in the name of development contribute to long-term hazards and reinforce the negative impact of vulnerability on the prospects for sustainable development.

However, because high and increasing vulnerability undermines the pursuit of sustainable economic strategies, reducing vulnerability and making progress in

sustainable development are mutually reinforcing. The linkage of the two may work either positively or negatively. Sustainable development is not possible without an explicit component that reduces vulnerability, and vulnerability will never truly be reduced until approaches to development are altered to meet the sustainability criteria now under discussion.

The characteristics of vulnerability

Above, we reviewed the growing understanding of disaster vulnerability gained through decades of experience with disaster response, and we discussed and identified the ways in which efforts to improve human life through development have been linked with trends toward increasing vulnerability. We further noted the interaction and mutual reinforcement of vulnerability reduction and sustainable development. With this background, we can identify five characteristics of vulnerability that must be understood and reflected in any vulnerability assessment framework. These characteristics are at the heart of the nexus of past development, increasing vulnerability, and future sustainable development. Specifically, vulnerability is complex, dynamic, cumulative, sometimes irreversible, and frequently impossible to contain.

Vulnerability is complex

It is not necessary to reiterate the myriad factors that together constitute and shape vulnerability, yet the starting point for assessing vulnerability must be to acknowledge that it is complex and affected by multiple factors. While always complex, however, vulnerability is shaped by different factors in different settings. That is, vulnerability is specific to a particular location, group, and circumstance.

Vulnerability is dynamic

Vulnerability is the product of interactions between natural and environmental forces and human, social, and political constructs. Because these are always changing in and of themselves and because they force corresponding changes through their interrelatedness, vulnerability is never static. Vulnerability assessments must, therefore, contain some system for noting and recording the direction and magnitude of change that is occurring.

Vulnerability is compounding and cumulative

Vulnerability is a self-compounding and cumulative phenomenon. Quite often, when people are vulnerable to and experience one disaster, they are left more vulnerable to subsequent hazards. If their resources are destroyed, if the assistance they receive promotes dependency, if their families or other social systems are undermined, they have less resilience for facing future hazards (Anderson and Woodrow 1989). Of course, disaster educators hope to see the reverse. That is, if people suffer once from their vulnerability, it is hoped that they will be motivated to undertake hazard preparedness and mitigation efforts that will reduce their vulnerability in the future. Too often, however, especially among poor and marginalized groups, vulnerability accumulates and compounds.

In addition to undermining economic reserves and personal confidence, vulnerability is additionally self-compounding in that one type of vulnerability, such as poverty, is often related to other types, such as poor health or lack of education. In this sense, too, people who are vulnerable in one aspect of their lives tend to be vulnerable in others.

Vulnerability is sometimes irreversible

Because depletion or extinction of the elements in the natural resource base lies at the heart of current vulnerabilities, sometimes these losses pose all the more serious threats because they are irreversible. That is, as resource use or effluent production approaches irreversibility in nature, vulnerability derived from them increases (Schramm and Warford 1989, pp. 11–12).

Vulnerability frequently has no borders and cannot be contained

Increasingly, also, environmentally based hazards (and vulnerability to them) are without borders or containment. Loss of the ozone layer, nuclear exposure due to accident, chemical poisoning, and so forth move with the winds and waters and atmosphere, so that the exposure to them (and resultant vulnerability) is separated from causation and is random and encompassing rather than controlled and limited.

It remains, now, to join these five characteristics of vulnerability to previously developed aspects of vulnerability assessment in a framework that communities and nations can use to analyze the sources of their vulnerability, to assess its seriousness, and to devise appropriate programmatic responses to reduce or eliminate it.

A vulnerability assessment framework

A vulnerability assessment framework must be simple enough to be useful but complex enough to capture reality. No framework can supplant thought or substitute for intelligence. As a tool, a framework can provide a schema for (1) ensuring that all factors considered critical for understanding are included in an assessment and for (2) picturing—and, thus, reminding us of the importance of—the relationships among these factors. It cannot, itself, make judgments or structure actions to be undertaken. It can be used by skilled, knowledgeable, and thoughtful people to help them do so.

Our framework has four steps. There is nothing surprising about these, because they reflect precisely the learning cataloged above.

Step 1: What? Identifying hazards

Scientific and technical information about the likelihood or probability of the occurrence and the magnitude, frequency, scope, and duration of hazards should be incorporated into this step. However, two categories of hazard must be considered. Technical and systems-based hazards must be included in addition to the so-called natural hazards of wind, water, earth, and fire. These include fuel, chemical, and nuclear accidents; breakdowns and disruptions in information, communication, and transport systems on which societies depend; and other dangerous perturbations that grow out of the production and distribution techniques of human societies.

This step can be pictured in the simple matrix shown below.

What?	*Probability*	*Magnitude*	*Frequency*	*Scope*	*Duration*
Natural hazards					
Human systems-based hazards					

Step 2: Who? Identifying exposure

Following the early vulnerability assessments, we acknowledge the importance of identifying the individu-

als, groups, and communities that are most exposed to any given hazard. This aspect of the assessment must take into account more than mere proximity, however. It must include any of the physical, geographical, economic, social, political, or psychological factors that cause some people to be particularly exposed to the dangers of any given hazard while others are, because of any of these factors, relatively protected. In some cases, because societies are connected to one another through environment, markets, and political systems, exposure is comprehensive and borderless. However, even though everyone has the potential to suffer from a borderless hazard, factors of wealth, reserve resources, options, and the like mean that different groups have differential risks. This step should consider all of these factors.

The matrix below depicts this step.

Who: Individual <—> Community <—> World

Factors	*Exposure*	*Capacity to withstand*
Proximity		
Economic class		
Social status		
Political status		
Psychological condition		

Step 3: Why? Identifying the complex sources of the hazard

This step incorporates the complexity and interrelatedness of natural, social, and developmental factors. Essential to assessing the impacts of hazards—to getting a complete picture of vulnerability—is analyzing why a particular hazard exists, why certain groups are more exposed to it than other groups, and whose actions, choices, or decisions were involved in creating it and why. Vulnerability is greater when the causes of hazards are deeply embedded in social and political or economic structures that are difficult to alter or reverse; when exposure to the hazard arises from deep-seated social and political structures for which we have no ready remedies; or when the decisionmakers and action-takers who help to "create" the hazard are powerful, removed from its consequences, and have little motivation to change their behavior or are powerless and poor and have few options other than to contribute to and exacerbate the hazard.

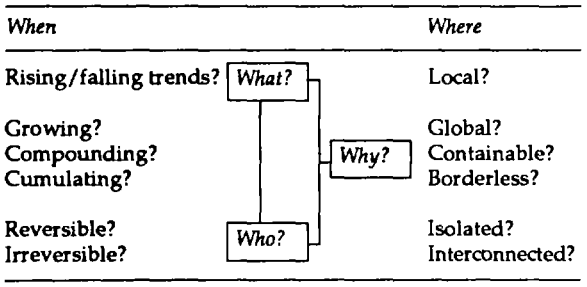
The diagram below depicts the major factors to be considered in asking why a particular hazard occurred and why a particular group was exposed.

Factor 1	*Factor 2*	*Factor 3*	*Factor 4*	*Factor 5*
History: What happened to make vulnerabi--lity high?	Who was involved in the decisions and choices?	What are their economic, social, political, and psychological characteristics?	Who is most affected by the decisions and choices?	What are their economic, social, political, and psychological characteristics?

Step 4: Time and space dimensions

Finally, the fourth step of vulnerability assessment takes account of the dynamic change and interrelatedness of factors that affect vulnerability. Included here are considerations of trends over time (increasing or decreasing? simple growth or compounding, cumulative growth? reversible or irreversible?) and over space (local or global? containable or borderless? isolated or interconnected?). Vulnerabilities that are growing, cumulating, tending toward irreversibility, and expanding through their interconnectedness without being containable within borders clearly pose far more serious problems and demand more immediate attention than those that exhibit the opposite characteristics. Assessment of vulnerability is incomplete without this step.

The fact that this step sets the broad context for the other three steps is illustrated in the diagram below.



As successive steps of the assessment framework incorporate the more immeasurable factors that require judgments based on values and the weighing of competing social, political, and economic goods, some people may become increasingly uncomfortable with the tool. Nonetheless, the importance of all of these factors is compelling. Their incorporation is neither utopian nor frivolous. They are essential aspects of the disaster vulnerability equation.

Additionally, although imprecise in the quantitative sense, all of these factors are increasingly evident and indisputable to researchers and policymakers alike. A broad review of the literature on vulnerability shows that these themes emerge time and again and that both research scholars and practical technicians cross traditional disciplinary boundaries and acknowledge even more complex factors as they seek to understand how and why vulnerability occurs.

Serious and humane motivations underlie efforts to expand the definition of vulnerability. The future of human life and of human social and political systems depends, to some large extent, on our ability to reduce our vulnerability to hazards, especially the vulnerability that is differentially experienced across social groups, and to pursue new approaches to development that ensure lasting, sustainable security and welfare.

Notes

1. In fact, we believe that solutions do exist, but they are not to be sought only in the scientific or technological spheres. Solutions will come, if they come at all and in time to reverse vulnerability, also from the spheres of social science—politics, communication, education, negotiation—that support effective decisionmaking and policy reform.
2. A billion is 1,000 million.

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4

Advantages and Limitations of Benefit-Cost Analysis for Evaluating Investments in Natural Disaster Mitigation

Randall A. Kramer

Natural disasters can be thought of as a sudden shock to the equilibrium of interrelations between natural systems and social systems. This results in a disequilibrium, the severity of which depends on both the magnitude of the disaster and the ability of the social system to absorb the shock (Albala-Bertrand 1993). Thus, a natural disaster with relatively low physical energy can have major social impacts if it occurs close to vulnerable human settlements and activities (for example, shantytowns in floodplains, hillside agriculture in deforested areas). Similarly a high-energy event can have modest social impacts if human settlements and activities are robust to disturbance (for example, due to building codes, windbreaks). Disaster mitigation is the activity of increasing the tolerance of the social system to the impacts of natural disasters. In areas subject to natural disasters, it is of great importance to analyze social investments within frameworks that allow consideration of the disaster risk exposure of the investments so that scarce development capital can be used in a risk-efficient manner.

Benefit-cost analysis is one means by which the economic effects of disaster mitigation and other social investments can be systematically evaluated. Since the impacts of natural disasters on development projects are inherently uncertain, risk must be explicitly introduced into benefit-cost analysis to obtain meaningful information for disaster mitigation. Although it is not uncommon for project benefit-cost analysis to include sensitivity analysis, it is less common to find more formal risk analysis incorporated. The purpose of this chapter is to examine the

potential for using benefit-cost analysis to improve project analysis related to disasters and disaster mitigation.

Natural disasters and project analysis

Development projects represent the investment of capital resources to produce a future stream of benefits that will support economic growth, reduce poverty, or achieve other social objectives. Careful project analysis is one of the most critical determinants of a project's successful outcome (Gittinger 1982). Although various typologies are used to characterize the project planning cycle, the three main phases are identification, pre-feasibility analysis, and feasibility analysis. As the name suggests, the identification phase is the search for potential projects in which to invest development capital. The pre-feasibility phase requires a rough calculation of project benefits and costs to eliminate those with low or negative net benefits. Of course, projects also may be screened at the pre-feasibility stage on the basis of environmental impacts, equity effects, and other criteria in addition to economic return. Finally, feasibility analysis requires refined economic and technical analysis of the viability of a project.

Most economic analyses of projects do not explicitly consider natural disaster information. As usually practiced, benefit-cost analysis fails to account for the fact that future project benefits may be highly uncertain if they are prone to the effects of natural disasters (Kramer and Grieco 1989). This is particularly true in developing countries where a high proportion of natural disasters occurs (Long 1978). The problem with ignoring risk is that a project implemented in an area subject to disasters may fail to realize the positive economic performance suggested by an ex ante benefit-cost analysis.[1] For example, if a tropical storm severely damages crops or if an earthquake seriously damages a new hydroelectric project, an agricultural development project's loan repayment may be jeopardized. Ideally, scarce capital funds should be invested in sectors with less vulnerability to natural disasters, or the projects should be redesigned to include effective disaster mitigation activities. This would prevent development projects from being hampered by economic analysis whose treatment of disaster risk is incomplete.

Several methods have been proposed for incorporating disaster information into benefit-cost analysis. Limited-information approaches include cutoff periods, discount rate adjustments, sensitivity analysis, and several game theory methods. These limited-information approaches allow analysts to recognize the impacts that natural disasters can have on project feasibility but are crude in their ability to convey useful information to decision-makers. If sufficient information is available to estimate the probability distribution of a project's stream of net benefits, several other approaches are possible, particularly safety-first analysis, mean-variance analysis, and stochastic dominance analysis. Each of these methods for incorporating disaster risk into the economic analysis of projects can improve investment decisions and help to avoid costly mistakes. Yet the methods are only as good as the underlying data, which are often inadequate for accurately characterizing disaster risk.

Risk-modified, benefit-cost analysis

The literature on benefit-cost analysis has long recognized the need to incorporate risk when project benefits and costs are uncertain (Mishan 1982). Various methods have been proposed for incorporat-

ing uncertainty, and these can be readily applied to assessing the risk associated with natural disasters. One set of methods is appropriate when partial information is available about the risk of natural disaster. A second set of methods can be applied when the analyst has enough information to estimate probability distributions of natural disaster events. The advantages and limitations of these risk-modified, benefit-cost methods will be considered below.[2]

Limited-information approaches

Various approaches can be used to determine the risk of natural disaster when information is limited. These include applying a cutoff period, adding a risk premium to the discount rate, using game theory approaches, such as maximin-gain and minimax-regret, and employing sensitivity analysis.

CUTOFF PERIOD

One of the simplest methods for dealing with uncertainty is to apply a rule-of-thumb cutoff period that dramatically shortens the assumed life of the project. This crude approach might be used if the primary concern is loan repayment rather than long-term development. In this case, economic feasibility relies on sufficient benefits to cover the project's investment costs in a relatively short time frame of perhaps two or three years. The logic of this approach is that net benefits are so highly variable beyond a selected cutoff date that they should be ignored in project evaluation.

Even this approach requires some information on natural disasters to guide the analyst. Episodic data on natural disasters or previous damage assessments can give the analyst a rough idea of the magnitude of disaster risk. Thus, for an agricultural project, a short payback period might be required if the project appears subject to a high risk of flooding or landslides. Note, however, that a short cutoff period is no guarantee that a project will be economically successful. A natural disaster might occur in the first year of the project and seriously disrupt the flow of benefits. The cutoff period approach is deficient since it does not deal with uncertainty in a systematic way and should only be used when a meager amount of information is available.

DISCOUNT RATE ADJUSTMENT

A second rule-of-thumb approach is to add a risk premium to the discount rate when there is significant uncertainty. The discount rate adjustment has the effect of giving less weight to increasingly uncertain future benefits and costs. Adding a risk premium is consistent with what has been observed in the private sector; loan managers generally charge higher interest rates for riskier investments. To use this approach, the analyst must first determine a risk-free discount rate and then determine the appropriate risk premium (Dasgupta and Pearce 1972). The risk-adjusted discount rate becomes:

$$(4\text{-}1) \qquad r_t = \frac{1}{(1 + i = j)^t}$$

where i is the risk-free rate, j is the risk premium, and t is the time period. To determine the risk premium, the analyst has to have some, albeit limited, information about natural disasters, similar to that used for the cutoff period approach.

Although it is relatively easy to employ, this approach reduces the expected value of a project's net benefits by a compound and arbitrary factor and does not recognize differences in the degree of uncertainty across different components of a project (Mishan 1982). This approach also reduces the worth of all future benefits whether or not they are subject to uncertainty.

GAME THEORY APPROACHES

In conducting an economic analysis of a project, especially at the pre-feasibility stage, an analyst may be aware of the possibility of impacts caused by natural disasters but may be unable to assign objective or subjective probabilities to the various states of nature that may occur. For example, records may exist of historical events such as earthquake damage to crops or buildings. Using such data, it may be possible to estimate roughly the benefits from a development project under varying degrees of natural disaster severity. One can then use several game theory approaches to guide investment decisions. Two are discussed here: maximin-gain and minimax-regret. Both use decision rules that focus on loss avoidance.

The maximin-gain criterion focuses on security of outcome by avoiding the worse possible result (Dasgupta and Pearce 1972). For this criterion, the decision rule is to compute the minimum payoff for each alternative and select the alternative with the highest minimum payoff. This can be illustrated with an example for a development project that generates agricultural benefits and offers protection from floods (Kramer and Florey 1987). Suppose three flood control alternatives can be included in the project at equal cost. Due to lack of more detailed information, the analyst considers two possible states of nature: heavy precipitation and normal precipitation. If precipitation is heavy, the net present values of the three flood mitigation schemes are $100 million, $120 million, and $150 million. If precipitation is normal, the mitigation alternatives provide net benefits of $30 million, $60 million, and $20 million, respectively. Project benefits are lower in the event of normal precipitation, since the primary objective of the project is flood control. The example is presented below:

Benefit matrix for alternative mitigation options

Option	*Heavy precipitation*	*Normal precipitation*
Option 1	$100 million	$30 million
Option 2	$120 million	$60 million
Option 3	$150 million	$20 million

The maximun-gain criterion would lead to the selection of option 2 since its minimum payoff is $60 million, which is larger than the minimum payoff of the other two options. This game theory method uses only part of the available information by focusing only on the worse outcome. It implies a conservative bias in project selection and hence might inhibit long-term development if used to guide social investments.

An alternative game theory approach is known as the minimax-regret criterion (Dasgupta and Pearce 1972). This criterion can be applied as follows. For each option, the actual payoff is subtracted from the potential payoff, where potential payoff is the amount that could have been realized if the state of nature was known in advance. This difference is defined as regret. For each option, the maximum regret that could occur is identified, and the option with the smallest maximum regret is chosen.

For the flood mitigation example above, option 3 would have the greatest benefit if heavy precipitation occurs. If option 1 had been selected, the regret associated with not selecting option 3 would have been $50 million ($150 million to $100 million). If option 2 had been selected, the regret would have been $30 million ($150 million to $120 million). If the state of nature had been normal rather than heavy precipitation, option 2 would have generated the greatest benefit, $60 million, and the regret would have been $40 million for option 3 and $30 million for option 1. Consider-

ing both states of nature—heavy and normal precipitation—the maximum regret would have been $50 million, $30 million, and $40 million, respectively, for options 1, 2, and 3. Hence, the minimax-regret strategy would lead to the choice of option 2 since it has the smallest maximum regret.

While the minimax-regret criterion is superior to the maximin-gain criterion because it uses all of the information in the benefit matrix, it still embeds a conservative bias. Furthermore, it implies cardinally measured utility since it measures regret by the difference between actual and potential outcome (Dasgupta and Pearce 1972).

SENSITIVITY ANALYSIS

Sensitivity analysis is perhaps the most widely used method to consider the impacts of uncertainty in benefit-cost analysis. Generally a table is presented showing the effects of changes in key parameter values on economic feasibility, such as net present value or benefit-cost ratio. The values might be varied by one standard deviation, although a more typical approach is to use arbitrary adjustments of 10 or 20 percent (Irwin 1978).

Sensitivity analysis could be useful in identifying which variables are important in determining project feasibility even when there is limited information about the occurrence and severity of a natural disaster. Furthermore, it could help to identify where mitigation might have the highest payoff. Although this approach is useful in identifying the relative importance of key variables in influencing a benefit-cost analysis, it does not consider the amount of uncertainty in key parameters or give any information about the relative riskiness of alternative investments.

Probability-based approaches

The limited information methods described above can be a useful first step in introducing considerations of natural disasters into the economic analysis of projects. Because they are not data intensive, these methods may be particularly relevant at the pre-feasibility stage of project analysis. However, for conducting feasibility analysis of a major project subject to considerable disaster impacts, the analyst would be advised to obtain probabilistic information on key variables. If probability distributions of natural disaster events can be obtained and linked to economic variables, a more rigorous and informative analysis can be conducted. Typically only a few variables that enter into a benefit-cost analysis are treated as stochastic, for example crop yields. Other variables are treated as known. The decision about which variables to treat as random will depend on both the availability of data and on the analyst's judgment about which variables are most important. This judgment may be based in part on an earlier sensitivity analysis. Once the decision is made about what to treat as stochastic, one can estimate probability distributions from historical data or from experts' subjective judgments. The various probability distributions can be combined to generate a probability distribution of net present value, internal rate of return, or some other feasibility measure.

Empirically, a probabilistic benefit-cost analysis can be carried out using stochastic simulation methods.[3] These methods draw random samples from specified probability distributions. If the random variables are believed to be correlated—for example, rice and maize yields—multivariate distributions can be used. The random draws are fed into a benefit-cost

analysis, and the resulting summary statistics are recorded. The procedure is repeated many times to generate a probability distribution of net present value or another feasibility measure. This generated distribution can then be used to convey information about the riskiness of the project in question.

Once the probability distribution of project benefits is available, it can be used in a variety of ways to rank investment alternatives. First, it can be used simply to compare expected net present value across projects. This is basically equivalent to a standard benefit-cost analysis in which one uses the most likely values of the important economic variables. The disadvantage of comparing expected outcomes is that such a comparison does not use all of the information in the probability distribution. Furthermore, it assumes that decisionmakers are risk neutral and hence indifferent between projects with equal means but different degrees of dispersion. If this was the case, one should have ignored risk to begin with. To make better use of the risk information at hand, other approaches are preferable. These include safety-first analysis, mean-variance analysis, and stochastic dominance analysis. Each will be discussed below.

SAFETY-FIRST ANALYSIS

This method focuses attention on the downside risk associated with project investments. If decisionmakers are concerned about the potential damages resulting from natural disasters, they may wish to use a decision criterion that emphasizes the lower tail of a probability distribution of project benefits. This is particularly useful if project benefits exhibit nonsymmetric distributions like the beta. One way to operationalize the safety-first decision rule would be to solve the following problem:

$$(4\text{-}2)\quad \textit{Maximize } \overline{NPV} \quad \text{subject to } Pr\,(NPV < t) \leq a$$

where Pr is probability, t is a critical threshold value, and a is a small probability level, such as 5 percent. This decision rule chooses projects with the highest mean return subject to the constraint that returns have a small chance of falling below a critical threshold level.

An interesting alternative formulation has been proposed for dealing with projects that have potential impacts on the survival of endangered species (Randall 1991). Known as a safe minimum standard, the emphasis of this formulation is even more explicit in minimizing risk:

$$(4\text{–}3)\quad \textit{Minimize } Pr\,(Z < u) \quad \text{subject to } OC \leq A$$

where Z is size of the species' population, u is a critical threshold for the population, OC is the opportunity cost of protecting the habitat, and A is a socially determined level of acceptable cost. In other words, in selecting project alternatives, the probability that the endangered species population will fall below a critical threshold is minimized as long as the opportunity costs of doing so (forgone development alternatives) are not unacceptably high.

MEAN-VARIANCE ANALYSIS

Another method for using probabilistic benefit-cost information is to compare the means and variances of the distribution of returns from different projects (see Keeney and Raiffa 1976). In particular, decisionmakers may want to consider tradeoffs between higher expected return and lower risk. A project with less chance of being undermined by a natural disaster might be chosen over a project with higher expected return but subject to greater disaster risk.

According to Dasgupta and Pearce (1972), the decision rule can be stated as follows:

(4–4) *Maximize* $U = E - bV$

where U is utility of project returns, E is expected return, b is a risk-aversion coefficient between 0 and 1, and V is variance of return from the project. The higher b is, the greater the aversion to risk.[4] This decision rule simultaneously considers the mean and variance of returns for each project. The second term in the expression serves to penalize projects with greater risk.

The mean-variance approach to decisionmaking is prevalent in financial decision analysis but is seldom applied to benefit-cost analysis. For financial analysis, procedures have been developed to elicit risk-aversion parameters to guide decisionmaking. An appropriate risk-aversion parameter for social investment decisionmaking is difficult to determine. However, by reporting means and variances for different projects or different versions of the same project, analysts can provide decisionmakers with information on the tradeoffs between expected return and risk. Those decisionmakers can then apply their own subjective weights in comparing projects.

STOCHASTIC DOMINANCE ANALYSIS

The final method for comparing probabilistic information on project returns is stochastic dominance analysis. This method is the most general technique used to compare probability distributions. It is consistent with axiomatic-based expected utility theory and does not require the strong assumptions of mean-variance analysis. Stochastic dominance analysis allows probability distributions to be ranked for different classes of risk averters. Using entire distributions of returns, alternative projects can be ranked. This approach has been applied to risky problems in the financial and agricultural economics literature but has not been used to examine the effects of natural disasters on the feasibility of development projects. However, it holds considerable potential as a rigorous method for ranking risky projects or different mitigation options.

Empirical issues

To use the probabilistic approaches discussed above, two empirical issues must be addressed: estimating probability distributions and evaluating nonmarket environmental impacts of natural disasters.

Estimating probability distributions

It is essential to estimate the probability distributions for natural disasters, crop yields, and other key variables. The distributions can be estimated with standard statistical techniques if historical data are available. For example, if the historical records indicate that hurricanes have struck an area in two of the past twenty years, a probability of 0.1 would be assigned to the likelihood that a hurricane would occur in any given year. If stochastic simulation methods are employed, a particular type of probability distribution (for example, normal or uniform) would be assumed and random draws that reflect historical frequencies would be generated. Probabilities based on historical frequencies are often referred to as objective probabilities.

When historical data are not available or when environmental changes have occurred that would render historical frequencies a poor predictor of future events (such as extensive deforestation causing an increase in landslides), the analyst may wish to use subjective probabilities. Subjective probabilities reflect personal judg-

ments about the likelihood of different states of nature. Since most decisionmaking is based on decisionmakers' subjective probabilities, subjective probability is now widely accepted for supporting decision analysis (Bessler 1984). Project analysts could use subjective probabilities from disaster experts about the likely occurrence of tidal waves, landslides, floods, and other natural disasters. They might also consult agricultural experts (including farmers) about the probability of different yield levels given various states of nature.

Various methods are available for eliciting subjective probabilities from decisionmakers (see Norris and Kramer 1990 for a review). One simple and effective approach is known as the triangular distribution method because of the shape of its probability distribution function. The apex of the distribution is at the mode, and the other two angles occur at the upper and lower end of the distribution. Thus only three values are needed to estimate the distribution: the mode and the maximum and minimum values.

Evaluating nonmarket environmental impacts of natural disasters

When natural disasters affect market activities, it is relatively straightforward to estimate the economic impacts. For example, disruptions in the transportation sector can be valued based on lost commercial traffic and damage to infrastructure. However, natural disasters often have impacts on the environment that are not readily monetized based on market prices. In such cases, nonmarket valuation methods are needed to estimate the impacts of natural disasters. These methods, which have come into fairly widespread use over the past decade, are briefly reviewed below (for more detailed descriptions of the methods, see Braden and Kolstad 1991; Freeman 1993; for applications in a developing-country context, see Kramer and others 1993; Munasinghe 1993). Each is a means of estimating shadow prices for changes in environmental quality.

TRAVEL COST METHOD

This method has been developed to estimate the recreational demand for particular sites when market prices are not available. The principle underlying this approach is that people spend time and money to travel to a recreational site, and these expenditures can be interpreted as a price, or willingness to pay, for the site.

To implement this valuation method, visitors to sites are surveyed to determine their costs of travel to the sites. In addition, data on socioeconomic characteristics are collected. Statistical regression analysis of the data is then used to estimate a demand function for the site. If a natural disaster such as a hurricane alters the possibility of using a recreational site, such as a beach area, the travel cost method could be applied to substitute sites to measure the economic losses associated with having fewer recreational opportunities.

CONTINGENT VALUATION METHOD

Another approach that is used to estimate nonmarket values is to ask people directly about changes in their welfare. This approach is based on a questionnaire administered to a sample of the population. Through a series of questions, an attempt is made to get respondents to reveal their willingness to pay for environmental services. For example, people can be asked to assign a value to a national park area damaged by a natural disaster. The question might be phrased as "How much would you be willing to pay to restore the park to its pre-disaster state?" Using

sample survey methods, the contingent valuation responses can be generalized to a larger population to estimate aggregate damage to resources.

There are some potential biases with the contingent valuation approach. For example, people's responses are for a hypothetical market and may not reflect their behavior if they were confronted with an actual market. Another problem is known as strategic bias. Fishermen may state a very high willingness to pay in hopes that this will lead to a wetlands area being preserved or restored. However, these biases can be overcome with proper questionnaire design and statistical analysis.

LAND PRICE ANALYSIS

Although many environmental attributes are not traded in markets, their presence may have an effect on property values. Land prices may be lower for land parcels subject to flooding or landslides. By statistical analysis, the component of land values attributable to environmental amenities or disamenities can be estimated if data are available on land prices, environmental characteristics, and other real estate characteristics for a large number of land parcels. Using multiple regression techniques, the contribution of natural hazards to land prices can be determined. This amount will be a measure of people's willingness to pay to avoid the hazard. A limitation of this approach is the difficulty of obtaining sufficient data on land parcels, especially in developing countries.

PRODUCTIVITY ANALYSIS

Productivity analysis uses a biological production function to measure the effects of environmental change on the productivity of a resource. This change in productivity is then measured in monetary terms using prices for the affected resource product. For example, a demand function could be estimated for fish to determine the benefits provided by wetlands habitat destroyed by hurricane. If the presence of wetlands before the natural disaster provided breeding areas and increased food supply for various fisheries, and these fisheries were commercially exploited, then the value of the lost or degraded wetlands could be measured by the dollar value of the decline in fish catches resulting from the wetlands damages.

This is a clear example of the need for an interdisciplinary approach. Biological information is needed on the effects of wetlands on the size and harvest of fish populations. This information can then be used to determine the contribution of the wetlands to the fish catch, and benefits can be calculated from the change in economic activity.

OPPORTUNITY COST ANALYSIS

This method values environmental resources based on the cost of replacing the services of a resource destroyed by a natural disaster. For example, if a wetland assimilates waste, the benefit of those services can be given a value by calculating the least-cost alternative of substituting for those services. If a wetland filters out nutrients from agricultural runoff, then the absence of the wetland would require some substitute way of preventing those nutrients from entering downstream waters in order to maintain the same level of water quality. For example, farmers might be required to change their agricultural technologies to reduce their fertilizer application rates or to increase the uptake of nutrients by their crops. By estimating the incremental cost of the new technologies, an economic value can be assigned to the waste assimilation services of a degraded wetland.

An illustration: Disaster mitigation for an agricultural project in St. Lucia

In this section, a case study of an agricultural development project on the Caribbean island of St. Lucia is introduced to illustrate the use of natural disaster information in benefit-cost analysis (Kramer and Grieco 1989). The project was designed to promote agricultural and natural resource development with an emphasis on crop production. The case study focuses on banana production on the Dennery Estate.

Bananas comprise the major agricultural activity in St. Lucia and were planted on 71 percent (10,000 acres) of the arable land at the time of the study. Banana production fluctuates widely; during 1970–84, the volume of exports ranged from 29,000 to 64,000 tons. The high variability of exports was due in part to production shortfalls arising from drought, high winds, and hurricanes (Hammerton, Calixte, and Pilgrim 1979). Efforts to address drought problems have relied on irrigation development. Damage from hurricanes and high winds is less amenable to mitigation. Crop damage can result from the defoliation action of rain, as well as leaching, erosion, uprooting, and flooding that result from the prolonged heavy rains that accompany hurricanes. The uprooting problem can be diminished by controlling nematodes, which weaken root systems.

The Dennery Estate was purchased by the government in 1978 to avert bankruptcy and assure stable employment in the area. In 1984, the Organization of American States (OAS) initiated a project to aid the government in rehabilitating the estate to increase agricultural income and employment. Because banana production was the major income producer for the estate, the project targeted 300 acres for new plantings of banana trees. The case study used OAS project data whenever possible, but no information was available on natural disasters. Additional data were introduced to conduct the risk analysis.

Existing roads were considered adequate to handle the additional farm production, so the new infrastructure was limited to a few buildings. Other initial investments included the purchase of a vehicle, the installation of irrigation equipment, and land clearing. The investment costs, obtained from the OAS project proposal, totaled EC$1,359,450 (East Caribbean dollars; see table 4-1). Operating costs for the project, which include transportation expenses and security, totaled EC$519,275 for the first year and increased slightly in later years due to higher transportation costs associated with rising yields. The production costs, including planting, weeding, fertilizing, and pesticide application, were EC$532,200 in the first year and dropped to EC$476,700 in later years.[5] These costs are also summarized in table 4-1.

The primary benefit of the project was the increased production of bananas. In the first year, 1,074 additional tons resulted from the project; in subsequent years, the projected mean yield was 1,434 tons a year. Based on growers' price, these annual production figures represented EC$397,595 and EC$530,866, respectively. Because of high unemployment in the area, wages paid to laborers were considered an additional project benefit.[6] Total project benefits, shown in table 4-1, were estimated to be EC$1,308,347 in the first year and EC$1,482,951 in subsequent years.

A conventional benefit-cost analysis could be conducted based on the data in table 4-1, but such an analysis would clearly be inadequate for consideration of

Table 4-1: Annual Benefits and Costs for an Agricultural Development Project in St. Lucia
(in East Caribbean dollars)

Benefits and costs	*First year*	*Each subsequent year*
Benefits		
Income from banana production	397,595	530,866
Direct employment	621,736	572,896
Off-farm employment	269,016	359,188
Road maintenance	20,000	20,000
Total benefits	1,308,347	1,482,951
Costs		
Initial capital costs	1,359,450	n.a.
Production costs	532,200	476,700
Other operating costs	519,275	519,914
Total costs	2,410,925	996,614

n.a. Not applicable.

Table 4-2: Disaster Return Frequencies and Estimated Effects on Yield
(percentages)

Type of disaster	*Return frequency*	*Decrease in yield*
Hurricane	5.95	90
Drought	14.20	15
Tropical storm	14.81	60
Moderate winds (13 to 24 miles per hour)	34.20	20

Source: Florey 1986.

the impacts of natural disasters. The most common disasters that affect banana production in St. Lucia are high winds, hurricanes, and drought, although volcanic eruptions, earthquakes, and flash floods have been reported in the general area. Any of these disasters could affect banana production—and hence the flow of project benefits—or require additional expenditures beyond the estimated rise in costs of the project. The amount of damage would depend on the type and magnitude of the disaster. A shortfall in banana production would reduce crop revenues as well as labor income in the production and processing sector.

Disaster return frequencies are shown in table 4-2. Each of these natural disasters could have significant impacts on yields. Using data from a variety of sources, yield impacts were estimated for a typical disaster event. As shown in table 4-2, the natural disaster impacts range from 15 percent for a typical drought event to 90 percent for a hurricane. The impacts on yield would be greater if more than one disaster occurred in a given year. Droughts and tropical storms have similar return frequencies, occurring approximately once every six years (14 percent), but tropical storms have a greater damaging effect on yields.

For purposes of this analysis, the disaster events were assumed to be distributed independently. It was also assumed that disasters only affected the project by reducing yields. Although additional costs may be incurred as a result of a storm or drought, no information was available to quantify such changes in costs. From anecdotal reports, it appears reasonable to assume that the primary impact of disasters on the project's net benefits is through the impact on agricultural yields.

The effects of natural disasters on project economics were initially captured by using an historical distribution of crop yields. Data on banana yield for the Dennery Estate were available for 1970–84. The mean yield was 4.78 tons per acre with a range of 2.77 to 8.15 tons. A statistical test for upward trend in the data revealed no systematic trend, hence the variation was apparently due to weather-related shocks to the production system. The historical yields were used to generate a probability distribution from which random draws were generated for the risk analysis. The randomly drawn yields were used to calculate the benefits and costs of the project and to calculate a new internal rate of return for each random draw. This allowed a probability distribution to be estimated for the project's rates of return. The random number generation and benefit-cost calculations were carried out with a stochastic simulation program written by the author.

Once the base benefit-cost analysis was completed, disaster mitigation was introduced. A mitigation practice advocated by agricultural experts is the use of nematicides to strengthen the roots of banana plants by protecting the root system from parasites. This reduces the chance of the plants being uprooted by low to moderate windstorms, although the practice is not effective against hurricanes. The use of nematicides was estimated to increase establishment costs by EC$74 per acre and annual production costs by EC$270 per acre. The primary benefit of mitigation would be an increase in banana production in years with windstorms.

The historical probability distribution of banana yields was truncated to reflect the risk reduction afforded by the mitigation measure. The truncation involved cutting off the lower tail of the distribution, which reflected disaster-reduced yields.[7] This truncated distribution was then used to estimate a probability distribution of project net benefits with the mitigation measure.

Several risk-modified, benefit-cost methods were used to examine disaster mitigation for this case study. The results for one of the methods, mean-variance analysis, are reported in table 4-3. If mitigation was not included, the mean rate of return to the project was 29.5 percent. The coefficient of variation (standard deviation divided by the mean) was 69 percent. Including the mitigation practice reduced the mean rate of return to 27.6 percent but also lowered project risk. The coefficient of variation was lowered to 62 percent,

Table 4-3: Internal Rate of Return for an Agricultural Development Project With and Without Disaster Mitigation

Indicator	*With mitigation*	*Without mitigation*
Mean	0.295	0.276
Coefficient of variation	0.691	0.616

indicating that the investment in mitigation brought about the desired reduction in risk. A decision based solely on the average of project economic indicators might lead to a rejection of the mitigation measures since the mean rate of return to the project was lower with the measure. This underscores the importance of the added information on variability of project returns. Depending on the degree of risk reduction, planners or policymakers might be willing to trade lower expected return for lower risk.

Implementation issues

Natural disasters are a global concern because they affect such a large portion of the earth's landscape and population, but the management of natural disasters is one of several environmental concerns that remain to be integrated into development planning (Bender 1991). In many cases, development planners view disaster prevention and mitigation as unaffordable extras when they plan projects and programs (Anderson 1991). The international development community can do much to promote the integration of disaster considerations into planning efforts. Risk-modified, benefit-cost analysis is one tool to assist these efforts. Since it represents an extension of a widely used analytical tool, it has considerable potential for adoption. Furthermore, the results of risk-modified, benefit-cost analysis can be used to show policymakers and planners that disaster prevention or mitigation is often less costly than disaster recovery.

However, obtaining the requisite data for estimating probability distributions is challenging in many cases. Oftentimes, historical or episodic data are of insufficient duration to estimate reliably the probability of an event. Alternatively, subjective probability elicitation methods can be used, but many benefit-cost practitioners are unfamiliar with these techniques. In addition to the challenges of estimating the frequency and severity of a disaster, there is the need to translate these physical impacts into monetary terms. Some impacts require the use of nonmarket valuation methods. While such methods are increasingly applied in a developing-country context, the skills needed to do so are in limited supply. For these reasons, a full integration of disaster considerations into project economic analysis will require considerable investments to upgrade the skills of project analysts.

In developing countries, poverty and vulnerability to natural disasters often go hand in hand. This is due to population growth and continued modifications in environmental systems brought on by uncontrolled changes in land use (Kreimer and Munasinghe 1991). Low-income populations are often the hardest hit by natural disasters, and the slow pace of the ensuing disaster recovery measures may exacerbate existing income inequalities. Hence, disaster mitigation can have significant equity implications. The distribution of benefits from projects with and without disaster mitigation components can be quite different. While benefit-cost results are often reported in the aggregate, the methods described in this chapter can be used to generate net benefit estimates for different groups in a society. This information would provide assistance to those concerned with how development alternatives affect poverty. Disaggregating the economic impacts would also provide insights into the local, regional, and national implications of disaster mitigation.

Implications for sustainable development

Natural disasters are a major impediment to economic development and cause massive loss of life and property. The losses are significant to the countries where they occur and to the private and public investors in development activities. Yet, national and international development agencies often act as if their programs and natural disasters are unrelated. Investing in disaster mitigation can lessen damage and hasten recovery. By maintaining the momentum of development, protecting some of the most economically and environmentally vulnerable populations, and reducing damages to natural environments, disaster mitigation holds promise for helping to achieve the goals of sustainable development.

This chapter has shown a variety of ways in which information about natural disasters can be included systematically in the economic analysis of projects and programs. Because risk-modified, benefit-cost analysis has not been widely integrated into the project activities of development agencies, it is not possible to judge fully its potential effectiveness. An applied research effort combining experts from social and natural sciences should be initiated to develop a series of case studies to determine which of the methods described here would be most effective in project analysis. The case studies should be selected so as to gain experience from applying the methods in a variety of sectors and a variety of disaster vulnerabilities. Only after such experience is gained can the practical value of modified benefit-cost analysis be judged appropriately.

Notes

1. Frank Knight proposed in 1921 a distinction between risk and uncertainty that relied on the unquantified nature of the latter. This distinction was adopted by many succeeding writers. With the emergence of subjective probability assessment as a legitimate means of quantification, much of the modern literature, including this paper, uses the terms risk and uncertainty interchangeably.
2. This section draws on earlier work by Kramer and Florey (1987).
3. Until recently, analysts wrote their own programs for probabilistic benefit-cost analysis. However, spreadsheet programs now offer risk analysis add-ons that simplify the procedures. One example is the commercial package @RISK, which allows probability distributions to be specified for random variables used in the Lotus 1-2-3 or Excel spreadsheet programs.
4. Mean-variance analysis can be consistent with the theory of expected utility decisionmaking if one either assumes a quadratic utility function or assumes that returns have a normal probability distribution. Although these are rather strong assumptions, much of the risk and finance literature argues that such assumptions are not unreasonable approximations. See, for example, Levy and Markowitz 1979.
5. A potentially significant cost not included in these figures is the environmental cost of agricultural production in rolling terrain. Bananas do not have good soil-holding properties, so increased soil erosion is likely to occur when natural cover is removed to plant bananas. The project plan called for removing highly erodible land from

production, which could offset increased erosion from the expansion of banana production. In addition, the project called for ecological monitoring to determine the extent of environmental damage resulting from project activities. More research is needed to estimate environmental costs of agriculture in the study area, using methods such as the travel cost method, contingent valuation method, land price analysis, productivity analysis, and opportunity cost analysis.

6. An OAS report states that "Crop production is expected to remain the principal source of income for the rapidly increasing population of the Valley. The main opportunity for sustaining, if not improving, *per capita* income will be in the more intensive use of the land" (OAS 1985, p. 25).
7. The years with the three lowest yields were assumed to have been affected by high winds since a check of disaster records showed no drought or hurricane events in those years. The yields for those three years were replaced with the mean of the remaining year's yields. See Florey 1986 for additional details.

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5

A Review of the Disaster-Related Activities of the Asian Development Bank: An Economic Perspective

Günter Hecker

Most of the Asian Development Bank's developing-country members are subject to disasters, which are defined as events that so disrupt the afflicted community that it is unable to cope.[1] In terms of the ADB's operations, a community would normally refer to a significantly large region or even a whole country. The Asia Pacific region is subject to about 60 percent of the major natural disasters of the world, resulting in losses of roughly $5 billion to $10 billion a year according to preliminary ADB estimates.[2] As population continues to become more dense in the region, many of the disadvantaged will be pressured to settle in hazardous areas. This will increase the vulnerability of the country as a whole to disasters. Each disaster threatens to impede economic development, and the ADB has been prompted by such events to seek better ways of helping developing-country members resume progress in their development as soon as possible. As a part of this process, the ADB is carrying out an economic evaluation of some of its disaster-related activities. The preliminary results indicate that greater stress could be placed on economic analysis for improving the quality of the ADB's disaster-related projects.

In this chapter, the following definitions are used:

- *Disaster mitigation.* Works and actions to reduce the losses from the next disaster, such as providing physical barriers to impede the disastrous event (flood levees or cyclone-proof housing) and setting up constraints to development that reduce the exposure of people and their possessions to disaster (thoroughly

implemented building codes, land use planning).

- *Predisaster planning.* The formulation of procedures, lines of communication, and levels of responsibility for counter-disaster activities; the storing or ready provision of equipment and materials; public preparedness campaigns that determine evacuation routes, emergency shelters, and backup systems; training and exercise programs for emergency service personnel; and procedures for restoring essential services and infrastructure as quickly as possible.
- *Disaster relief.* Activities that provide the basic necessities of food, clothing, shelter, transport, and medical, psychological, and social assistance; the ADB is neither involved nor designed to become involved in this field.
- *Disaster repair.* Activities such as restoring essential services, reinstating communication links (including transport), providing temporary infrastructural items (such as temporary school rooms), and rapidly restoring items that are easily made workable again, even if in incomplete form.
- *Disaster reconstruction.* Restoration of damaged infrastructure to its level of effectiveness (or better) before the disaster.

The ADB's increasing response to disasters

Following its charter, until mid-1980, the ADB sought to foster economic growth and cooperation in the Asia Pacific region and to help accelerate economic development in its developing-country members. This aim was interpreted as requiring the ADB to concentrate on activities that emphasize long-term growth. Accordingly, the ADB developed policies and procedures that were appropriate for laying the groundwork for economic progress. Projects emphasized efforts to develop infrastructure, strengthen institutions, and improve economic and financial efficiency. With this perspective, the ADB regarded its role as providing the infrastructural basis for coping with cataclysmic events and fostering self-reliance by strengthening those agencies needed to develop and maintain that infrastructure. In other words, it perceived its role as funding large disaster mitigation projects that frequently entailed heavy engineering construction *before* the event. Thus emphasis was typically placed on projects such as flood mitigation and drainage works and technical assistance to complement these projects.

Development of the ADB's role

In the 1980s, the ADB broadened its involvement in the field of disasters. Following requests for assistance after natural disasters in the mid-1980s, the ADB adopted policy papers to guide staff on recovery assistance following disasters. The first of these, *Rehabilitation Assistance to Small DMCs Affected by Natural Disasters* (Asian Development Bank 1987), was intended for small developing-country members, particularly Pacific Island countries and the Maldives. This policy paper outlined how to support simple repair projects by providing limited funding for imported goods needed for urgent repairs and associated local costs. It was reasoned that this specialized facility was desirable because the disasters would be more disruptive to very small economies than to larger ones.

To accommodate requests from larger countries, a more general policy was outlined in a follow-up paper, *Rehabilitation Assistance after Disasters* (Asian Develop-

ment Bank 1989). Again, the stress was on modifying procedures that would enable the ADB to help developing-country members to recover expeditiously.

Both policies justified ADB assistance to disaster reconstruction by noting that, as a multilateral agency, the ADB would have a role in responding to the needs of developing-country members affected by disasters if the resultant damage threatened to interrupt, or was prejudicial to, economic growth and development.

Recent considerations of the ADB's role

Recently, the ADB began to reconsider the role it plays in supporting reconstruction following a disaster and in coordinating the efforts of donors who are assisting with disaster relief, repair, and reconstruction.

DISASTER RECONSTRUCTION

Simply reproducing previous structures may not always be the most viable approach because outdated and weak structures may be destroyed and should be replaced by more modern and stronger ones better suited to meeting the country's long-term development requirements. Such new structures may even help to prevent damage from disasters in the future. It follows that a disaster may provide an opportunity to improve previously existing facilities, and the next opportunity may only arrive when the next disaster strikes.

To overcome the dilemma of trying to implement a disaster reconstruction project quickly and ensuring the project is of a high quality, some recent projects have been implemented in two stages: repair and reconstruction. In the repair phase, the emphasis is on restoring sufficient facilities to allow economic life to start to return to normal. Examples of such items are bailey bridges, temporary school buildings, temporary shelters, and portable power generators. Such repairs reduce the pressure for hasty action and give planners time to formulate the final project, which constitutes the reconstruction phase.

DONOR COORDINATION

A matter requiring increased attention is ensuring proper coordination of the donors who are assisting with disaster relief, repair, and reconstruction (disaster recovery). Different donor agencies have different sectoral strengths and country programs, and every effort should be made to take advantage of these. It is becoming apparent that the coordination must do more than simply facilitate sharing the task of helping the country recover from the disaster. It is essential, first, to agree on the fine details of who is responsible for different aspects of the disaster-recovery program, particularly where activities and schedules are linked. It is also important for the overall progress of each donor to be monitored, to ensure that the work is appropriate, that any gaps in the assistance provided are attended to before they become serious, and that there is close liaison with the developing-country member.

An economic review of some of the ADB's disaster-related projects

The ADB is involved in both disaster mitigation and disaster reconstruction projects funded by emergency loans. This section reviews and evaluates those efforts and presents a case study of a flood-prone road network in Bangladesh.

Disaster mitigation projects

Since 1972, nine loans totaling nearly $660 million in support of disaster mitigation have been approved, of which, five have

had their benefits evaluated. All of the disaster mitigation projects except one were concerned with flooding. In addition, ten new disaster mitigation loans amounting to $490 million are in the pipeline for 1994–96. Considerable technical assistance was also provided during this period, mostly in support of the loans. A pipeline of seven technical assistance loans costing nearly $4 million is earmarked for 1994–96.

Based on the assessments of completed and ongoing mitigation projects, through the ADB's post-evaluation activities, criteria were selected to analyze the relative successes and weaknesses of the various loans. The projects encompassed major public works such as embankment protection, construction of dikes, dredging, and improvement of drainage.

The cost of the mitigation project loans ranged from about $10 million to $160 million. The completed projects were all successful in securing land against regular inundation or against interruptions in the supply of water for irrigation. Support was also extended to the fisheries sector, and some projects addressed issues related to poverty reduction. In projects that covered settlements of a certain magnitude, issues of urban development, housing, and sanitation were also addressed (for example, the Secondary Towns Integrated Flood Protection and Dhaka Integrated Flood Protection projects in Bangladesh and the Irrigation and Flood Protection Rehabilitation Project in Viet Nam).

Although project objectives seldom changed, the scope of the projects frequently entailed time extensions. Most projects were flexible enough to adapt to changing circumstances, and this is to be commended. Most of the project objectives were achieved, as were additional benefits, most noticeably, an increase in private construction, employment, and economic activity.

The economic internal rate of return at appraisal averaged 31 percent per project and ranged from a low of 12 percent to a high of 42 percent. In one project, Special Agricultural Inputs Supply in the Philippines, the implementation period was deemed too short to calculate its economic internal rate of return, and its benefit-cost ratio was computed instead. A note of caution is warranted: many of the projects analyzed were explicitly concerned with the robustness of the calculated result. A primary cause was the lack of high-quality data. The paucity of data, both ex ante and ex post, is a serious impediment to measuring the benefits of disaster-management projects in general. The intrinsic issue is the need to assess what would have occurred without the project. In most of the projects reviewed, social and economic benchmark indicators were not available for the period before and after the disaster, which impeded any attempt to assess the benefits of the project. If net benefits are to be estimated with any degree of certainty—and this needs to include the evaluation of certain intangibles—then increased project expenditures are necessary to ensure that the data relevant for assessing project outcomes are collected.

The required information often does exist, albeit in an uncommon form or in a location different from that of the government agency with which the ADB is dealing. Also, sometimes local knowledge or judgment may be used, as was done in Viet Nam to assess the stability of Hanoi Dike when subject to floods. This assessment was used to estimate the probability that the dike would fail before and after rehabilitation. To ascertain this information in a more scientific manner would have taken more time and expense than

was warranted at that stage. These matters are being addressed in a forthcoming publication, *Handbook for Preparing Emergency Loans* (Asian Development Bank, forthcoming). There has also been a growing appreciation of socioeconomic and environmental concerns in line with the general policy directions of the ADB.

Disaster reconstruction projects funded by emergency loans

Since 1987, 8 percent of the ADB's soft Asian Development Fund loans have been for emergency projects totaling $606 million. This total comprises twenty emergency loans, whose benefits are normally high. This is not surprising, since the work of rehabilitation frequently builds on existing assets, which, although they are damaged, substantially reduces the need for expensive tasks such as clearing, land purchase resettlement, foundations, and earthworks.

The practice of not accounting for sunk costs—funds already spent and related to the project—warrants closer attention in calculating the costs and benefits of a project. Marginal analysis requires that only additional benefits and costs actually accruing to the project be considered. Sunk costs are precluded. If activities having high marginal returns are considered, regardless of existing accumulated investment, the actual benefits of a project may be distorted. A careful approach is therefore necessary in defining the scope of projects involving reconstruction.

Because the benefits realized by disaster-recovery projects are almost invariably high, the ADB formulated guidelines for preparing emergency loans that downplayed the need to evaluate the benefits of a project. It was argued that because the worthiness of the project was almost self-evident, the benefits for urgent projects did not have to be proved. As it turned out, once the new guidelines were issued, few emergency projects had their benefits evaluated.

In hindsight, this advice did not put sufficient stress on a second use of benefit-cost analysis, namely the insight it gives for improving the form of the project. In order to address this shortcoming, a handbook is being written to guide ADB staff on preparing emergency loans. One section of this handbook will outline techniques for rapidly evaluating the benefits of emergency loans. Although their accuracy will be relatively poor, such evaluations are still valuable for several reasons:

- When a project manager knows only the cost of a project, he or she may try—albeit unconsciously—to minimize those costs, rather than to maximize the benefits.
- Without understanding the benefits of a project, the project designer will have to rely on noneconomic criteria such as standard practices and judgment. However, these can be misleading, because the circumstances of the ADB's projects vary considerably.
- In a sense, less stress could be placed on the estimated economic internal rate of return of the disaster-recovery project because it is virtually certain to be very high. What is important is the set of questions that the investigator asks when evaluating the benefits. That is, asking questions that enable the benefits to be calculated may uncover contradictory information. This may suggest that a given line of action, which seemed appropriate initially, may not be all that beneficial.

In Western Samoa, for example, a severe cyclone, with storm surges and highly erosive waves, damaged the south coast

of the island of Upolo in 1991. As part of the rehabilitation strategy, beach protection was proposed using large rocks. However, these rocks would detract from the last unspoiled beaches on the island and would reduce the attractiveness of the beaches to tourists and thus the income derived from them. Further, when seeking to quantify the benefits of these coastal protection works, it was found that, based on historical records, this was the first cyclone to affect the southern coast for more than a hundred years. It was concluded that the high cost of coastal protection works was not justified.

Evaluation of the benefits of disaster-related projects

Under the ADB's guidelines, a project is normally evaluated to provide an economic internal rate of return to justify assistance. Project analyses tend to focus on easily measurable costs and benefits. Most of the flood-control projects reviewed here simply analyzed the benefits derived from reducing direct property damage. Even the indirect benefits derived from preventing the intrusion of saline water by improving drainage systems and from using embankments as roads and temporary shelter for the populace and livestock during floods were rarely assessed. Such benefits do not necessarily have to be evaluated, insofar as the direct benefits may be sufficient to demonstrate that the project is viable. However, where the economic evaluation is to be used as a tool for designing the most cost-effective project, this omission can be important.

Furthermore, if the project also has disadvantages, these may need to be balanced against both the direct and the indirect benefits both to determine the project's feasibility and to formulate projects with high cost-effectiveness. By the same token, negative externalities from flood control, drainage, and irrigation systems are not always considered. Examples of common environmental impacts from flood-mitigation works are changes to the level and quality of groundwater and separation of juvenile fish-breeding areas and local drainage lines by dikes that are built to protect against mainstream flooding.

To assess all economic benefits, it would be necessary to take account of social and environmental effects as well as benefits readily measurable in monetary terms. However, these have rarely been quantified in economic terms. In disaster mitigation or reconstruction projects, social effects can, in one sense, be more important than economic benefits represented simply by capital stocks and flows. Victims often report that the social impacts of a disaster are worse than any monetary loss even when there is no injury or loss of life. This implies that, in evaluations, overall economic benefits (which include social and environmental benefits) can normally be assumed to be considerably greater than benefits that can be readily measured in monetary terms, such as the reduction in damage to property.

This raises an important issue: how should the ADB take the social impacts of disasters into account. On the one hand, the ADB needs to ensure that both itself and the borrower get a return on the investment. On the other hand, the ADB has a commitment to pay special attention to vulnerable groups such as children, indigenous people, ethnic minorities, squatters, socioeconomically disadvantaged people, disabled people, and immigrants. Such groups are often poor and unable to absorb shocks and, in the nature of many disasters, tend to be disproportionately represented among the victims. What is required are measures to

evaluate the social and environmental costs and benefits of disasters, and these are being developed in a forthcoming ADB publication, *Handbook for Preparing Emergency Loans*. On top of this, vulnerable groups frequently receive a very high proportion of their incomes in the informal sector, and an economic analysis may have to ensure that the impacts of disasters take the informal sector into account.

Despite the problems of valuing intangibles such as social and environmental effects using conventional numeraires, other ways of taking social and environmental impacts into account have been used. For example, ADB's policy states that projects should have economic internal rates of return that reach 12 percent. However, although the Tulungagung Drainage Project in Indonesia did not quite reach this value, it was approved partly because of its obvious social benefits. Even so, the economic internal rate of return remains the main criterion for selecting subprojects, and this needs further consideration.

Various tests on projects have been undertaken using social benefit-cost analysis. However, these might come up with a range of results, some higher because of existing infrastructure, some lower because of density of population. This is demonstrated in an evaluation of the benefit-cost ratios of projects to rehabilitate sea dikes in North and Central Viet Nam. These sea dikes are vital for protecting coastal agricultural lands against storm surges and waves generated by the four to six typhoons that strike Viet Nam in an average year. The benefits to the North Vietnamese coastal dwellers were about ten times the costs, while the benefit-cost ratio for the Central Vietnamese coastal zone was only two. Yet the people of Central Viet Nam are extremely poor, and many suffer malnutrition. This suggests that a simple ranking based on benefit-cost analysis may not recognize the extent of damage from a social perspective. Moreover, disasters that occur frequently may have little physical impact, but serious dislocational effects. This would go some way toward overcoming the criticisms made by developing-country members that some ADB projects have not been as appropriate to their needs as could be desired.

As a first step in taking account of these social costs, a greater degree of thoroughness might be exercised in capturing the monetary benefits. The higher the benefits, the better the project that could be justified and the lower the social losses. A second means of capturing social costs might be to put more effort into developing simple models of income generation attributable to the provision of infrastructure, particularly among the poor. For example, Kumar and Bhattarai (1992) document how landless people increased their caloric intake 7.5 percent and their caloric adequacy 9 percent through better access to improved employment, wages, and prices.

Results from a case study of a flood-prone road network in Bangladesh

As part of the project to produce the *Handbook for Preparing Emergency Loans*, some current emergency loans of the ADB were investigated to provide case studies to illustrate the procedures. One of these studies was of a flood-prone road network south of Chittagong in Bangladesh. The study area was subjected to floods in 1987, 1988, and 1991. The initial work of recovery after the 1987 flood was funded under the Flood Rehabilitation Project by retroactive financing. whereby the funds are formally approved by the Board after the work commences. Following the 1988

flood, funds were diverted to enable work to start straight away before the Flood Damage Restoration (Roads and Railways) Project was initiated. In contrast, in 1991 the project ran into substantial delays, and nearly three years were lost before reconstruction began.

Rapid analyses of the projects have been carried out to simulate what would need to be done after a disaster, and these have come to the following conclusions:

- It may be justified to spend more on reconstruction if this would help to avoid delays.
- If the delay can be avoided, the break-even period of the project could be reduced.
- It seems justified to raise the level of some of the roadways to above the currently designed 5 percent flood level.

These results reinforce two points made earlier: disasters require very rapid responses to reduce the delay as much as practicable, and evaluating benefits even roughly should help to formulate a cost-effective project. Although cost-benefit analyses are always used in regular loans to improve the form of the project, more emphasis could also be given to this task in the approval of emergency loans.

Conclusions

ADB's involvement in disaster management is based on the principle that disasters disrupt economies. Although the ADB's position on disaster rehabilitation is clearly focused, conceptual analyses of other important issues need to be addressed, including the extent and nature of disaster management assistance and implementation. The extent of disaster assistance is large and represents an important component of the ADB's Asian Development Fund loans. In addition to addressing disaster reconstruction with loans totaling about $600 million between 1988 and 1993, the ADB also supported disaster mitigation projects totaling about $660 million, mainly in irrigation and flood control. Ten new disaster mitigation loans are programmed for 1994–96 amounting to about $500 million.

Following a disaster, donor coordination is vital and should adopt the principles of project management. Although most completed projects were hampered by cost and time overruns, they generally met their objectives and were sufficiently flexible to adapt to changing circumstances.

Economic benefits should be calculated to include social and environmental aspects. Greater effort should be put into evaluating such benefits and ensuring that externalities entailing property damage are taken into account. Paucity of data is a serious impediment to the measurement of benefits of disaster-management projects in general, and more time should be allocated to collecting relevant data. The treatment of sunk costs requires further consideration to avoid distorting benefits.

Disaster mitigation activities must be recognized for their value in preventing or alleviating serious economic disruptions and are thus critical in determining a country's path of economic growth. Disasters are clearly linked with poverty: poverty increases vulnerability to disasters, and disasters, in turn, have a particularly devastating effect on the destitute and the poor. More consideration should be given to the practicalities of implementing disaster-recovery projects in two phases, a repair phase and a rehabilitation phase. This may result in earlier recovery by affected communities.

Notes

1. This chapter was prepared with the assistance of Terry Lustig (staff consultant), John Brooks, Dagmar Graczyk, and Bruno Carrasco (World Bank staff). The views expressed are those of the author and not necessarily of the Asian Development Bank.
2. A billion is 1,000 million.

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6

The Role of Insurance in Reducing Losses from Natural Hazards

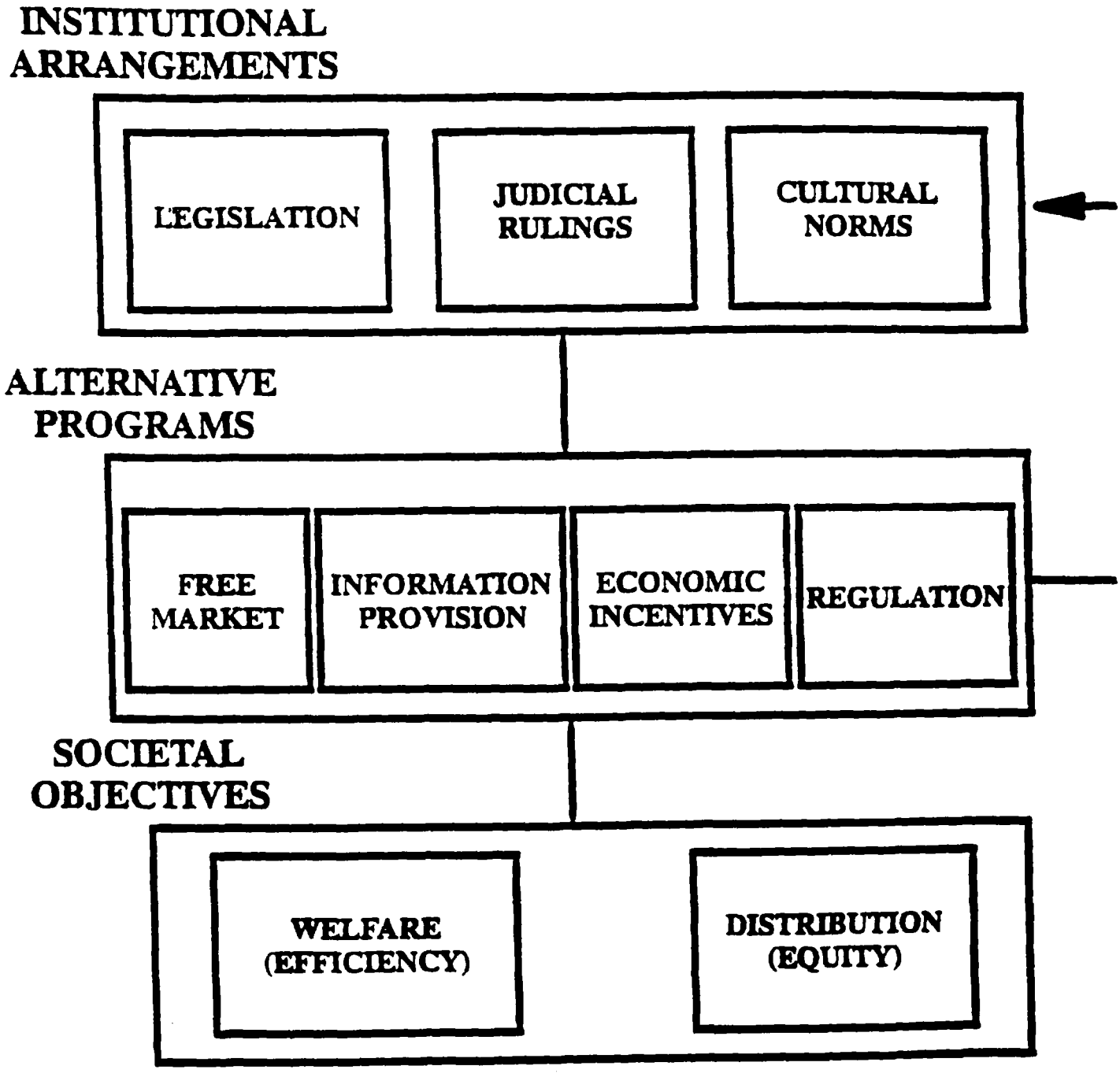
Howard Kunreuther

This chapter addresses the role of insurance in reducing losses from natural disasters.[1] In theory, insurance should be ideally suited to aid the financial recovery of victims suffering damage from natural disasters while at the same time reducing losses from future ones. A homeowner or business who has purchased insurance is protected against a severe loss through the payment of a small premium. At the same time, if premiums are based on risk, then insurance should encourage individuals to adopt cost-effective loss-reduction measures on their homes.

Figure 6-1 depicts a conceptual framework that should enable different countries to evaluate how insurance coupled with other policy tools, such as mitigation and land use regulations, can reduce losses from natural hazards. The current institutional arrangements—existing legislation, judicial rulings, and cultural norms—affect the benefits and costs of different strategies for reducing disaster losses.

A starting point is to provide information on the risks facing individuals in hazard-prone areas. Insurance can do this very effectively through a rate schedule. Higher premiums for the same amount of coverage or protection imply a greater chance of suffering losses. Another way to convince individuals to take certain actions is through economic incentives. Here insurance can play a key role by reducing the premiums for persons who invest in mitigation or loss-reduction measures. Finally, one can turn to standards and regulations. Insurers can require that certain standards (for example, building codes) be met before issuing an insurance policy; financial institutions can refuse to issue a mortgage unless the owner has insurance.

Figure 6–1: Framework for LP–HC Events



These different policies need to be evaluated with respect to their effects on resource allocation (efficiency) as well as distribution (equity). For example, if insurance rates are based on risk, then low-income individuals living in high-hazard areas may not have funds to adopt cost-effective mitigation measures or purchase an insurance policy. Should they receive low-interest loans or grants to undertake loss-reduction measures? Should insurance be subsidized so the rates are affordable to them? The answers to these questions will differ between countries as a function of the types of hazards they face, the composition of their population, and the available resource bases. In addition, the current institutional arrangements, as depicted in the top row of figure 6-1, will play a key role in ranking alternative disaster management programs.

In examining the potential role of insurance in reducing losses from natural hazards, the following questions need to be addressed:

1. Why do so few individuals voluntarily purchase insurance and adopt cost-effective mitigation measures for natural hazards?
2. Why are private insurers reluctant to promote and market coverage against natural hazards?
3. What are the features of an insurance program that will be attractive to potential disaster victims and insurers and will promise to reduce losses from future natural disasters?

This chapter addresses the first question by looking at empirical evidence on homeowner behavior in hazard-prone areas of the United States and examines the conditions for making a risk insurable. Next, the challenges insurers face in providing coverage against some natural hazards are examined, followed by discussion of a hazard management plan in which insurance coupled with regulations and standards play a central role. This hazard management plan takes into account individuals' reluctance to protect themselves from disaster damage as well as private insurers' reluctance to provide coverage. Finally, questions are posed regarding implementation of the hazard management plan.

Although the empirical portions of the discussion focus primarily on experience in the United States, the framework and conceptual ideas should have relevance to other parts of the world. Of course, the actual design of a hazard management plan will vary from one country to another because of differences in past history and current institutional arrangements.

Why interest in insurance and mitigation is limited

Consider the following hypothetical example to illustrate the potential role of insurance in reducing losses from natural hazards. Suppose that seismologists have estimated that the annual chances that a severe earthquake will damage a home in Tokyo is 1 in 200 and that the total damage will be $20,000. If there is no deductible on an insurance policy, then the actuarially fair annual premium for covering the $20,000 loss is $100.[2]

If a homeowner is averse to risk and hence wants to pay a small premium to avoid a large loss, then insurance should be an attractive option even if the premium somewhat exceeds $100. Following an earthquake, the family will be reimbursed by its insurance company rather than having to finance recovery with its own resources, bank loans, or disaster assistance from the federal government.

Now suppose that a homeowner could invest $50 to attach the family's water

heater securely to the wall and thus prevent it from toppling during an earthquake. If the water heater falls and breaks a gas or electrical line, the result may be a fire as well as water damage (see California Seismic Safety Commission 1992 for a detailed description of alternative loss-reduction measures that homeowners can adopt). Suppose that by adopting this measure, the best estimate of the *reduction* in damage to the home and contents if a severe earthquake occurs is estimated to be $4,000. This means that the insurer can reduce the actuarially fair premium to the homeowner by $20 (that is, 0.005 x $4,000). The homeowner now has to decide whether to invest $50 today to save $20 each year over the life of the house. This investment is clearly cost-effective for any house that is likely to be occupied for even just a few years (the next section analyzes the relevant tradeoffs in showing how to determine whether a particular mitigation measure is cost-effective).

In developing programs for reducing losses from natural hazards, it is important to recognize that the vast majority of individuals do not purchase insurance voluntarily or invest in mitigation and loss-prevention methods. In a recent survey of 3,500 homeowners in four California counties subject to earthquake damage, Risa Palm and her colleagues reported that only between 5 and 9 percent had adopted any loss-reduction measures (Palm and others 1990). If most of these homeowners had purchased earthquake insurance, their behavior could have been explained by their belief that they were covered against potential losses. That was not the case, however. Although recently there has been much more interest in earthquake insurance than there was twenty years ago, only 30 percent of homes in earthquake-prone areas of California have coverage today.

With respect to flood insurance, most individuals in hazard-prone areas do not purchase coverage voluntarily. Of the approximately 9.6 million households in flood-prone areas of the United States, less than 2 million currently have flood insurance (Kusler and Larson 1993). As a specific example, consider the seven Midwest states affected by the Mississippi floods of August 1993. Less than 42,000 households out of the 803,000 residing in special flood-hazard areas had purchased flood insurance as of August 3, 1993 (Karr 1993).

There are several principal reasons why individuals do not protect themselves voluntarily against the consequences of natural hazards. Many individuals initially focus on their perceived probability of a disaster (p) and unconsciously set a threshold level (p^*) below which they do not worry about the consequences at all. If their estimate of $p < p^*$, then they assume that the event will not happen to them and take no protective actions.

This decision to ignore events where $p < p^*$ is exacerbated by a tendency for individuals to underestimate the probability of a future disaster if they have not personally experienced the event. For this reason, many individuals do not believe that they will suffer damage to their homes, even in areas where scientists have predicted that a severe disaster is likely to occur in the next decade.[3]

The contingent weighing model proposed by Tversky, Sattath, and Slovic (1988) provides a useful framework for characterizing how individuals decide whether to adopt protective measures such as insurance. In this descriptive model, individuals make tradeoffs between the dimensions associated with alternatives, such as probability and outcomes. The weights they put on these dimensions are contingent, because they

may vary depending on the context of the problem and the way in which information is presented. People often weight these dimensions differently than would be suggested by normative models of choice such as expected utility theory (see Camerer and Kunreuther 1989 for a more detailed discussion of the decision processes of individuals with respect to low-probability high-consequence events).

It is easy to see why the "it will not happen to me" strategy violates the tenets of expected utility theory or benefit-cost analysis. Instead of weighing the outcome of an event by its perceived probability of occurrence, individuals who use a threshold model treat low probabilities as having a zero chance of occurrence. They do not even consider the consequences of events that they treat as impossible but that, in fact, may actually occur. Those homeowners who follow this decision process have no interest in purchasing insurance because they *do not* think about the consequences of a disaster. Even though their actions *are not* motivated by the possibility of generous disaster relief, such funds may still be available to them after a major catastrophe.

Another reason why many individuals do not voluntarily purchase insurance is because they view such expenditures as poor investments. Many homeowners have a difficult time justifying the voluntary purchase of coverage next year if they have *not* made a claim on their policy in previous years. In the case of natural hazards, it is highly unlikely that a disaster of any magnitude will occur to any specific individual during a three- to five-year time period. It is difficult for many people to continue to buy coverage against a loss and say to themselves and others that the best return is *no* return at all.

A third reason why some homeowners will not invest in cost-effective loss-reduction measures is that they focus on up-front expenditures without recognizing the potential long-term benefits realized by these loss-reduction measures. In other words, their calculation of benefits is based on very short time horizons so that the cost of the investment appears large relative to the returns that are calculated over just the next year or two.

Premium reductions that reflect the benefit of the protective measure would help a person see the wisdom of this investment. However, because of myopic behavior the annual premium reduction has to be relatively large to encourage them to invest in these measures. The example presented in the introduction illustrates this point. If the homeowner only considers the $20 premium reduction over the next two years, then the $50 investment in mitigation appears to be a poor investment (Kunreuther, Slovic, and Hastie 1994).

Homeowners are not the only ones who fail to adopt protective measures and purchase insurance prior to a disaster. While empirical data on business behavior are limited, a recent study reveals that relatively few small businesses have earthquake insurance, unless they are required to purchase coverage in order to secure a loan. In particular, firms located in earthquake-prone areas of the Midwest or Eastern United States appear to have an "it will not happen to me" attitude (Alesch and others 1993).

With respect to the degree of protection undertaken in the public sector, a comprehensive study by Burby (1992) and his colleagues reveals that most local governments do not adopt hazard mitigation measures or purchase insurance. More specifically, a study by French and Rudholm (1990) of the damage to public property in the Whittier Narrows, California, earthquake of October 1987 re-

vealed that few public buildings were protected by earthquake insurance, even though it was readily available from the private sector. Consequently, a large portion of the damage was paid for by the Federal Emergency Management Agency in the form of disaster relief.

What makes a risk insurable

Any firm should be interested in offering coverage against any natural hazard that satisfies the conditions of insurability. The conditions of insurability are widely discussed in most insurance textbooks and were formalized in a book by Berliner (1982). This section discusses the key elements of insurability that need to be taken into account.

Uncertainty

Insurance policies are designed to cover events that are unintended and uncertain. There is general agreement that natural disasters satisfy this condition. A risk is uninsurable based on this condition if seismologists can accurately predict the timing, location, and magnitude of earthquakes in the future. Insurers would then have no interest in providing coverage to individuals and firms who face a certain loss from an earthquake next year, except by charging a premium that approaches the magnitude of the loss itself.

Low correlation

The possibility of a catastrophic loss from a single event may make the risk uninsurable. When the risks covered by the insurer are independent of one another, such as an automobile accident, then the losses from any single event are likely to be small. If the insurer fears the possibility of a catastrophic loss from a single event, such as a flood or an earthquake, then it is reluctant to cover a large number of homes that are located in the same hazard-prone area.

Identification of losses

Losses must be well defined as to time and place. In the case of a piece of property, it is generally possible, using past data, to determine the likely distribution of damages from fires. For natural disasters such as floods and earthquakes, scientific studies by hydrologists and seismologists relate the characteristics of a particular disaster (duration, magnitude) to the loss. For example, to estimate the damage to a particular structure from an earthquake, it is necessary to determine the magnitude and duration of groundshaking, which is then translated into some type of scale such as the modified Mercali intensity. This scale is then used to estimate the percentage of the structure that will be damaged should such a quake occur (Arnold 1990). Even if the epicenter and type of quake that will occur are known, the extent of the damage to the structure is still uncertain (Dames and Moore 1990).[4]

The probability of loss

Ideally, the probability distribution of future losses should be accurately estimated in setting insurance premiums. If considerable ambiguity is associated with the chances of certain events occurring, then the risk may still be insurable. However, underwriters and actuaries generally reflect this uncertainty by charging a higher premium than they do for better specified risks (Kunreuther, Hogarth, and Meszaros 1993).

For frequently occurring disasters, such as fire, it is possible to estimate the chance of their occurrence. Low-probability, high-

consequence events, such as hurricanes, floods, and earthquakes, present more challenging problems because the availability of past data is limited. Here one has to rely on risk assessments undertaken by hydrologists and seismologists. These scientists are the first to admit that estimating the chances that a particular disaster will occur in a specific area is highly uncertain and ambiguous. For example, many seismologists and geologists believe that we are now entering a cycle of high earthquake activity, but they do not know whether this cycle will culminate in a large earthquake in 50, 100, or 200 years and where such a disaster will occur (Hamilton 1992).

Moral hazard

Moral hazard refers to a situation where the insured behaves more carelessly than he normally would simply because he knows that his losses are now covered by insurance. Some hazards have a limited degree of moral hazard because the individual *cannot* control the risk. Natural hazards normally fall into this category, since the events are triggered by external forces. Even in these situations, the possibility of moral hazard exists. For example, if an insured person is warned that a flood may damage the basement of his house, he may move old furniture there with the intention of collecting on his policy.

One way to avoid such behavior is to impose a reasonably high deductible or coinsurance clause on the policy (an 80 percent coinsurance clause indicates that the insurer pays 80 percent of any loss and that the insured party absorbs the other 20 percent). Individuals are much less reluctant to behave carelessly if they know that they will have to pay some of the resulting losses out of their own pockets.

Adverse selection

A risk is uninsurable if the premium is based on the experience of a large population but only those in the highest risk category purchase coverage. This is known as adverse selection. Insurers inspect a house before providing fire coverage or require medical exams before issuing a health insurance policy in order to estimate individual risks more carefully and charge premiums that reflect these risks.

Adverse selection presents special problems in the case of natural disasters if the insurer sets a uniform premium across a wide area and only those who face the most severe risk purchase coverage. Thus, if only those individuals living closest to the river buy flood insurance at a premium that reflects the damage to a much broader area, then the insurer has an adverse selection of policies.

The principal way of avoiding adverse selection is to take advantage of scientific studies differentiating the hazard coupled with an inspection of individual structures prior to issuing an insurance policy. This would enable insurers to customize rates based on risks. This may be a relatively costly process if the insurer has to bear the costs; however, if each owner incurs this expense as a condition for obtaining a mortgage, then it may be feasible.

Why insurers do not promote coverage against natural disasters

The two principal reasons that private insurers do not offer flood policies or actively promote earthquake and hurricane coverage is because the risk is uncertain and the economic consequences of a catastrophic disaster are too great.

Turning to the uncertainty of the risk, a recent survey of underwriters illustrates how ambiguity affects their premium-setting behavior. A questionnaire asked underwriters of primary insurance companies and reinsurance firms to specify the prices they would charge to insure a factory against property damage from a severe earthquake under the following four cases: case 1, well-specified probabilities (p) and known losses (L); case 2, ambiguous probabilities (Ap) and known losses; case 3, well-specified probabilities and uncertain losses (UL); and case 4, ambiguous probabilities and uncertainty losses.[5]

For the nonambiguous case, the probability of the earthquake (p) was set at either 0.01 or 0.001, and the loss should the event occur (L) was specified at either \$1 million or \$10 million, yielding four different scenarios (these well-specified scenarios are $p = 0.005$, $L =$ \$1 million; $p = 0.005$, $L =$ \$10 million; $p = 0.01$, $L =$ \$1 million; and $p = 0.01$, $L =$ \$10 million). Standardizing the premium set by the underwriter at 1 for the nonambiguous case allows us to examine how ambiguity affects pricing decisions. Table 6-1 depicts the ratio of the other three cases relative to the nonambiguous case (p,L) for the four different scenarios that were distributed randomly to underwriters in primary insurance companies.

For the highly ambiguous case (Ap,UL), the premiums were between 1.43 to 1.77 times higher than they were for a nonambiguous risk. The ratios for the other two cases were always above 1 but less than the Ap,UL case (Kunreuther, Hogarth, and Meszaros 1993).

Turning to the fear of crippling catastrophic losses, empirical analyses show that insurers have a right to be worried. In the past several years, several disasters within close proximity to each other have caused billions of dollars in damage to different regions of the country and created large losses to the insurance industry. The insurance industry's catastrophic losses during 1989–92 were more than \$34 billion in 1992 dollars, more than the combined total for such loss during the previous twenty-one years ("ISO President Outlines Steps" 1993).

Table 6–1: Ratio of Underwriter Premiums for Ambiguous or Uncertain Earthquake Risks Relative to Well-Specified Risks

Scenario	*Case 1, p,L*	*Case 2, Ap,L*	*Case 3, p,UL*	*Case 4, Ap,UL*	*Number of respondents*
$p = 0.005$ $L =$ \$1 million	1	1.28	1.19	1.77	17
$p = 0.005$ $L =$ \$10 million	1	1.31	1.29	1.59	8
$p = 0.01$ $L =$ \$1 million	1	1.19	1.21	1.50	23
$p = 0.01$ $L =$ \$10 million	1	1.38	1.15	1.43	6

Note: Ratios are based on mean premiums across number of respondents for each scenario.
Source: Adapted from Kunreuther, Hogarth, and Meszaros 1993, table 3.

To be more specific, damage from the 1989 Loma Prieta earthquake caused more than $900 million in losses to the insurance industry (California Department of Insurance 1991–92). The losses to the insurance industry from Hurricane Andrew are now estimated to be $15.5 billion, making it the single most costly natural disaster in history. Insurers such as State Farm and Allstate suffered financial losses from Andrew of $3.5 and $2.5 billion, respectively (Snyder 1993). A computer simulation model indicates that if Hurricane Andrew had hit Miami, the losses could have exceeded $40 billion and led to many more than the seven insolvencies that resulted from the actual disaster (Insurance Services Office 1994).

A recent study also suggests that a catastrophic earthquake would have severe consequences on the surplus held by private insurers in the United States (Doherty, Kleffner, and Kunreuther 1991). Data were collected from eighteen insurance firms providing earthquake coverage in California to determine the financial impact to them should a disaster occur of the same magnitude and geographic location as the 1906 San Francisco earthquake. The study found that if such a catastrophic earthquake were to occur, five out of the eleven firms with surpluses less than $2 billion would suffer losses that would exceed their surplus and cause them to be insolvent. The seven larger firms in the survey with surpluses exceeding $2 billion would be less severely affected by the catastrophic earthquake. Although none of these large firms would be insolvent, three of them would have to curtail their current business or raise new capital because their surplus would be sufficiently depleted that they would not be able to meet current regulatory guidelines.

Medium and small-size insurers in the United States use the reinsurance market to protect themselves against the possibility of large losses from events such as a catastrophic earthquake (some of the large personal lines insurers do not purchase any reinsurance). Because reinsurance data are not in the public domain, a questionnaire was distributed to the eighteen firms in the sample to determine the amount of catastrophic reinsurance in force. Fourteen companies responded to the survey. Three of the five firms that were predicted to be insolvent from the catastrophic earthquake if they did not have reinsurance responded to the survey; all of them would still be insolvent even if the reinsurers paid all their claims.

The impact of a catastrophic disaster on the private reinsurance market has not been well studied. These firms are likely to face an even greater problem than the primary insurers if such an event occurs. The premiums that the reinsurers believe they can charge for such an event are relatively small because of its low probability, but their losses from a large-scale disaster could be enormous.

If one looks at the catastrophe-related claims that have been paid for all disasters in the United States in the past forty years, 45 percent have been paid since 1990. As a result of the extraordinary trend in both the frequency and severity of natural catastrophes, the capacity of reinsurance to cover insurers and their policyholders has diminished. The largest U.S. reinsurance broker reports that between 1989 and 1993, the amount of catastrophic reinsurance that it was able to place for its client base decreased 57 percent (Nutter 1994).

A proposed program for integrating insurance with mitigation

Homeowners and insurers are thus reluctant to deal with natural disasters for very

different reasons. Many homeowners at risk are not anxious to purchase insurance because they believe that the disaster will not happen to them; others have compared costs with potential benefits and may believe that insurance and loss-reduction measures are not good investments. Private insurers are reluctant to promote coverage against hurricanes, floods, and earthquakes because the risk is uncertain and they are concerned with the financial consequences to them of a catastrophic disaster. Hence they want to limit their exposure.

The present situation can be costly to all of the interested parties concerned with disasters. First, the potential damage from natural hazards will be larger than it would be if cost-effective, loss-reduction measures were adopted on new and existing property. Second, the large losses and potential insolvencies to insurers resulting from a catastrophic disaster will significantly reduce their surplus and lead them to set higher premiums and restrict coverage on policies that are unrelated to the specific disaster in question (that is, automobile coverage, homeowner's insurance).

In other words, the impact of a particularly severe flood, earthquake, or hurricane could have a negative impact on the availability of insurance throughout the country (Doherty and Posey 1992; Gron 1989; Winter 1988, 1991). Doherty, Posey, and Kleffner (1992) examine how insurers responded to a variety of surplus shocks in the past. Their analysis suggests that only 50 percent of the lost surplus is likely to be replaced following a catastrophic loss, so that the availability of coverage in many different lines of insurance will have to be reduced.

Third, many uninsured homeowners will be saddled with large recovery costs following a severe disaster. If the past is a guide to the future, the federal government will come to the rescue by providing victims with liberal disaster relief. Hence all citizens will have to pay for the losses generated by severe disasters in the future.

To cope with each of these three problems, the following elements of a hazard management program should be explored. A more detailed discussion of the objectives of such a program and an expanded treatment of the interaction between different policy tools can be found in Kunreuther, Ericksen, and Handmer (1993).

Institute more stringent building codes on new homes

Relevant government agencies should develop stringent building codes that incorporate cost-effective mitigation measures on new structures and ensure compliance with, and enforcement of, the codes. The limited voluntary adoption of these measures on existing homes in the United States suggests that innovative ways are needed to encourage homeowners and the building industry to modify structures to meet appropriate standards. This means ensuring that key players, like the building industry and homeowners, support the program.[6]

Although building codes can serve an important function in reducing future property damage, Cohen and Noll (1981) provide an additional rationale for having them. The collapse of a building may create economic dislocations and social costs in addition to the economic loss suffered by the owners. These may not be taken into account when owners evaluate the importance of adopting a specific mitigation measure.

Use seals of approval on structures that meet codes

Each building that meets or exceeds the specific building code could be given a seal of approval. This would provide homeowners with the knowledge that the building has been safely designed and built in accordance with a federal or national code. One way to institutionalize the procedure would be for financial institutions to require an inspection of the facility at the time that a mortgage is issued. This inspection, which would be a form of buyer protection, is identical in concept to the termite inspection that is normally required as a condition for obtaining a mortgage in the United States. A new homeowner is unlikely to know how safe the structure is, so this inspection should be viewed as desirable.[7]

Use insurance to encourage hazard mitigation

To reduce their losses from disasters, insurers may want to limit coverage to structures that are given a seal of approval. If banks require insurance as a condition for a mortgage, then financial institutions together with the insurer can help to enforce building code regulations. The reduction in potential losses from the adoption of building codes should be reflected in reduced premiums, lower deductibles, or higher coverage limits.

The government could require insurance as a condition for federally backed mortgages. In the United States, the National Flood Insurance Program has such a condition for homes located in Special Flood Hazard Areas. Unfortunately, this requirement has not been routinely enforced. A survey conducted in Texas following a major flood in 1989 revealed that 79 percent of the owners of damaged properties who were required to purchase flood coverage when taking out their mortgages were uninsured at the time of the disaster (U.S. General Accounting Office 1990).

An interesting set of competitive pressures creates a lack of interest by banks in requiring homeowners to take flood insurance as a condition for a mortgage. Prospective homeowners who are not concerned with the flood hazard will want to obtain their mortgage from a bank that does not require flood coverage. Until a recent court decision in the state of Connecticut, banks were *not* fined if a house in the floodplain was uninsured nor did they have to pay for flood damage if the house was flooded. For similar reasons, banks have no incentive to ensure that homeowners renew the flood insurance coverage they purchased at the time of their mortgage.

Fines or other penalties should be imposed on lenders who are obligated to require flood insurance but do not do so. A recent bill introduced into the U.S. Congress would require lenders to inform purchasers of how to obtain insurance and penalize them up to $350 for each violation. This penalty may only be partially successful in forcing banks to take the appropriate action. A much more effective penalty would be to hold banks and financial institutions responsible for the costs of repairing an uninsured home that had been required to have coverage (Kunreuther and White 1994; the maximum amount of the fine could be determined by the amount of insurance that the structure would have under required coverage).

Develop all-natural hazards insurance

The insurance industry should be encouraged to market a new type of homeowner's

insurance that includes protection against earthquake, flood, and hurricane damage. Rates would be based on risk, with the potential losses diversified throughout the country. This type of insurance policy would also eliminate having to determine the causes of a loss, as insurers in the United States currently have to do for hurricane damage.

Institute government reinsurance

The federal government should provide reinsurance protection against catastrophic losses from all disasters on the newly designed homeowner's policy. Private insurance firms would build up the fund by being assessed premium charges in the same manner that a private reinsurance company levies a fee for protection. The need for such a government fund arises from the apparent inability of the private reinsurance market, due to limited financial capacity, to provide sufficient protection against large-scale disasters that might occur in the United States.

The advantage of a federal reinsurance program is that it reduces uncertainty to insurers about the consequences of a catastrophic disaster and should enable them to reduce their premiums for disaster coverage. By having federal involvement in one portion of the natural disaster program, it is then possible for some government agency (for example, the Federal Emergency Management Agency) to play a more salient role in encouraging the enforcement of mitigation measures.

In addition, federal reinsurance for catastrophic losses would restore the financial conditions of insurers following a catastrophic loss and hence greatly reduce the likelihood that insurers will reduce the availability of coverage in the future. For example, following Hurricane Andrew eight companies announced that they would reduce coverage in Florida due to their severe losses. Insurers also reduced availability of homeowner's insurance in other hazard-prone areas such as the Massachusetts shoreline (Blanton 1993).

Subsidize low-income families

Many poorly constructed homes are owned by low-income families who cannot afford the costs of mitigation measures on their existing structure nor the costs of reconstruction should their house suffer damage from a disaster. Two measures should be undertaken to aid these households:

- Low-interest loans and grants to adopt cost-effective mitigation measures or to relocate their home.
- Special disaster assistance to aid their recovery process.

In summary, coupling insurance requirements with building codes and risk-based premiums for adopting cost-effective, loss-reduction measures would constitute a giant step toward reducing losses from future natural disasters as well as aiding the recovery of homeowners who suffer severe damage to their property.

Open questions and issues

This concluding section raises a set of questions and issues that need to be considered by countries as they reflect on the role of insurance as part of a hazard management program. They are grouped under headings that address the insurability issue and the role of insurance coupled with other policy tools in reducing losses from future natural hazards.

Estimating the risk

- What risk-assessment techniques are currently available for determining the potential losses to structures in different hazard-prone areas?
- How costly is it to undertake these risk assessments?
- Is it appropriate for government to bear the costs of risk assessments, or should they be borne by residents in the hazard-prone community?

Enforcing building codes

- What are the challenges in having federal and state governments develop more stringent building codes and a low-cost system of compliance and enforcement at a local level of authority?
- Are adequate data available to specify cost-effective mitigation measures for different hazards?

Offering seals of approval

- How easy is it to determine whether a particular structure meets a specific code or standard to receive a seal of approval (building consents and code compliance permits)?
- How easy is it to determine whether a damaged building has or has not met the building code following a disaster?
- Who would determine whether a structure meets code (scientific experts, local government building inspectors)?
- Is it appropriate to require the local government to pay for the full damage from a disaster if the code has not been met?
- Will the threat of such a penalty induce local governments to inspect buildings carefully before a disaster to see that the building code is met?

Linking insurance with seals of approval

- What type of competitive pressures may lead insurers to provide coverage for structures that do not have seals of approval?
- Under what circumstances are banks likely to require insurance as a condition for a mortgage?

Offering premium reductions for adopting mitigation measures

- What are the most effective ways for insurers to reflect the loss reduction so that homeowners perceive the benefits of mitigation (such as lower deductibles, lower premiums, higher coverage, or some combination of these)?
- Can analogies from other types of coverage (such as fire insurance) assist the industry in answering the above question?

Developing an all-natural hazards insurance program

- Are there legal impediments in developing all-natural hazards insurance (for example, is it possible to include flood damage in such a program in the United States given the existing National Flood Insurance Program)?
- How feasible is it to charge rates based on risk that varies considerably from one region of the country to another?
- Should the insurance industry share the responsibility for, and cost of, identifying natural hazards on a regional basis?

Structuring federal reinsurance

- How can a government reinsurance program be structured so that it is not perceived to be a bailout for the insurance industry and so that companies are not inclined to buy less commercial reinsurance?
- What data are available to show that there is not enough private reinsurance capacity available to cover a catastrophic loss?
- How large a reduction in premiums or an increase in coverage at the same premium is possible under a government reinsurance program?
- Is there capacity for reducing premiums in a highly competitive market?

Subsidizing low-income families

- What are the appropriate measures of income to determine whether individuals qualify for loans or grants to undertake mitigation measures?
- What types of disaster assistance are most appropriate to aid the recovery of low-income families?

Notes

1. This paper reflects many helpful discussions with Neil Doherty, Dean Flesner, Eugene Lecomte, Frank Nutter, and Gilbert White. Support from the William and Flora Hewlett Foundation is gratefully acknowledged.
2. A deductible refers to the amount of money that the policyholder has to pay from his or her own resources before collecting on insurance. In the United States, the normal deductible is 10 percent of the value of a policy. Hence if a homeowner purchases coverage of $100,000, then he would be responsible for covering the first $10,000 of any losses from an earthquake. An actuarially fair premium is determined by multiplying the probability of the event by the resulting loss. In this case, 0.005 x $20,000 = $100.
3. Similar behavior has been found with how motorists estimate their driving ability. Svenson (1981) found that more than 90 percent of subjects interviewed said that their driving ability was above average.
4. Even if the magnitude of the loss is uncertain, the insurer is normally protected by the upper limit on the policy it issues. Thus if a $250,000 house is insured against earthquake for only $100,000, then the insurer knows that the policy limit will define the maximum it will ever have to pay even if the house is destroyed by a severe shock.
5. An ambiguous probability refers to the case where "there is wide disagreement about the estimate of p and a high degree of uncertainty among the experts." A well-specified loss (L) means that all experts agree that if a specific event occurs, the loss will equal L. An uncertain loss refers to the situation where the experts' best estimate of a loss is L with estimates ranging from L_{min} to L_{max}.
6. The Insurance Institute for Property Loss Reduction in the United States is now in the process of establishing a relationship with the American Society of Home Inspectors to enhance compliance with the building code. The specific elements of the program have not been identified yet (personal communication with Paul Cogswell, May 6, 1994).
7. If a house does not meet the relevant building code, the question is whether it must be improved prior to sale or whether the new buyer simply must

receive this information. This area has both economic and political ramifications.

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Appendix 1

Yokohama Declaration

World Conference on Natural Disaster Reduction
Yokohama, Japan, May 23-27, 1994

Outcome of the conference including a plan of action for natural disaster reduction

We, the States Members of the United Nations and other States, having met at the World Conference on Natural Disaster Reduction, in the city of Yokohama, Japan, from 23 May to 27 May 1994, in partnership with non-governmental organizations, and with the participation of international organizations, the scientific community, business, industry and the media, deliberating within the framework of the International Decade for Natural Disaster Reduction, expressing our deep concern for the continuing human suffering and disruption of development caused by natural disasters, and inspired by the Yokohama Strategy and Plan of Action for a Safer World,

Affirm that:

1. The impact of natural disasters in terms of human and economic losses has risen in recent years, and society in general has become more vulnerable to natural disasters. Those usually most affected by natural and other disasters are the poor and socially disadvantaged groups in developing countries as they are least equipped to cope with them.
2. Disaster prevention, mitigation, preparedness and relief are four elements which contribute to and gain from the implementation of sustainable development policies. These elements, along with environmental protection and sustainable development, are closely interrelated. Therefore, nations should incorporate them in their development plans and ensure efficient follow-up measures at the community, national, subregional, regional and international levels.
3. Disaster prevention, mitigation and preparedness are better than disaster response in achieving the goals and objectives of the Decade. Disaster response

alone is not sufficient, as it yields only temporary results at a very high cost. We have followed this limited approach for too long. This has been further demonstrated by the recent focus on response to complex emergencies which, although compelling, should not divert from pursuing a comprehensive approach. Prevention contributes to lasting improvement in safety and is essential to integrated disaster management.

4. The world is increasingly interdependent. All countries shall act in a new spirit of partnership to build a safer world based on common interests and shared responsibility to save human lives, since natural disasters do not respect borders. Regional and international cooperation will significantly enhance our ability to achieve real progress in mitigating disasters through the transfer of technology and the sharing of information and joint disaster prevention and mitigation activities. Bilateral and multilateral assistance and financial resources should be mobilized to support these efforts.
5. The information, knowledge and some of the technology necessary to reduce the effects of natural disasters can be available in many cases at low cost and should be applied. Appropriate technology and data, with the corresponding training, should be made available to all freely and in a timely manner, particularly to developing countries.
6. Community involvement and their active participation should be encouraged in order to gain greater insight into the individual and collective perception of development and risk, and to have a clear understanding of the cultural and organizational characteristics of each society as well as of its behavior and interactions with the physical and natural environment. This knowledge is of the utmost importance to determine those things which favour and hinder prevention and mitigation or encourage or limit the preservation of the environment for the development of future generations, and in order to find effective and efficient means to reduce the impact of disasters.
7. The adopted Yokohama Strategy and related Plan of Action for the rest of the Decade and beyond:
   a) Will note that each country has the sovereign responsibility to protect its citizens from natural disasters;
   b) Will give priority attention to the developing countries, in particular the least developed, land-locked countries and the small island developing States;
   c) Will develop and strengthen national capacities and capabilities and, where appropriate, national legislation for natural and other disaster prevention, mitigation and preparedness, including the mobilization of non-governmental organizations and participation of local communities;
   d) Will promote and strengthen subregional, regional and international cooperation in activities to prevent, reduce and mitigate natural and other disasters, with particular emphasis on:
      i) Human and institutional capacity- building and strengthening;
      ii) Technology sharing, the collection, the dissemination and the utilization of information;
      iii) Mobilization of resources.
8. The framework of action of the International Decade for Natural Disaster Reduction provides all vulnerable coun-

tries, in particular the developing countries, with the opportunity to achieve a safer world by the end of this century and beyond. In this regard, the international community and the United Nations system in particular must provide adequate support to the International Decade for Natural Disaster Reduction, and its mechanisms, especially the secretariat of the Decade to enable them to carry out their mandate.

9. The Yokohama Conference is at a crossroad in human progress. In one direction lie the meagre results of an extraordinary opportunity given to the United Nations and its Member States. In the other direction, the United Nations and the world community can change the course of events by reducing the suffering from natural disasters. Action is urgently needed.
10. Nations should view the Yokohama Strategy for a Safer World as a call to action, individually and in concert with other nations, to implement policies and goals reaffirmed in Yokohama, and to use the International Decade for Natural Disaster Reduction as a catalyst for change.

Appendix 2

Program of Session E on Economic Aspects of Disaster Prevention for Sustainable Development

World Conference on Natural Disaster Reduction
Yokohama, Japan, May 23–27, 1994

Opening remarks

Caroline Clarke, U.S. National Academy of Sciences
Mohan Munasinghe, World Bank

I. Overview/Introduction

Moderator: Omar Dario Cardona Arboleda, Oficina Nacional para la Prevención y Atención de Desastres, Colombia

- *The impacts of natural disasters on national economies and the implications for the international development and disaster communities*

  Romulo Caballeros-Otero, Economic Commission for Latin America and the Caribbean, Mexico

  Ricardo Zapata-Marti, Economic Commission for Latin America and the Caribbean, Mexico

- *The context of disasters and sustainable development: the case of a growing city in a developing country*

  Atiq Rahman, Bangladesh Centre for Advanced Studies, Bangladesh

- Discussion

II. Decisionmaking to reduce the potential losses in development investments

Moderator: Stephen Bender, Organization of American States

- *Disaster vulnerability and sustainable development: a general framework for assessing vulnerability*

  Mary Anderson, Collaborative for Development Action, United States

- *Advantages and limitations of benefit-cost analysis for evaluating investments in mitigation*

  Randall A. Kramer, Duke University, United States

- *Disaster-related activities of the Asian Development Bank: An economic perspective*

  Günter Hecker, Asian Development Bank, Philippines

- Discussion

III. Sharing the risks/costs through insurance arrangements

Moderator: Harry Jayasinghe, Asian Disaster Preparedness Center, Thailand

- *The role of insurance in reducing losses from natural disasters*

  Howard Kunreuther, University of Pennsylvania, United States (Walter Lynn, U.S. National Committee for the IDNDR, presented Kunreuther's paper)

- *Country experiences from Italy and China illustrate how insurance arrangements share the cost and risk of natural disasters*

  Gianfranco de Giusti, Unione Italiana de Riassicurazione

  Wang Fushan, The People's Insurance Company of China

- Discussion

Closing summaries

Omar Dario Cardona Arboleda, Stephen Bender, Harry Jayasinghe, and Victor Osipov

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