DISASTER RISK
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# Managing Disaster Risk in Mexico

## *Market Incentives for Mitigation Investment*

*Alcira Kreimer, Margaret Arnold, Christopher Barham, Paul Freeman, Roy Gilbert, Frederick Krimgold, Rodney Lester, John D. Pollner, Tom Vogt*

The World Bank

Disaster Risk Management Series

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# Contents

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This report summarizes the findings of a World Bank mission on disaster management, mitigation, transfer, and financing conducted in Mexico, October 19–28, 1998. It incorporates the insights generated at a workshop on the preliminary findings of the mission held in Mexico City, February 23–24, 1999.

The report was prepared by a team led by Alcira Kreimer. Team members included Margaret Arnold, Christopher Barham, Rodney Lester, and John Pollner (World Bank); Tom Vogt (International Finance Corporation); and Paul Freeman, Roy Gilbert, and Fred Krimgold (consultants). Tom David and Francisco Javier Pérez, from Impact Forecasting, L.L.C. (a subsidiary of the Aon Group), participated in the mission as private sector partners in the Market Incentives for Mitigation Investment (MIMI) initiative; we acknowledge their helpful inputs to the study. Natural disaster management experts Daniel Bitrán Bitrán, Ricardo Toledo, and Luis Enrique Gutiérrez Alcaráz also made valuable contributions to the study. The report was edited by Barbara Karni and laid out by Suzanne Luft of Communications Development.

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# Abbreviations

| | |
|---|---|
| CATEX | Catastrophe Exchange |
| CENAPRED | National Center for Disaster Prevention (Centro Nacional de Prevención de Desastres) |
| CNA | National Water Commission (Comisión Nacional del Agua) |
| FONDEN | Fund for Natural Disasters (Fondo para Desastres Naturales) |
| LIBOR | London interbank offer rate |
| MIMI | Market Incentives for Mitigation Investment |
| NGO | Nongovernmental organization |
| PAHO | Pan American Health Organization |
| PEMEX | Petroleos Mexicanos |
| SEMARNAP | Ministry of Environment, Natural Resources, and Fisheries (Secretaría de Medio Ambiente, Recursos Naturales y Pesca) |
| SINAPROC | National Civil Protection System (Sistema Nacional de Protección Civil) |

# Executive Summary

Natural disasters have had a formidable impact on development in Mexico. Disasters have destroyed human, social, and physical capital, and they have derailed economic development, as funds are reallocated from ongoing programs to finance relief and reconstruction assistance. The consequences for development and economic growth are ominous.

The aim of this study is to assess the current capacity of Mexico to deal with disaster risk and to identify ways in which the impacts of catastrophes on the economy can be reduced. The study analyzes the three main components of a comprehensive disaster risk management strategy: risk identification, risk reduction, and risk transfer and financing.

Mexico is vulnerable to a variety of natural disasters, including earthquakes, hurricanes, and volcanoes. Despite the frequency with which these disasters strike, however, inadequate investment is made in mitigation efforts, and insufficient funds are set aside to pay for relief and reconstruction efforts. As a result, when a disaster occurs, the government is often forced to use funds that had been allocated to other programs, disrupting the operations of those programs. The effect is to reduce growth and derail important development efforts.

The Mexican government could use mechanisms to manage risk so that ongoing programs are not disrupted following a disaster. Doing so involves identifying the risks the country faces, mitigating the damage caused by those risks, and transferring the risk to other parties (namely, insurance companies and the capital markets).

## Risk Identification

Formulation of an effective risk management strategy must begin with the identification of risk. Mexico should identify the principal hazards it faces and assess the vulnerability of principal settled areas, infrastructure, and economic assets. The analysis should include estimates of the direct, indirect, and secondary impacts of natural disasters.

Mexico has highly competent intellectual and institutional resources for hazard and vulnerability assessment at the National Center for Disaster Prevention (CENAPRED) and the National Autonomous University of Mexico. CENAPRED is a unique institution that bridges the gap between academic researchers and the government by channeling research applications developed by university researchers to the Ministry of the Interior. Neither CENAPRED nor the National Autonomous University receives the budgetary attention it deserves, however.

## Risk Reduction

The damage caused by disasters can be reduced by changing perceptions and behavior so that all members of society place a high priority on safety in planning and development. All stakeholders must contribute to the creation of a culture of safety.

Civil defense in Mexico (as in many other countries) has focused mainly on monitoring, preparedness, and response to disasters. These efforts are crucial to mitigating the effects of disasters. However, the core of a mitigation program should consist of more "upstream" measures, such as the safe location, design, and construction of structures, infrastructure, and settlements.

Mexico has taken some important steps in this direction. Scientific advisory committees have been established, standards for civil works have been set, engineering advances have been made, schools have been retrofitted

to withstand earthquakes, and a program for certifying hospitals that meet disaster readiness standards has been put into effect. Much more could be done, however, to reduce vulnerability to disasters in the long term. The government should develop strategies for improving education about disaster mitigation, creating incentives, and adopting regulations that will encourage individuals and businesses to reduce the risks they face and promote a culture of social protection.

Active programs of dissemination, targeted professional education, and broad public education on disaster risk and mitigation should be developed and delivered throughout Mexico. Programs should include dissemination of information on natural hazard risk, mitigation, and insurance (possibly through a collaborative effort by the government and the insurance industry); the inclusion of disaster preparedness and mitigation materials in elementary and high school curricula; and special programs to target low-income communities, which are often worst hit by disasters.

The regulatory approach to encouraging disaster mitigation in Mexico requires a comprehensive reassessment of the formal land use and building regulatory processes. New approaches to land use management and building quality management must be developed that effectively contribute to public safety in the informal sector. In recognition of the fact that most mitigation decisions are made at the community level, resources must be allocated to increasing the capacity and authority for risk management and disaster mitigation at the state and community levels.

New initiatives should also focus on positive incentives, such as provision of community-level technical assistance for disaster mitigation, establishment of "low-risk districts" or development of historic centers that include tax incentives for those that invest in mitigation, granting of financial assistance for engineering analysis of risk, and establishment of certification programs. The private sector could consider donating engineering design assistance or providing it at low cost.

Disaster relief and recovery assistance, distributed through the government's Fund for Natural Disasters (FONDEN) can also play an important role in post-disaster mitigation in areas in which disasters are recurrent. Temporary employment programs established as part of the relief effort following a disaster could be used to implement mitigation measures, such as strengthening buildings in earthquake- and wind-prone areas, improving irrigation facilities in drought-prone areas, resettling communities away from hazardous sites, clearing stream beds and drainage channels, constructing flood protection, and participating in reforestation.

### Risk Transfer

The Mexican property and casualty (or "general") insurance market is underdeveloped, with the great majority of property owners uninsured against major natural catastrophes. The lack of property and casualty insurance coverage in Mexico appears to be caused largely by demand-side rather than supply-side factors. Although some factors distort the supply of property and casualty insurance in Mexico, excess catastrophic reinsurance capacity is available and a potentially large distribution system has been developed.

In order to increase insurance awareness and penetration among small and medium-size enterprises and the general population, affordable insurance products must be available to the public. Capacity could be increased and prices reduced in several ways:

- Catastrophic premium rates could be formally deregulated, with a maximum tariff set at the current level.
- The discontinued 10 percent compulsory surcharge on earthquake premiums could be reintroduced and extended to all catastrophe classes (including civil disturbances). These funds could be placed in a central pool managed by the Mexican Insurance Association, which would help stabilize reinsurance costs and cover catastrophe-induced insolvency. Companies could continue to be required to accumulate catastrophic reserves up to an agreed-upon standard retention level.
- This industry-run pool could be required to offer catastrophe-only coverage, which would be distributed by insurance companies.
- In order to raise insurance awareness, the mandatory automobile liability insurance requirement, which was postponed, could be implemented as soon as possible.

- The insurance industry, in cooperation with the government, could be encouraged to educate the public about insurance.
- The government could consider providing targeted incentives to expand insurance density.

In addition, private sector insurance companies could be used to help Mexico deal more effectively with risk in the public sector. The public sector should purchase insurance through international brokers and risk transfer specialists; individual agencies should not be purchasing insurance on their own. More cost-effective coverage should be purchased by increasing the deductible level and purchasing higher levels of catastrophe coverage.

### The Role of FONDEN

Funds earmarked for relief and reconstruction after catastrophe events in Mexico are maintained in FONDEN, which provides funds for the repair of uninsured infrastructure, immediate assistance to restore the productivity of subsistence farmers, and relief to low-income victims of disasters. Budgetary allocations for FONDEN have not been sufficient to cover the fund's obligations since 1996, and shortfalls are made up by diverting funds from other government budgets. The government could explore several innovative techniques to make more efficient use of the assets it allocates following disasters. These include purchasing reinsurance, making use of new capital markets instruments, and using contingent financing.

Before the government can make use of risk transfer and risk-financing tools, it must modify the way FONDEN is organized. Changes should include the following:

- Refocus FONDEN's efforts by absorbing only those residual catastrophic risks that cannot be absorbed by third parties, encouraging economically worthwhile mitigation by the public sector, and fostering the development of private sector risk reduction and transfer mechanisms.
- Clearly define the risks for which FONDEN bears responsibility, beginning with the infrastructure fund. Limit coverage to those infrastructure items that are essential to support the country's economic and social affairs following a natural disaster and those items that have already been insured for noncatastrophic risks. Limit agricultural coverage to farmers who are unable to afford private insurance; farmers who are able to afford private insurance should be obligated to purchase it. Subsume welfare payments to subsistence farmers under the victims fund or route them through other social safety net programs.
- Reconstitute FONDEN as a legal entity that is capable of transferring risk.
- Inventory all vital infrastructure and estimate FONDEN's risk exposure. Catastrophe modeling—which analyzes the frequency of hazard events, the severity of the events, the vulnerability of assets that are the responsibility of FONDEN, and the value of those assets—could be used to make these estimates.
- Develop financial models that allow various policy options to be evaluated. Financial modeling based on the data developed in the catastrophe modeling would yield various options and prices for the transfer of risk.
- Group similar risks together in funds so they can be aggregated, priced, and transferred separately. Allocate sufficient dedicated capital and premium-paying capacity to FONDEN to support its risk placements in the insurance or capital markets.
- Modify FONDEN's mandate so that it is permitted to disburse funds for studies and training on mitigating risk before a disaster occurs. Funding for studies and training would represent an addition to the annual budgets of executing agencies; the actual financing of mitigation works would presumably be carried out as part of the public investment programs executed by the various government departments.
- Consider linking the terms of FONDEN financing for reconstruction following a disaster to the extent to which mitigation measures had been implemented before the disaster (possibly through varying the cost-sharing arrangements with states and municipalities).
- Establish guidelines to be followed by other government agencies in managing the risks they bear. FONDEN could, for example, specify the types and acceptable limits for insurance coverage for various types of infrastructure. It could also help federal, state, and local authorities purchase property insurance on a group basis.

## The Role of the World Bank

The study has helped the World Bank define more clearly ways in which it could help developing countries manage disaster risk more effectively. Instruments that could be of value include the following:

- *Loans for investment in mitigation and reconstruction.* Loans could be provided to finance retrofitting plans aimed at reducing losses (to schools, hospitals, public buildings) and the reconstruction of infrastructure damaged by natural disasters. An important feature could be to link the terms of reconstruction financing to the extent of mitigation carried out by the final beneficiaries of the financing. A technical assistance component could support capacity building for various aspects of disaster management.
- *Contingent loans for reconstruction.* To make sure that funds are accessible immediately when disaster strikes, the Bank could establish a credit line that could be drawn upon under certain conditions. Establishing such a line would speed the delivery of funds during emergencies.
- *Contingent loans for risk financing.* Catastrophe risk is normally "packaged" into "layers" and financed or transferred through a variety of arrangements, including primary insurance, reinsurance, credit financing, and bond and derivative financing.[1] The combination of instruments used depends on specific circumstances, including the relative costs of the various instruments. The Bank could consider providing contingent loans to finance a credit layer in a risk management package.
- *Partial risk guarantees.* The Bank operates a guarantee program that supports private investment in borrowing countries by guaranteeing against risks associated with policy or contractual performance by the government. Under the program, the government counterguarantees the Bank guarantee by agreeing to repay the Bank for any payments it makes to investors under the terms of the guarantee. In principle, this program might provide credit enhancement for catastrophe bonds and commercial contingent credit lines, thereby improving their terms and attractiveness to investors.

In summary, there is much that Mexico can do, even in the short term, to improve its ability to reduce and manage natural disaster risk. Leadership on hazard and vulnerability assessment, mitigation research and diffusion, insurance reform, and improved public sector risk management programs are among the key actions Mexico should take. This case study and future discussions with the Mexican government should help refine these options so that they address Mexico's primary concerns and contribute to more sustainable social and economic development.

### Note

1. A "layer" constitutes a commitment to cover losses in excess of an agreed-upon minimum value and up to an agreed-upon maximum value.

Aerial view of Mexico City after 1985 earthquake.

*Chapter 1*

# Introduction

The World Bank established the Disaster Management Facility in July 1998 to provide proactive leadership in coordinating efforts to introduce disaster prevention and mitigation practices in the range of development-related activities. One of the facility's key activities is the Market Incentives for Mitigation Investment (MIMI) initiative. MIMI seeks to create public-private partnerships to advance disaster risk awareness and to provide effective incentives for institutional and individual investment in disaster mitigation measures. The initiative is important because increasing World Bank and member country capacity to mitigate risks would save development resources and protect future investments. Privatization of disaster risk, where applicable, would allow governments to shift funding from emergency relief and reconstruction activities to more effective and sustainable disaster mitigation investment.

Partnerships are key to the MIMI initiative. As the manager of the MIMI initiative, the Disaster Management Facility has mobilized team members from various parts of the World Bank Group, including regional country departments, the Financial Sector Development Department, and the International Finance Corporation. Team members also include academic institutions (Virginia Polytechnic Institute and the International Institute for Applied Systems Analysis) and private sector insurers (the Aon Group, Gerling Global Reinsurance, Munich Reinsurance, and Renaissance Reinsurance, Ltd.), which provide valuable expertise, information, and support to the team's research and policy development work.

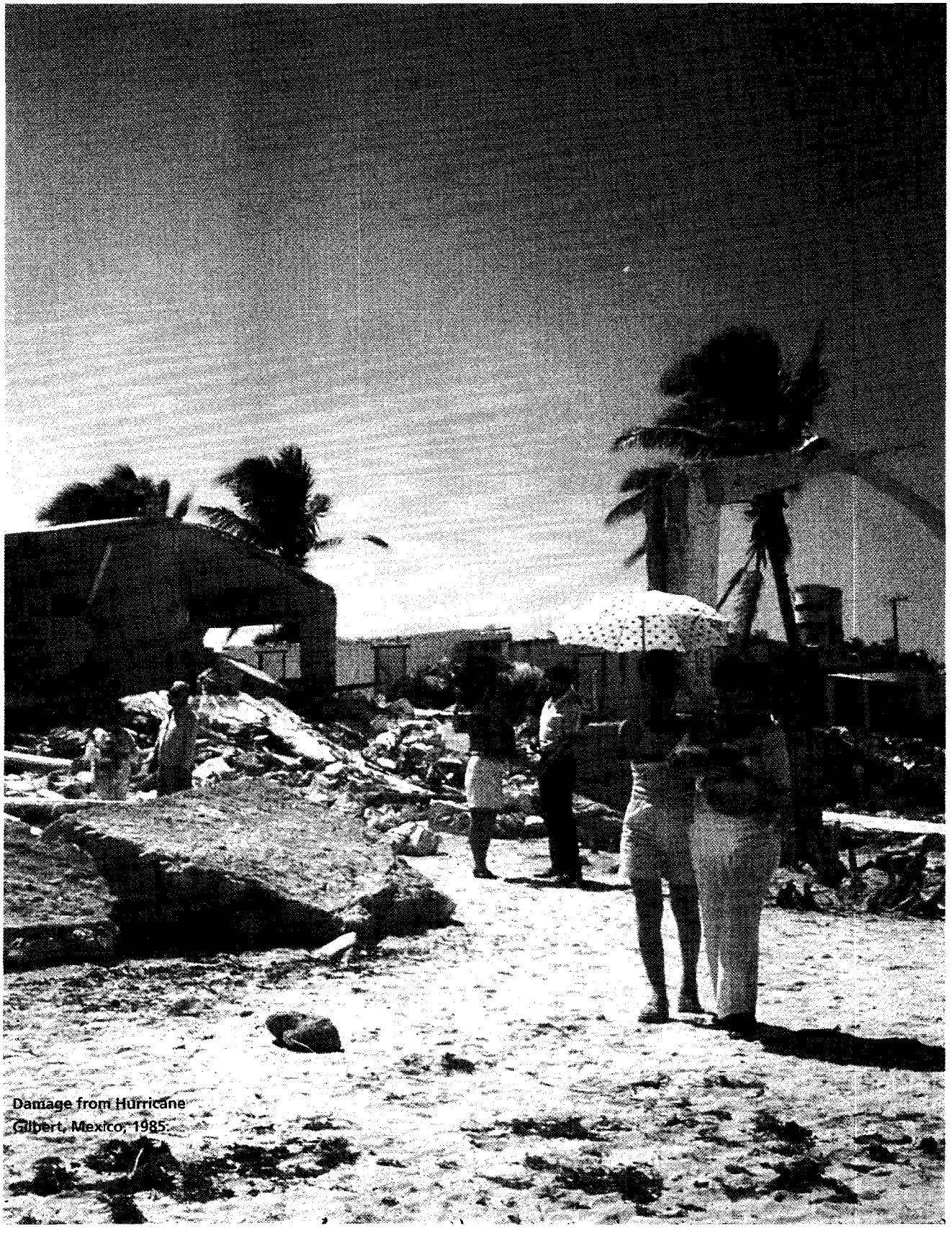
The linchpin of the MIMI initiative is its country case studies. These studies document current disaster exposure, insurance coverage, and the use of mitigation practices and assess the potential for mobilizing mitigation investment through the insurance and financial markets.

Mexico was chosen for the first appraisal mission because of its extensive experience with losses from natural disasters and because it is considering significant public policy changes to its insurance regulations. The mission to Mexico, carried out in October 1998 at the request of the Mexican government, found that Mexico can take steps to reduce natural disaster losses through mitigation and to finance losses more effectively when they do occur. This report synthesizes the findings of the October 1998 mission and incorporates the comments and proceedings of a workshop held in Mexico City, February 23–24, 1999.

The specific objective of the study is to assess the current capacity of Mexico to deal with disaster risk and to identify ways in which the impacts of catastrophes on the economy can be reduced. The study analyzes the three main components of a comprehensive disaster risk management strategy: risk identification, risk reduction, and risk transfer and financing.

Chapter 2 examines risk identification, the first step of comprehensive risk management. Risk identification is the process of assessing potential losses due to natural disasters. Estimation of potential losses entails hazard assessment and vulnerability assessment. The chapter includes recommendations for expansion and improvement of natural disaster risk assessment in Mexico. Chapter 3 examines risk reduction, which includes the physical measures to reduce exposure or increase resistance to natural hazards. Disaster mitigation measures are those that reduce the physical impacts of disasters. The chapter describes current disaster mitigation activities in Mexico and suggests ways in which the public and private sectors can provide incentives for effective risk reduction. Chapter 4 examines how Mexico could transfer risk to the insurance industry. It describes the role of insurance and reinsurance and explains why insurance coverage in Mexico is low. It proposes a series of steps that could help Mexico use private insur-

ance companies to improve the public sector's ability to deal with risk. Chapter 5 examines how Mexico might be able to use new financial instruments, such as catastrophe bonds and options to transfer or finance risk. It also looks at the structure of FONDEN, making recommendations on ways the fund could be reorganized. Chapter 6 summarizes the study's main findings and recommendations.



Damage from Hurricane Gilbert, Mexico, 1985.

*Chapter 2*

# Risk Identification: Assessing Hazards and Vulnerability

In many countries, including Mexico, devastating natural disasters are a frequent occurrence. A natural disaster occurs when an extreme event (flood, earthquake, drought) affects vulnerable structures, such as buildings and infrastructure, and the consequences surpass a society's ability to respond. Extreme natural events such as fires, floods, earthquakes, and droughts, have always been part of the natural cycle; virtually all parts of the world are exposed to them.

But accelerated changes in demographic and economic trends in Mexico, as in other countries, have disturbed the balance between ecosystems, increasing the risk of human suffering and death. Rapid population growth increases pressures on natural resources and the environment and raises the consequent risks associated with human activities (Kreimer and Munasinghe 1991). Major disasters not only damage capital assets but have long-term effects on the economy as well.

Despite the repeated experience of disasters, public officials often react with surprise at the results of an "act of God." Awareness of risk to extreme natural events is not well established in the process of public and private investment decisionmaking. Inadequate provision of disaster response and reconstruction funds before disasters often leads to ad hoc fund transfers, disrupting and postponing planned development activities. Such diversion of development funding postpones progress toward long-term economic and social improvement.

While the precise scale, time, or location of disaster events cannot be predicted, areas of hazard and vulnerability can be identified. Aggregate losses can be anticipated at the national level, and provision can be made for extreme events.

## Hazard and Vulnerability Assessment

The process of disaster risk management begins with risk identification. Risk identification includes hazard assessment and vulnerability assessment. These activities are essential for the definition of strategies to manage disaster risk, including risk reduction (mitigation of the impact of disasters) and estimation of potential losses necessary for financing or transferring risk. Hazard assessment requires scientific understanding of relevant natural phenomena and interpretation of historical records of the occurrence of extreme events.

Hazard assessment provides the basis for the identification of hazard zones, which can be presented on maps at various scales. Such maps may indicate the expected peak intensity of an event (as is done on earthquake zone maps) and the frequency of occurrence in a particular area (as is done on floodplain maps). See annex 1 for a map of some of the risks facing Mexico.

Vulnerability assessment focuses on the targets of natural hazards. It involves the evaluation of expected performance of structures, infrastructure, and institutions under the load exerted by extreme natural events. Unreinforced masonry buildings, for example, are known to perform poorly in particular types of earthquakes. Buildings with poorly secured roofs are known to suffer damage in hurricanes. More sophisticated differentiation of expected performance is possible for a range of classes of structures and infrastructure.

When hazard assessment and vulnerability assessment are combined, it is possible to develop estimates of potential losses. With established probabilities of natural event occurrence and expected structural performance it is possible to attach estimates of probability to specific loss scenarios. Modeling of expected disaster losses represents a valuable tool for public and private

decisionmakers. Investors and insurance companies can evaluate the security of their investments and the extent of their exposure to disaster risk. Governments can use such models to plan for development, evaluate options for mitigation or risk reduction investments, and plan for response needs before a disaster occurs.

The foundation of hazard assessment is the historical record of extreme events, including their location, time, and intensity. The interpretation of this record in light of scientific understanding of the particular phenomenon provides the basis for hazard mapping and estimation of event frequency.

## What Kind of Disasters Occur in Mexico?

Mexico has a long history of natural disasters. Earthquakes and floods figure prominently in Mexican tradition and folklore. According to one legend, the modern age began after a powerful earthquake destroyed the area's original inhabitants, the Quinametin giants. Another legend claims that Quetzalcóatl sent a hurricane to destroy the city of Cholula.

Between 1980 and 1998 Mexico experienced 79 disasters. These events included weather-related events (hurricanes, storms, floods, droughts, and forest fires); geology-related events (earthquakes, volcanic eruptions, and landslides); and events caused by human action (industrial accidents, chemical and oil spills and explosions, and structural fires). More than half of the events were weather related, with hurricanes and flooding as the leading causes of damage.

Much work has already been done in Mexico. Risk atlases, for example, identify vulnerable areas within cities. Such tools can help policymakers develop effective strategies for reducing or transferring risks in those areas. No comprehensive analysis of vulnerability exists, however. Some sense of Mexico's vulnerability can be gained from examining the frequency and magnitude of various kinds of disasters.

### *Earthquakes*

Mexico is a seismically active country. It is located along the world's "fire belt," where 80 percent of the earth's seismic and volcanic activity takes place. Between 1900 and 1998 Mexico experienced 84 major earthquakes (earthquakes measuring more than 7.0 on the Richter scale).

To estimate the potential for catastrophic loss from earthquakes in Mexico, the country's seismicity needs to be analyzed in conjunction with patterns of human and industrial habitation in disaster-prone areas. While significant research has focused on earthquake prediction, it is difficult to estimate earthquake frequency.

Earthquakes occur frequently in Mexico because the country sits atop four tectonic plates, and movement between the plates increases the risk of earthquakes. Epicenters of earthquakes stronger than 7.0 on the Richter scale are located on the Pacific coast of the states of Jalisco, Colima, Michoacán, Guerrero, and Oaxaca. The most active seismic region in Mexico is the Guerrero coast, where scientists believe a major seismic event is long overdue. The Guerrero coast is a highly developed area, with a significant concentration of population, structures, and infrastructure. The loss potential from a seismic event in the region is thus very high.

The major earthquakes of 1908, 1909, 1911, 1987, and 1988 occurred in the northeast section of the "seismic gap." Most earthquake damage has occurred in the regions between Jalisco, Chiapas, and the Isthmus of Tehantepac. Major earthquakes have also occurred in Veracruz, Puebla, the State of Mexico, and Baja California, especially near the border with the United States.

The complexity of seismic events is illustrated by the characteristics of the earthquake that struck Mexico City in September 1985, an event that took more than 6000 lives and damaged the housing of about 180,000 families. The ground movement resonant cycle coincided with the natural vibration period movement of the 5- to-12-story buildings that make up the city's dense historic center, making this earthquake the most destructive in the hemisphere's history. Poorly built tenements housing low-income families in overcrowded conditions suffered the worst damage. Also affected were 340 office buildings, in which 145,000 government workers were employed; 1,200 small industrial shops; 1,700 hotel rooms; 1,200 schools; and 2,000 hospital beds. The economic losses exceeded $4 billion.

### *Tropical Storms and Hurricanes*

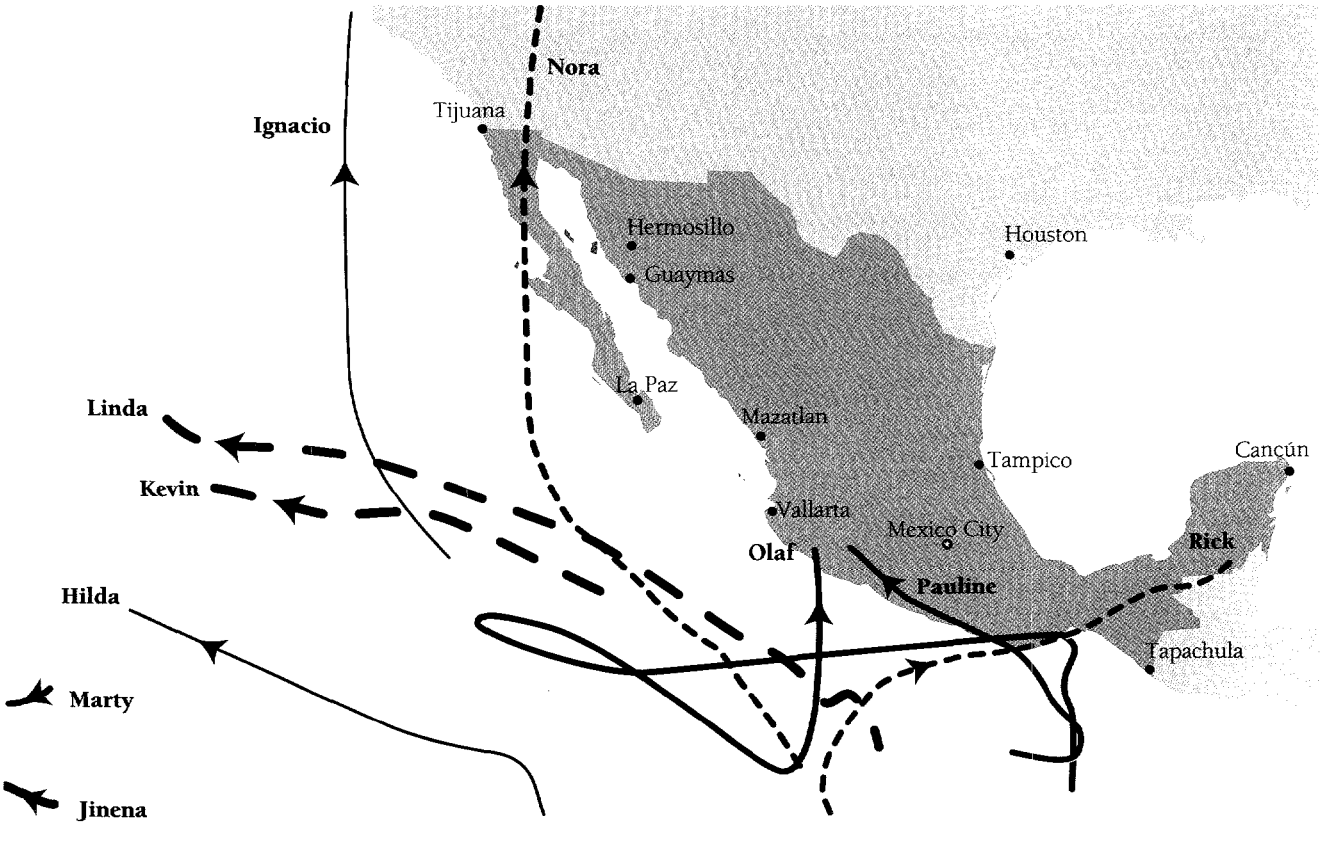
Mexico is one of the countries most severely affected by tropical storms. It is one of the few regions in the world that can be affected simultaneously by two independent cyclone regions, the North Atlantic and the North Pacific. The frequency of hurricanes would justify a well-organized system to deal with this hazard, something that is not in place (Rosengaus 1998).

Between 1980 and 1998 Mexico suffered 43 weather-related disaster events. That period may have been atypical, however. During the 10 years between 1967 and 1977, Mexico suffered 157 severe weather events, including 57 hurricanes that caused serious damage in six states. Many parts of Mexico are affected by cyclones and tropical storms during the summer months (June to October). During the winter, nontropical storms can lead to heavy rainfall in some parts of the country. Other parts of the country are frequently affected by long periods of drought, leading to the loss of cattle and crops.

The hurricanes affecting Mexico come from four main regions: the Gulf of Tehuantepec, the Sonda de Campeche portion of the Gulf of Mexico, the Eastern Caribbean, and the tropical Atlantic Ocean. The Gulf of Tehuantepec becomes turbulent around the end of May. Most hurricanes head out to sea, but some make landfall. The Sonda de Campeche portion of the Gulf of Mexico becomes turbulent in June. Winds head north, affecting Veracruz and Tamaulipas. Hurricanes of great intensity occur in the Eastern Caribbean between July and October, affecting Yucatán. The Atlantic Ocean between 8° and 12° latitude north becomes active in August. Winds head westward, penetrating the Caribbean Sea, Yucatán, Tamaulipas, and Veracruz. The precise location of these four regions is unstable and can vary as a result of ocean currents and their temperatures.

The states of Baja California Sur, Michoacán, Sinaloa, Sonora, and Tamaulipas have been worst hit by hurricanes, with hurricanes making landfall on average every two to four years (map 2.1). About 40 percent of the population, or some 4 million people, live along the coast in these regions and are exposed to hurricanes.

**Map 2.1** Path of Pacific Ocean hurricanes, August–November 1997



Hurricanes can be devastating. In 1997 Hurricane Pauline claimed hundreds of victims, caused flooding and landslides, and cut electricity, communications, and water. Acapulco, Mexico's most famous tourist destination, was badly hit when homes in squatter settlements on hillsides were destroyed, leaving many people homeless. Pauline had such devastating effects because it followed the coastline of Oaxaca and Guerreo, whipping up strong waves and currents. The region's uneven topography also made it vulnerable to flooding and landslides following the hurricane. Rapid urbanization in coastal areas in recent years has increased the potential damage that hurricanes like Pauline can cause to large population centers.

### *Volcanoes*

Mexico has dozens of volcanoes, 14 of which have erupted in recent history. Volcanic eruptions can produce ashfall, tidal waves, lava and mud flows, and volcanic earthquakes. These phenomena vary from one volcano to another.

The most recent volcanic eruption that resulted in catastrophic losses in Mexico was el Chichón in 1982, which completely destroyed eight communities and claimed 2,000 lives. The eruption lasted nearly six hours and caused $117 million worth of losses to crops, cattle, and damage to cultivable land within a 50-kilometer radius (Gutiérrez 1998).

Between 1993 and 1998 Popocatépetl, el Colima, el Tacaná, and el Everman were active, with all but el Everman threatening settled areas. A major eruption of Popocatépetl would affect settlements within a 20–30 kilometer radius, according to researchers at the National Autonomous University of Mexico. The volcano is being carefully monitored to allow for preparedness measures, including evacuation of the communities in the vulnerable area.

In major cities—such as Puebla, Cuernavaca, and Mexico City, where the closest volcano is 43 kilometers away—the effects of a volcanic eruption are likely to be limited to falling volcanic ash. Falling ash lasting for many hours can darken the sky and lead to electrical storms that can interfere with telecommunications. Day suddenly turning to night can also have negative psychological effects upon inhabitants. While not toxic, volcanic ash is irritating to the lungs and eyes, and people are advised to take shelter until the air clears. Falling ash can be dangerous for air traffic, which should be suspended during volcanic eruptions. Ash can damage motors, the moving parts of machines, and infrastructure as well, blocking drains and causing electricity networks to short circuit. Excessive accumulation of volcanic ash on rooftops can weaken structures.

### *Floods*

Flooding caused by rivers overflowing their banks occurs almost every year in Mexico. Heavy rainfall also causes erosion and landslides. Flooding is naturally less frequent in semi-arid regions, but it can be particularly devastating when it does occur there (as it did in Monterrey in 1988, for example).

Floods are rarely caused by heavy rains alone. Soil erosion caused by deforestation, inadequate agricultural practices, and increasing urbanization all increase the risk of flooding. Despite considerable investment in drainage infrastructure, Mexico City experiences losses every year from flash flooding. The occurrence of flooding is increasing in flood plain areas that have been urbanized, as changes in land use broaden the capture of rainfall, producing flows that the natural basin cannot cope with. Such urban flooding affects assets of considerable economic value.

The loss from flooding in Mexico has been high. Between 1973 and 1990 more than 1,800 people died and about $7.7 billion in economic losses were incurred (Gutiérrez 1998).

### *Forest Fires*

Mexico experiences forest fires every year. The magnitude of these fires depends in part on climatic conditions. In 1998, for instance, excessively dry conditions, strong winds, and high temperatures resulting from the El Niño phenomenon increased the number and severity of forest fires. Damage from forest fires was particularly severe in 1998, when about 850,000 hectares, including 198,000 of forested land, were destroyed (table 2.1). Worst affected were the states of Chihuahua, Oaxaca, and Durango.

Slash and burn agriculture was responsible for more than half of all forest fires in Mexico in 1998, according

**Table 2.1 Forest fires in Mexico, 1993–98**

| *Year* | *Number of fires* | *Hectares affected* |
|---|---|---|
| 1993 | 10,251 | 235,020 |
| 1994 | 7,830 | 141,502 |
| 1995 | 7,860 | 309,097 |
| 1996 | 9,256 | 248,765 |
| 1997 | 5,163 | 107,845 |
| 1998 | 14,445 | 849,632 |

*Source*: Ministry of Environment, Natural Resources, and Fisheries 1998.

to the Ministry of Environment, Natural Resources and Fisheries. Natural causes accounted for only 3 percent of all forest fires.

## How are Hazards and Vulnerability Assessed in Mexico?

Risk identification is composed of hazard assessment and vulnerability assessment. Vulnerability is generally a function of location or construction. Assessing vulnerability compares the resistive capacity or strength of a structure to the expected natural hazard loads associated with the structure's location. Buildings and infrastructure are classified by structural type and material. Based on laboratory tests and actual disaster damage experience, engineers are able to estimate the expected performance of structures subjected to such factors as ground shaking intensity or wind speed. Survey and evaluation of the stock of buildings and infrastructure can provide estimates of potential damage and can help to identify weaknesses in critical structures or systems. The vulnerability assessment provides the basis for risk reduction activities. Once vulnerable structures and infrastructure are identified, strategies can be developed to strengthen or replace them.

Mexico is fortunate to have highly competent intellectual and institutional resources for hazard and vulnerability assessment. For hurricane, flood, coastal flooding, and drought, hazard assessment is carried out by the National Water Commission. For earthquake, volcano, and landslide hazards, assessment is handled by the National Center for Disaster Prevention (CENAPRED) and units of the National Autonomous University of Mexico.

Following the 1985 Mexico City earthquake significant progress was made in identifying natural disaster risk. The establishment of CENAPRED in the General Directorate of Civil Protection of the Ministry of the Interior represents a major contribution to natural hazards data collection and analysis. CENAPRED was established with financial and technical assistance from the Japanese government. It is located on the campus of the National Autonomous University of Mexico and benefits from close cooperation with the university.

CENAPRED is a unique institution that bridges the gap between academic researchers and the government by channeling research applications developed by university researchers to the Ministry of the Interior. It is involved in both research and information dissemination. Its collaboration with academic researchers and practical application of scientific knowledge represent a model that could be adopted by other disaster-prone countries.

## How Do Natural Disasters Affect Economic Development?

An important component of vulnerability assessment is the analysis of disaster damage in order to determine the resistive capacity or strength of a structure to the impacts of a particular natural hazard. Understanding the full economic impacts of natural disasters is also essential to developing disaster risk management policy.

Over the past 25 years, a growing body of research has analyzed the economic impacts of disasters in developing countries (Benson 1997; Benson and Clay 1998). The United Nations Economic Council for Latin America and the Caribbean (ECLAC) has carried out systematic studies of the short- and long-term economic consequences of disasters. ECLAC's methodology distinguishes three types of losses: direct losses, indirect losses, and secondary effects. While some work has been done in Mexico on direct losses, very little information is available on indirect and secondary losses.

### *Direct and Indirect Losses*

Direct losses include losses of physical assets owned by individuals, businesses, and the government. They include damage to structures and infrastructure as well as loss of inventory and agricultural produce.

Indirect losses are losses caused by the disruption of resource allocation across sectors and within markets. These losses include the forgone production of goods and services as a result of interruptions in utility services, transport, labor supply, suppliers, or markets. Indirect losses also include the cost of providing interim services while the original operating capacity is being restored.

Most estimates of disaster loss in Mexico have examined only the direct losses of life and property (table 2.2). While direct damage is an important measure of impact, it does not capture the full impact of the event on the economy.

### *Secondary Economic Effects*

Secondary effects include impacts on such macroeconomic variables as economic growth, the balance of payments, public spending, and inflation. Estimating these costs is difficult because of data limitations.[1] These effects can hurt long-term economic development in several ways:

**Table 2.2 Annual deaths and direct economic losses caused by disasters in Mexico, 1980–98**

| *Year* | *Deaths* | *Direct economic losses (millions of U.S. dollars)* |
|---|---|---|
| 1980 | 3 | 310.4 |
| 1982 | 50 | 314.0 |
| 1984 | 1,000 | 26.3 |
| 1985 | 6,043 | 4,159.9[a] |
| 1986 | 0 | 1.5 |
| 1987 | 6 | 0.3 |
| 1988 | 692 | 2,092.9 |
| 1989 | 0 | 648.0 |
| 1990 | 391 | 94.5 |
| 1991 | 11 | 167.5 |
| 1992 | 276 | 192.5 |
| 1993 | 28 | 125.6 |
| 1994 | 0 | 3.8 |
| 1995 | 364 | 689.6 |
| 1996 | 224 | 5.3 |
| 1997 | 228 | 447.8 |
| 1998 | 199 | 2,478.8 |
| Total | 9,515 | 11,758.7 |

*Note:* Figures for 1981 and 1983 were not available. Figures are based on data available on particular events and do not represent a comprehensive economic assessment of all direct losses. Figures in U.S. dollars are based on conversion rates in the year the losses were incurred.
a. Includes $515 million in indirect losses.
*Source:* Bitrán Bitrán 1999.

1. *Ad hoc reallocation of expenditure following a disaster can jeopardize long-term development goals.* Emergency reconstruction requirements in the immediate aftermath of a natural disaster often demand a substantial reallocation of resources and government expenditure in the short run. In Mexico funds that had been committed to other programs have been reallocated to provide disaster assistance. Funds supported by World Bank lending have also been diverted to deal with emergency needs. As much as 30 percent of World Bank–financed funds earmarked for water sector projects in Mexico, for example, are believed to have been reallocated to disaster-related programs. Even if funds are well spent on disaster-related operations, a sudden unplanned reallocation can undermine, if not sacrifice altogether, the longer-term development objective of the project that was bled of its resources. In agriculture, for instance, production targets may not be met. Indivisible infrastructure projects—such as power plants, highways, and ports—may not be built at all. Failure to fund these projects reduces economic growth.

2. *The need to respond to natural disasters may undermine financial planning and budgeting as an instrument of economic and social development.* In countries prone to natural disasters, ad hoc reassignment of government funds inevitably becomes frequent, if not routine, unless efforts are made to mitigate the effects of such disasters. If budgetary allocations are regularly pillaged to deal with natural disasters, confidence in the government's commitment to long-term economic and social development and its ability to pursue such goals will be undermined. Unpredictable budget commitments are also likely to undermine efforts by state and municipal governments that contribute to long-term economic development. Disasters are normal events in Mexico, occurring an average of three times a year between 1980 and 1998. The government thus needs to take these events into account in its development planning. Disaster mitigation and risk transfer measures can help the government restore the sustainability of its support—through the budget—for economic and social development.

3. *Expenditures on disaster recovery can cause budget deficits.* Reallocation of budgetary assignments to disaster-related reconstruction may not be enough to meet all emergency needs; additional funds may be needed to

meet the needs of people affected by the crisis. The difficulty of funding such needs may be exacerbated by the fact that public sector revenues may be interrupted by the disaster. Pressures to meet such needs can thus increase public sector deficits, possibly driving up interest rates and the rate of inflation. Such deficits undermine international investors' confidence in the continuity of government policy, reducing both domestic and foreign investment. Measures to mitigate the effects of natural disasters can help attenuate such effects.

4. *Natural disasters can adversely affect the balance of payments.* Natural disasters are likely to hurt a country's balance of payments, particularly if the area hit is a major exporting region. Developing models that classify regions in terms of their effects on the balance of payments could help governments pinpoint where disaster mitigation efforts could be most beneficial in terms of preventing deterioration of the trade deficit.[2]

5. *Investors are likely to demand higher rates of return following a disaster to compensate them for higher perceived risks.* Changes in the perception of risk can adversely affect an economy if investors demand higher rates of return. Entrepreneurs who do not believe they are being adequately compensated for the risk they face may decide to close their businesses or move to a less risky location. If a business closes, the national economy suffers a loss of income; if a business relocates within the country, income is merely transferred from one region to another. Both cases have negative impacts on the local economy and could serve as an inducement for local governments at the state and municipal level to take measures to mitigate the effects of natural disasters.

## Recommendations

Before it can develop an effective risk management strategy, Mexico must identify the principal hazards it faces and assess the vulnerability to those hazards of its major settled areas, its infrastructure, and its economic assets. A good starting place would be a complete inventory of federal government assets. The risk assessment should include estimates of direct, indirect, and secondary losses from disasters in order to provide a better understanding of the most appropriate policy options.

Efforts already under way at CENAPRED and the National Autonomous University of Mexico should receive additional support so that these institutions can continue to operate as centers of excellence in natural hazard research. The valuable role CENAPRED plays in identifying earthquake and volcano hazards should be expanded to include the other principal hazards affecting Mexico.

### Notes

1. Given the enormous size of Mexico's economy—GDP was $335 billion in 1997—most studies have been unable to detect the effects of disasters on macroeconomic variables. The sole exception is the 1985 Mexico City earthquake, which adversely affected macroeconomic variables in 1986.

2. Some attempts have been made to estimate the effect of natural disasters in Mexico on the balance of payments. According to one estimate, the 1985 earthquake in Mexico City increased Mexico's balance of payments deficit by $8.6 billion in the five years following the quake (Jovel undated).

Improved building standards for post-earthquake reconstruction, 1989.

*Chapter 3*

# Mitigating Damage by Reducing the Level of Risk

Natural disasters result when an extreme natural event coincides with a vulnerable human settlement. Put simply, disasters are a product of hazard and vulnerability:

**Disaster = hazard × vulnerability**

The risk of disaster can be reduced by reducing either the hazard factor or the vulnerability factor (or both). In the case of some hazards, such as floods and landslides, engineering technologies can reduce the effect of a hazard. For other hazards, such as earthquakes and hurricanes, no effective means are available to modify the intensity, frequency, or location of a hazard event. In the short term, real time hazard monitoring can provide useful information that can help communities prepare for disasters, mobilize resources, and evacuate populations. Such monitoring can reduce deaths caused by flooding, hurricanes, and volcanoes.

Civil defense in Mexico (as in many other countries) has focused mainly on monitoring, preparedness, and response to disasters. While effective preparedness and response strategies are crucial to mitigating the effects of disasters, the core of a mitigation program should be more "upstream" measures, such as the safe location, design, and construction of structures, infrastructure, and settlements.

## Developing a Risk Reduction Strategy

The most important means of reducing disaster risk is reducing vulnerability. Two basic strategies are used: avoidance and resistance. Avoidance seeks to reduce the effects of hazards on settlements by banning building in hazard zones or modifying the pattern of occurrence of the hazard with structures such as dams or irrigation systems. Resistance seeks to reduce the damage caused by hazards by constructing settlements that can withstand their effects. Both strategies are essential to reducing disaster risk. Avoidance strategies should be used in land use and development planning. Resistance strategies should be used in building safe structures.

The first priority in natural disaster vulnerability reduction must be to ensure that new structures, infrastructure, and settlements are structurally sound and located in areas that are not vulnerable to hazards. Doing so will require clear delineation of hazard zones and the establishment of construction standards that correspond to expected hazard exposure. More problematic are existing structures, which may be difficult to relocate and expensive or impossible to reinforce.

The estimation of potential disaster losses provides a useful reference for evaluating the cost and benefits of mitigation expenditures. Building codes, for example, can be analyzed to compare the added costs of construction, supervision, and regulation with the potential savings from reducing the expected damage from future extreme events.

## Coordinating Risk Mitigation Efforts throughout the Country

The Mexican government established the National Civil Protection System (SINAPROC) in 1986 as the main mechanism for interagency coordination of disaster efforts. SINAPROC is responsible for mitigating the loss of lives and material and the interruption of essential society functions caused by disasters. Responsibility for the system lies with the General Coordinating Body for Civil Protection in the Ministry of the Interior. The

system synchronizes the technical work of various ministries (table 3.1).

In 1990 the National Council for Civil Protection (Consejo Nacional de Protección Civil) was added to SINAPROC. The council is an advisory, planning, and coordinating committee for civil protection. It is headed by the President of Mexico and made up of 12 ministers and the mayor of the federal district of Mexico City.

At the subnational levels, governors of states and presidents of municipalities are responsible for implementing and coordinating local Civil Protection Systems. These State and Municipal Councils for Civil Protection are responsible for planning, prevention, and implementation of recovery actions after natural disasters. These offices provide requested support to state and municipal governments. Each state and municipal council also has its own technical unit for civil defense. The autonomy of these subnational councils sometimes conflicts with the effective integration and coordination of national efforts by SINAPROC.

**Table 3.1 Responsibility for technical support to SINAPROC**

| *Type of hazard* | *Technical coordinator* |
|---|---|
| Geologic | Ministry of Social Development |
| Hydro-meteorological | Ministry of Environmental, Natural Resources, and Fisheries |
| Chemical | Ministry of Trade and Industrial Development |
| Health | Ministry of Environmental, Natural Resources, and Fisheries |
| Social-organizational | Ministry of the Interior |

*Source:* Ministry of the Interior.

SINAPROC's Program for Civil Protection 1995–2000 is set up as a national regulatory and operational instrument. The program defines the prevention and response actions required to deal with natural disasters. It also defines the authority, responsibilities, and relationships among different offices and organizations. The program covers prevention, rescue, and recovery.

SINAPROC issues public warnings based on the level of emergency response required (table 3.2). It then coordinates responses by different ministries (table 3.3). Once an emergency is over, responsibility for reconstruction reverts to the ministry responsible for the sector affected.

To help prepare for and mitigate the effects of different kinds of potential disasters, SINAPROC has set up mechanisms for monitoring disasters. This monitoring, which covers earthquakes, cyclones, and volcanoes, is performed by various institutions:

- *Earthquakes.* The National Broad Band Seismology Network was designed by the Engineering Institute of the National Autonomous University of Mexico to monitor earthquake activity in Mexico. A new network has also been developed to improve the understanding of the earthquake hazard in Mexico.
- *Cyclones.* Working with regional hurricane centers in Miami and San Francisco, Mexican authorities analyze tropical cyclones in order to help forecast the movement and intensity of hurricanes heading toward Mexico. These forecasts are made available to the Ministry of the Interior's Civil Defense Directorate and state representatives of the (national) Ministry of Agriculture and Water Resources. Mexico also monitors tropical cyclones through its own information network. Between May and

**Table 3.2 Actions taken during various states of emergency**

| *Emergency state* | *Definition* | *Action* |
|---|---|---|
| Prewarning | Occurrence of catastrophic phenomenon possible. | Prevention actions taken by local authorities. |
| Warning | Occurrence of catastrophic phenomenon imminent. | Preparedness program readied for search and rescue. |
| Alarm | Catastrophic phenomenon produces damage. | Local emergency declared and emergency program executed. |
| Emergency | Health and security risk exceeds state capacity to respond | State of emergency declared and emergency program executed. |
| Disaster | More than one state suffers severe damage affecting social structure and vital systems. | President declares disaster.<br>Federal response measures required. |

*Source:* SINAPROC.

**Table 3.3 Emergency actions and technical coordinators**

| *Action* | *Technical coordinator* |
|---|---|
| Warning | Ministry of the Interior |
| Damage assessment | Ministry of the Interior (CENAPRED) |
| Emergency plans | Ministry of the Interior (National Center of Operations) |
| Emergency coordination | Ministry of the Interior (National Center of Operations) |
| Security | Ministry of the Interior |
| Search and rescue | Ministry of National Defense |
| Logistical support | Ministry of the Interior |
| Health | Ministry of Health |
| Provisions | Ministry of Trade and Industrial Development |
| Emergency communications | Ministry of the Interior |

*Source:* Ministry of the Interior.

November, observation and related telecommunications networks constantly monitor weather systems, providing updated satellite imagery every 30 minutes. Bulletins and warnings of tropical cyclones are passed on to the Ministry of the Interior's Civil Defense Directorate three times a day, allowing civil defense directors to alert civil defense units in at-risk zones.

- *Volcanoes.* Four volcanoes are currently being monitored in Mexico. CENAPRED and the National Autonomous University of Mexico monitor Popocatépetl; the University of Colima monitors Colima; the governments of Mexico and Guatemala monitor Tacaná; and CENAPRED and Vera Cruz University monitor Pico de Orizaba. Emergency response programs have been designed for dealing with eruptions of Popocatépetl and Colima.

SINAPROC provides a structure for coordinating emergency preparedness and response activities at the federal and subnational levels. Long-term disaster risk reduction, however, requires the mobilization of different institutions and skills from those appropriate for emergency response. Long-term mitigation must be incorporated into strategies for sustainable development and tested against overall social and economic goals. Efforts for longer-term risk reduction in Mexico are discussed below.

## What Steps Have Been Taken to Mitigate Risk?

Important steps have already been taken in Mexico to mitigate disaster risk. Scientific advisory committees have been established, standards for civil works have been set, engineering advances have been made, schools have been retrofitted to withstand earthquakes, and a program for certifying hospitals that meet disaster readiness standards has been put into effect.

### *Scientific Advisory Committees*

In response to the active state of the Popocatépetl volcano since December 1994, CENAPRED set up scientific advisory committees to aid the monitoring and decisionmaking process. Four committees, each made up of unpaid experts in the appropriate field, were established to study geology-related events, weather-related events, chemical-related events, and the social implications of an eruption of Popocatépetl. Each of these committees has contributed to the mitigation effort in Mexico:

- The scientific advisory committee on geology-related events has four functions. It strengthens efforts to enhance the safety of dikes securing water reservoirs, undertakes the necessary studies and monitoring of Mexico's active volcanoes, promotes and coordinates the updating of local building regulations and their enforcement, and supports detection, monitoring, and warning systems for tsunamis in Mexico.
- The scientific advisory committee on weather-related events provides information on weather conditions and forecasts, especially information relating to tropical storms and hurricanes; assesses the vulnerability of bridges to being swept away by floods; and calibrates and uses meteorological radar in Mexico. It analyzed the government's performance before and during Hurricane Pauline.
- The scientific advisory committee on chemical-related events monitors the processing and transportation of dangerous substances, forest fire management, command systems and transport and distribution of toxic waste; assesses the vulnerability of communities to industrial accidents; and fosters mutual industrial help groups.

- The scientific advisory committee on social sciences has undertaken studies on the social problems faced by communities at risk from an eruption of Popocatépetl and created a council made up of chairpersons of the scientific advisory committees.

### *Building and Readiness Standards*

The Federal Electricity Commission has played an important role in natural hazard mitigation in Mexico by developing the Manual of Civil Works. This 10-volume work includes current engineering standards for earthquake-, wind-, and flood-resistant designs. The manual serves as a voluntary reference standard for design engineers in all parts of Mexico that lack modern and complete design standards. Regrettably, the research team that has updated the manual has been disbanded because of budget constraints, and the future of this critical reference is uncertain.

Thanks to studies of the seismic risks facing Mexico City and seismic engineering instruments that have been installed, much is now known about the characteristics of ground motion during earthquakes. Current building regulations in Mexico take into account subsoil types in different parts of the Mexico Valley to determine the kind, size, and use of construction allowed. Mexico City's construction norms are now very strict, resulting in much safer buildings than those built before 1985. Programs for retrofitting and reinforcing damaged buildings with weak structures have been developed, with priority given to hospitals and schools.

All school buildings in seismic areas of Mexico were retrofitted to comply with the *Manual of Civil Works* in 1989. The project was initiated and managed by Daniel Ruiz, the former director of the Earthquake Engineering Institute of the National Autonomous University of Mexico and current director of the National Water Commission. The effort represented an extension of the program financed by the 1986 World Bank Emergency Reconstruction Loan, which financed the strengthening of schools in Mexico City. All school buildings in Mexico are now insured by the federal government.

The Earthquake Engineering Institute of the National Autonomous University of Mexico has played a particularly important role in the revision of seismic design standards following the 1985 earthquake. The university faculty have worked with the Mexican Society for Earthquake Engineering to bring up-to-date training to practicing engineers in other parts of Mexico.

The Pan-American Health Organization has created a program of voluntary certification of disaster readiness for health facilities interested in preparing for and mitigating the effects of disasters—a concept that could be extended to other types of institutions, such as schools, government agencies, municipal governments, and private companies. The program provides guidance on appropriate measures and certifies compliance with those measures based on expert evaluation of structural safety, provision for functionality following a disaster, programs for mass care, special staff training, and organizational and administrative orientation. Certification enhances an institution's reputation and indicates its level of disaster preparedness. Despite the benefits of certification, however, less than 5 percent of hospitals have undergone the process.

### *Urban Planning as an Instrument of Disaster Mitigation in Cities*

Mexico's urban areas are home to 74 percent of the country's population. Rapid and uncontrolled growth of the major cities has increased the vulnerability of their inhabitants—especially those with low incomes—to the effects of disasters. A recent example was Hurricane Pauline, which caused great human losses, not through high winds or tidal surges but through extraordinarily high rainfall, which led to runoff down steep slopes of mountain sides that had been settled illegally.

Mexico's National Plan of Urban Development (1995–2000) details the country's policy for the sector. The plan makes proposals concerning the location of population and economic activity at the national and subnational levels taking into consideration the historic formation of human settlements in Mexico, the internal organization of population centers with regard to land use, and the basic infrastructure requirements of the population.

Land management policy at the national level ties the objectives of settlement policy to those of urban development. This is done in a framework of coordination that aims to promote local economic activities, generate employment, improve living conditions, and increase

equity in public sector management. The National Plan of Urban Development (1995–2000) incorporates strategies in four areas:

- Urban development of 100 cities
- Consolidation of large metropolitan cities
- Land use planning and support of urban development
- Promotion of participation of all stakeholders in urban development by establishing consultative councils at all levels and providing technical assistance to these councils

Urban design is an essential tool of disaster mitigation. Planning, land use management, and building regulations by themselves can make an enormous contribution to mitigating the worst effects of natural and other disasters. In practice, however, the implementation and impact of these regulations has been limited. Disaster risk management should be integrated into urban planning to ensure the safety of human settlements and their infrastructure.

## Recommendations

Disaster risk can be reduced if high priority is placed on safety in all planning and development. Doing so requires a change in attitudes and behaviors, however. Three approaches can help effect such change:

- *Education.* Accurate, understandable information on disaster risk and mitigation measures must be provided to key decisionmakers and to the public at large.
- *Regulation.* Those who disregard public safety should be restrained in the public interest. Permission to build in known hazard zones should be denied, and safe construction should be required by law. Local governments, which regulate urban planning and land use, must ensure that hazardous sites are not occupied by punishing violators who put public safety at risk. Structures built in contravention of the law, including structures in hazard zones and structures that do not meet safety standards, should be demolished.
- *Incentives.* Individuals and corporations that engage in appropriate behavior (choosing safe locations and constructing safe facilities) should be rewarded. Where economically justified, public sector incentives could include fiscal measures, such as tax credits or direct subsidies for mitigation. Private sector incentives could include reduced insurance premiums or reduced interest rates on construction loans.

### *Education*

The educational approach to changing attitudes is based on knowledge. Knowledge about natural hazards, vulnerability, and mitigation is based on scientific and engineering research. Continued strong funding for the high-quality research on natural disaster risk reduction conducted at such institutions as the National Autonomous University of Mexico and CENAPRED is critical to the success of the educational approach.

Dr. Roberto Meli, director general of CENAPRED, has highlighted four main research areas that can contribute to mitigation efforts:

- *Evaluation of the management of recent Mexican disasters.* Recent disasters can provide valuable lessons on improving disaster prevention and mitigation strategies. Investigation of contributing factors, damage evaluation, and emergency management and recovery measures in three recent disasters—Hurricane Pauline (1997), the 1998 Chiapas rain storms, and the 1998 forest fire season—could prove particularly instructive.
- *Modernization of building codes and quality verification programs.* Building codes in Mexico need to be updated. They also need to be made more uniform and enforced throughout the country. Model codes should be developed that correspond to local hazard risks and construction practices. Mechanisms to ensure code enforcement should also be studied.
- *Methodologies for local community risk management studies.* Sound disaster mitigation programs can be prepared and implemented only on the basis of detailed risk studies in which local physical and social conditions are taken into account to build alternative damage scenarios. Such studies should use a common methodology leading to the development of mitigation measures and emergency management programs tailored to local communities. A pilot "microzonation" study could be performed to demonstrate the proposed methodology.
- *Formulation of megadisaster scenarios.* The occurrence of a rare unanticipated natural disaster could produce much more severe losses than those covered

by Mexico's disaster relief fund. To establish insurance coverage needs and prepare mitigation strategies, it is necessary to estimate the maximum losses that could be incurred given the occurrence of various events with different probabilities of transpiring. Some possible megadisasters include a Mitch-like hurricane hitting the Yucatan Peninsula and the Mexican Gulf Coast, damaging the Campeche offshore oil fields, the Tabasco-Veracruz petrochemicals facilities, and highly populated areas; an 8.2 Richter magnitude earthquake in the Guerrero gap, damaging Acapulco and Mexico City; and a Plinian eruption of the Popocatépetl volcano, with large pyroclastic flows destroying nearby inhabitated areas and heavy ashfalls covering a radius of 80 kilometers from the crater (including much of Mexico City).

Convincing the public of the importance of taking action to mitigate natural disasters is difficult, because most people are unaware of the level of risk they face and are unwilling to invest in programs that may yield benefits only in the long run. Information and education are key to overcoming these barriers. Active programs of dissemination, targeted professional education, and broad public education on disaster risk and mitigation should be developed and delivered throughout Mexico. These efforts should include a broad program of public information on natural hazard risks, risk mitigation, and insurance, undertaken as a collaborative effort by the government and the insurance industry. The objective of this program should be to create a "culture of safety."

Including disaster preparedness and mitigation in elementary and high school curricula is also recommended. Helping to develop a culture of safety among young children would provide long-term benefits. Special efforts should also be made to educate low-income communities, which are typically the most vulnerable to disasters, on disaster mitigation.

Mexico has made substantial progress in mitigating disaster risks since its 1985 earthquake, thanks in part to the world-class experts at CENAPRED and the National Autonomous University of Mexico. Efforts have not been uniform throughout the country, however. Specialized training in earthquake engineering and other specialties related to disaster mitigation are not available in many parts of the country. Lack of training in seismic, wind, and hydrologic design means that many practicing engineers have only a limited understanding of special design provisions. The Mexican Society for Earthquake Engineering has worked to promote education about earthquakes in some parts of the country. Training on mitigation must be provided throughout the country, and it must cover all potential disasters. Providing this training will necessitate additional funding for CENAPRED and the National Autonomous University of Mexico.

### *Regulation*

The traditional approach to natural hazard mitigation is coercive regulation. Building codes and zoning laws are promulgated by public agencies and enforced through the legal system, with varying degrees of effectiveness. There is no provision for choice of risk exposure by individuals.

This approach is feasible if there is an organized and effective plan review and field inspection process and if the population accepts the rationale of the regulation and is able and willing to pay the costs of enforcing it. Where these conditions are not met, the effectiveness of the regulatory approach may be reduced.

In Mexico, as in many other countries, regulation and enforcement are not applied uniformly. To improve the effectiveness of this approach, policymakers should conduct a comprehensive reassessment of regulations governing land use and building construction. At the same time, new approaches to land use and building quality management should be developed that effectively contribute to public safety. Recognizing that most mitigation decisions are made at the community level, resources must be allocated to increase capacity and authority for risk management and disaster mitigation at the state and community levels.

### *Incentives*

The incentive approach involves both public and private sector incentives for engaging in behavior that reduces risk. The public sector could encourage desir-

able behavior by providing community-level technical assistance for disaster mitigation, establishing low-risk districts that include tax incentives for mitigation investment, providing financial assistance for engineering analyses of risk, and establishing certification programs, such as the Pan-American Health Organization program for health facilities described above.

The private sector could also encourage risk mitigation. Engineering firms could donate design assistance or provide such assistance at low cost. Most important, insurance companies could play a much larger role than they currently do in Mexico.

In industrial countries the insurance industry is one of the primary sources of information and expertise on dealing with risk. Households and businesses covered by insurance enjoy greater security both because they adopt risk reduction measures and because they transfer the risk to the insurer (and are therefore ensured that their losses will be replaced). Insurance coverage would thus be of great value to people in disaster-prone developing countries, where most of the population lacks reliable information on the risks to which they are exposed and knowledge of effective means to mitigate those risks.

Insurance density—defined as the share of the potential property loss that is insured—is generally low in developing countries, where many people cannot afford to purchase insurance (see chapter 4). Regulators should support greater penetration of insurance in Mexican society and greater access to the insurance mechanism for people and enterprises of modest means. Regulation should also encourage the broad provision of technical assistance for loss management and premium pricing to provide incentive for mitigation investment.

### The Role of the Fund for Natural Disasters (FONDEN)

The Mexican government allocates budgetary funds for disaster relief and reconstruction efforts by placing them in the Fund for Natural Disasters (FONDEN). FONDEN is not currently permitted to use its funds for pre-disaster mitigation purposes. It can, however, allocate funds to postdisaster mitigation efforts in areas where disasters are recurrent. Such postdisaster mitigation could help break the cycle in disaster-prone areas.

Following a disaster, FONDEN could help mitigate future disasters by providing grant funds worth 5–10 percent of the relief allocation to be used for approved mitigation projects in impacted areas or states. Temporary employment programs, which are generally part of the relief effort, could be structured to implement mitigation measures. Temporary workers could help strengthen buildings in earthquake- and wind-prone areas, improve irrigation facilities in drought-prone areas, resettle communities away from hazardous sites, clear stream beds and drainage channels, construct flood protection, and reforest damaged areas.

Mitigation programs that require some financial input from beneficiaries through cost recovery mechanisms could help educate the population about the risk and cost of disasters and the need to mitigate them. Such programs could be developed and overseen by CENAPRED and assisted by student mitigation teams. FONDEN could also require municipalities or states to participate in mitigation projects by conditioning assistance on participation in such projects. Support, for example, could be conditioned on the state's commitment to review and update building and zoning codes and to carry out a comprehensive hazard assessment.

Mexican family outside a reconstructed home, 1987.

*Chapter 4*

# Mitigating Losses by Transferring Risk to the Insurance Industry

In most countries in which potential losses are insured, catastrophe risk is transferred from the national insurance system into worldwide risk-sharing pools. These pools are managed by international reinsurance companies and backed by substantial capital resources, sometimes supported by generous tax regimes that allow the accumulation of reserves against future catastrophes out of pre-tax income. In countries without well-developed direct insurance systems and countries in which the potential loss is very large, much of the catastrophic risk remains within the country, where it has the potential to adversely affect macroeconomic variables.

## Insurance and Reinsurance Coverage throughout the World

One measure of the extent of insurance coverage within a country is insurance density, the estimated proportion of private property (buildings and contents) insured against natural hazard. Insurance density varies across countries and across types of events (table 4.1).

As table 4.1 indicates, a high level of income is necessary for high insurance density. Even in high-income countries, however, density can be low if the risk and possible severity of an event is high (as in Japan).

The reinsurance markets have historically adopted an implicit financing approach under which losses incurred in one period are "paid back" in subsequent periods through increases in the cost of reinsurance. As a result, reinsurance prices have fluctuated widely, and these fluctuations are passed on to the consumer. Rate increases after natural disasters can be large enough to affect the viability of businesses. Occasionally, reinsurance coverage is canceled altogether after a disaster (as it was in some small island countries hit by severe tropical cyclones). Often some risk mitigation has been required to reattract the reinsurance industry.

A number of mechanisms have been developed in wealthier countries in recent decades to cope with large risk exposures. National disaster funds have been established in Turkey and Mexico. Compulsory state-mandated insurance-based pools—often backed by high-level reinsurance or capital market instruments—have been established in Florida, France, New Zealand, and Norway. In Tokyo financial instruments have been developed that rely on objective measures of the severity of the event (rather than the loss). All of these measures could potentially be applied in developing countries. (For a description of some of these mechanisms, see annex 3.)

**Table 4.1 Estimates of insurance density**
(percent)

| *Event/location* | *Insurance density* |
|---|---|
| *Earthquake* | |
| South Africa | 95 |
| Sydney, Australia | 90 |
| Israel | 90 |
| Vancouver, Canada | 50 |
| California, United States | 40 |
| Italy | 20 |
| Belgium | 10 |
| Mexico | <10 |
| Tokyo, Japan | 5 |
| *Flood* | |
| United Kingdom | 95 |
| United States | 10 |
| Germany | <10 |
| Netherlands | <5 |

*Source:* Swiss Reinsurance Co. 1997.

## Demand for Property and Casualty Insurance in Mexico

The Mexican property and casualty (or "general") insurance market is underdeveloped, with the great majority of property owners uninsured against major natural catastrophes. According to the 1990 population and housing census, 8.2 million of Mexico's 16 million houses (51 percent) were built with solid materials. Assuming 85 percent of these homes had potable water and drainage, about 7 million houses in Mexico were insurable in 1990. Given an estimated annual rate of increase in housing of 1.85 percent since 1990, about 8.3 million houses were insurable in 1998. Of that number, only 150,000 homes, or 1.8 percent of the market, were actually insured in 1998, according to industry sources. More than 8 million homes in Mexico are thus insurable but uninsured.

The main reasons for lack of coverage are lack of awareness and understanding of the role of insurance, the belief that the government will fund any serious losses arising from natural disasters, and lack of income. While more research needs to done on the relationship between income levels and insurance consumption, the data suggest that high and evenly distributed income is correlated with increased insurance consumption (table 4.2).

Insurance consumption in Mexico rose before the 1994–95 economic shock, but it has dropped since then. In 1996 insurance density in Mexico was among the lowest in the world for countries with similar income levels (table 4.3).

The limited capacity to consume insurance in Mexico may reflect the high cost of catastrophic insurance coverage in many parts of the country. In area highly prone to earthquake, including Mexico City, annual property coverage costs about 0.5 percent of the amount insured. Insuring a house worth $20,000 would thus cost about $100 a year—about 3 percent of the average Mexican's annual income. It is unrealistic to expect low-income families in developing countries to allocate this large a proportion of their income to insurance when most of their income is devoted to food, shelter, and transport.

In contrast, the country's major corporate and national public sector assets employ world standard risk management methodologies. About 90 percent of industrial enterprises and 50 percent of commercial enterprises are insured. The rate of coverage is much lower in the small business and private property sector, where only about 2 percent of the market is insured.

The public sector accounts for about a third of all property insurance premiums in Mexico. Federally owned assets appear to be adequately insured. State and municipal governments appear to be insured on an ad hoc basis, however, and their coverage may be insufficient.

Increasing demand for insurance in Mexico will

**Table 4.2 Insurance penetration and macroeconomic indicators in selected countries, 1996**

| Country | GDP per capita (U.S. dollars) | Gini coefficient[a] | Insurance premiums as a percentage of GDP[b] |
|---|---|---|---|
| United States | 26,030 | <35 | 4.8[c] |
| United Kingdom | 19,720 | <35 | 3.4 |
| Spain | 14,810 | <35 | 2.9 |
| Sweden | 28,271 | <35 | 2.3 |
| Argentina | 8,584 | >45 | 1.2 |
| **Mexico** | **3,512** | **>45** | **0.8** |
| Philippines | 1,197 | >45 | 0.8 |
| Zambia | 325 | >45 | 0.6 |

a. The Gini coefficient is a measure of income distribution. The lower the coefficient the more equally income is distributed.
b. Exclusive of life insurance.
c. The consumption figure is heavily influenced by the private health insurance system.
*Source:* Swiss Reinsurance 1998.

**Table 4.3 Insurance penetration in selected developing countries, 1996**

| Country | Per capita consumption of insurance[a] (U.S. dollars) | Insurance premiums as a percentage of GDP[a] |
|---|---|---|
| Panama | 82 | 2.70 |
| Costa Rica | 61 | 2.28 |
| Columbia | 39 | 1.77 |
| Slovakia | 62 | 1.76 |
| Poland | 56 | 1.62 |
| Tunisia | 32 | 1.51 |
| Venezuela[b] | 46 | 1.49 |
| Thailand | 40 | 1.32 |
| Russia | 28 | 0.95 |
| **Mexico** | **28** | **0.81** |
| Peru | 17 | 0.68 |

a. Exclusive of life insurance.
b. Figures include some social insurance.
*Source:* Swiss Reinsurance Co. 1998.

depend on several factors. Income levels must rise so that more of the population will be able to afford property insurance. Greater awareness of insurance products must also be created, and the population must come to understand that the government cannot meet all needs following serious catastrophes.

## Supply of Property and Casualty Insurance in Mexico

Lack of property and casualty insurance coverage in Mexico appears to be caused largely by demand-side rather than supply-side factors. Although some factors distort the supply of property and casualty insurance in Mexico, excess catastrophic reinsurance capacity is available and a potentially large distribution system has been developed. Moreover, by 2000 the market will be open to unconstrained competition.

### *Industry Concentration and Competition*

Mexico has the most concentrated insurance industry in Latin America. In 1997 the top five insurers wrote 70 percent of all property insurance policies. (Comparable figures for other Latin American countries were 27 percent in Argentina, 51 percent in Brazil and Chile, 50 percent in Colombia, and 43 percent in Venezuela.) Although concentration in Mexico has dropped since 1997 as a result of the influx of new companies, it still remains much higher than in other countries in the region.

Development of the property and casualty insurance sector is inhibited by several factors. First, all policies written in Mexico must be underwritten by local underwriters unless special authority is granted to place a policy with a foreign insurer. Second, the Mexican insurance industry is currently preoccupied with developing the pension and life insurance markets. Relatively little attention has been paid to the property and casualty market. Third, the leading insurance companies in Mexico are privately owned and may have a more conservative approach to underwriting and growth than traded companies with access to strong capital markets.

Mexican insurance companies do not offer stand-alone catastrophic insurance, which must be purchased as an extension of a basic fire policy. About 50–80 percent of Mexicans buying fire coverage purchase catastrophic coverage. While most insurance is priced competitively, earthquake coverage is subject to an industrywide price agreement approved by the government. In practice, however, earthquake rates are discounted.

### *Reinsurance*

Premiums for property and casualty insurance against natural catastrophes reached 1.6 billion pesos (about $200 million) at the end of 1997, 37 percent of the amount spent on fire and catastrophic premiums. About 1.1 billion pesos of this amount was transferred to reinsurance companies.

Reinsuring domestic risk makes sense, because it helps local insurers spread risks over a worldwide pool of insurers. However, catastrophe reinsurance pricing was very volatile in the late 1990s (table 4.4). The very high catastrophe reinsurance premium rates in 1994 and 1995 reflected the enormous losses incurred by the global reinsurance sector in 1992 through 1994 and the tight worldwide market for reinsurance that followed. With increasing capacity attracted by high profits, prices have dropped in recent years. Given Mexico's heavy and

**Table 4.4 Reinsurance pricing of catastrophic risks in Mexico, 1994–98**
(percent)

| *Item* | *1994* | *1995* | *1996* | *1997* | *1998* |
|---|---|---|---|---|---|
| Catastrophe reinsurance coverage as a percentage of reference loss[a] | Up to 122 | 7–156 | 3–118 | 2–140 | 2–170 |
| Rate on line paid (percent sum at risk for reinsurers)[b] | 4.4 | 4.5 | 3.0 | 1.7 | 1.0 |
| Pure risk rate on line (percent sum at risk for reinsurers) | 0.7 | 1.6 | 2.0 | 1.5 | 1.2 |

a. Reference loss is the estimated insured loss for which primary insurers are liable in the event of a major natural disaster.
b. Rate on line is the reinsurance premium paid as a percentage of the layer of catastrophe reinsurance purchased.
*Source:* Mexican Insurance Association.

growing reliance on this method of risk transfer, mechanisms may need to be created to cushion the insuring public from price shocks (which may result from disasters occurring outside Mexico, most likely in the United States or Japan).

The total underwriting profit made by offshore reinsurers in recent years from fire insurance (including catastrophic coverage) has been very high relative to premiums, despite the large number of earthquakes and hurricanes, some of which caused considerable damage (see annex 2). This demonstrates the market failure of the insurance mechanism in Mexico. The reinsurance mechanism can be economically effective only if the underlying insurance industry covers a high proportion of risks in the country (table 4.5).

### *Compulsory Reserves*

Another source of additional potential market distortion in Mexico arises from the requirement that all insurers set aside 35 percent of their cumulative earthquake premiums as reserves. For the industry as a whole, more than $400 million was held in reserves in 1998, and these are required to be invested in liquid, short-term government bonds.

The legal status of these reserves remains unclear. Mexican regulators interpret the law to mean that earthquake reserves are held in perpetuity against infrequent but large catastrophes. The industry position is that they are part of capital and revert to shareholders in the event that the business is terminated or ceases to write catastrophic risk policies. Rules are currently being drafted to clarify the status of these funds and ensure a more effective relationship between risk exposure and prudential management of insurers' balance sheets.

### *Sale of Insurance*

Insurance is sold largely through agents and brokers licensed by the insurance supervisor, the National Insurance Commission. About 20,000 agents and brokers are licensed, although the majority work part time or are inactive, according to industry sources.

Insurance can also be purchased through banks in Mexico. Experience elsewhere in the world suggests that sales through banks are likely to represent the fastest means of expanding market penetration among small businesses and individuals, especially if an active mortgage market is developed by the main commercial banks.

## Mitigation of Risk by Insurance Companies

Mexican insurance companies have done little to contribute to the prevention or mitigation of damage from disasters. Higher premiums for earthquake coverage are charged for buildings without seismic resistant design features. Because quality control during construction is often lax or nonexistent, however, lower premiums for buildings that are supposed to be earthquake-resistant do little to mitigate disasters.

Collaboration between the Mexican insurance companies and the National Autonomous University of Mexico has taken place, but the work has focused only on tariff setting and reserves. Contacts with CENAPRED have been superficial, and no actions have resulted from them to date.

## Recommendations

Private insurance companies in Mexico are better able than the public sector to deal with risk. Much needs to

**Table 4.5 Underwriting profit earned by offshore reinsurers, 1995–97**
(millions of U.S. dollars)

| *Item* | *1995* | *1996* | *1997* |
|---|---|---|---|
| Property (fire) premiums written in Mexico | 451.5 | 448.5 | 488.2 |
| Premiums reinsured | 315.1 | 305.6 | 336.8 |
| Underwriting profit to foreign reinsurers (before reserves) | 105.1 | 183.6 | 159.6 |
| Insurance claims paid | 265 | 7 | 40 |
| Number of earthquakes | 3 | 1 | 0 |
| Number of windstorms (including hurricanes) | 3 | 3 | 2 |

*Source:* Mexican Insurance Association and National Insurance Commission.

be done, however—including getting support from multilateral agencies—before insurance can play an important role in preventing and mitigating the effects of disasters.

Private insurers should be encouraged to deal with the risks faced by small and medium-size enterprises. Letting the private sector deal with this part of the market would reduce the load on the public sector at the time of a natural disaster, and it would generate foreign exchange inflows at a time when the balance of payments may be under pressure. Private sector involvement would also lead to speedier claims assessment and settlement. In addition, insurers in a developed market generate useful risk management information for businesses and individual homeowners because the price of insurance rates varies according to the characteristics of the risk.

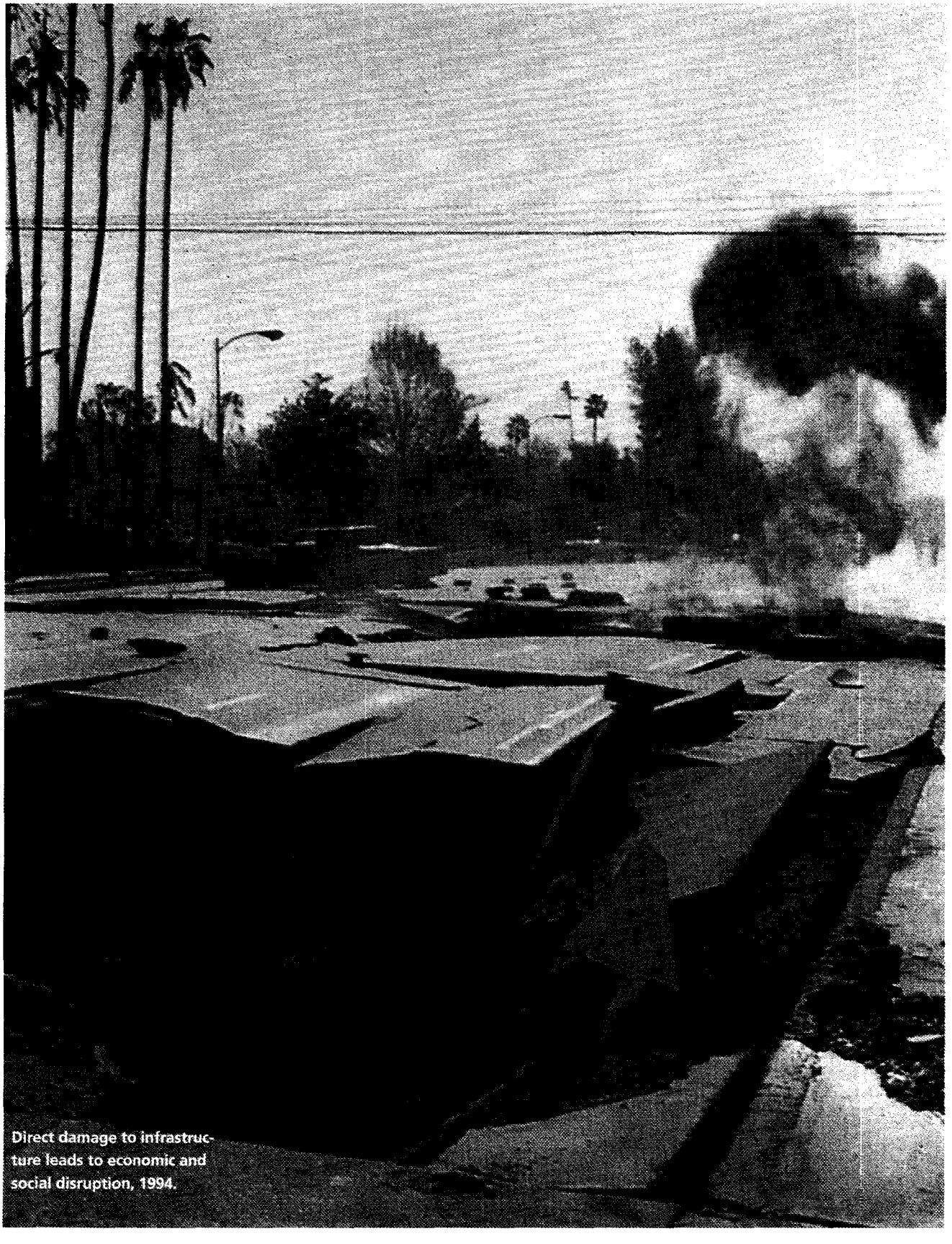
To increase insurance awareness and density, insurance products must be made available to the public at affordable prices. Catastrophe insurance can currently be purchased in Mexico only as part of fire insurance, and the cost of such insurance is prohibitively high for most Mexicans, especially those in Mexico City. A number of changes could be made in the short term to increase capacity and reduce prices:

- Catastrophic premium rates could be formally deregulated, with a maximum tariff set at the current level. Deregulating premiums would mean that consumers could benefit from low reinsurance costs.
- The discontinued 10 percent compulsory surcharge on earthquake premiums could be reintroduced and extended to all catastrophic classes (including civil disturbances). These funds could be placed in a central pool managed by the Mexican Insurance Association for use in smoothing out reinsurance pricing cycles and as a guarantee fund in the event that any insurer became insolvent following a major disaster. Companies could continue to be required to accumulate catastrophic reserves up to an agreed upon standard retention level.
- If the insurance industry is not prepared to provide catastrophe-only coverage, an industry-run pool could also be required to offer such coverage, which would be sold through private insurers. The pool would be available only to insured risks, however.
- In order to raise insurance awareness, the mandatory automobile liability insurance requirement, which was postponed, should be implemented as soon as possible. At the same time, the insurance industry, in cooperation with the government, should be encouraged to educate the public about insurance.
- The government may wish to consider providing some incentives for householders and small businesses to buy insurance, possibly through the use of (means-tested) vouchers or tax rebates.

Improvements in insurance coverage could also be achieved by changing the public sector's procurement process. The government's mandatory tendering procurement process has resulted in a suboptimal level of insurance coverage for all but the most sophisticated purchasers of insurance (such as PEMEX). Given that 90 percent of all government business (other than PEMEX) is currently placed with the two leading private insurance companies, the current individual government agency approach appears to be inefficient. Consolidation of purchasing combined with the employment of international brokers and risk transfer specialists should be considered for all public sector risks.

The efficiency of insurance as a risk transfer mechanism could be increased if public sector agencies purchased higher levels of catastrophic coverage while absorbing higher levels of initial losses. The Ferrocarriles Nacionales de México (national rail carrier), for example, purchased a $20 million multi-risk policy, which stipulated that only the first $1 million were available for property losses. The overall level of coverage was grossly inadequate and failed to cover much of the damage to railway tracks incurred in the 1998 flooding in Chiapas.

Insurance advisers putting the insurance programs together set prices so low that it is not possible to design properly researched risk management programs that take a holistic approach to mitigation, loss control, and risk transfer. Information provided to insurers reportedly includes only details of a few peak risks for some agencies; very little information is provided on other exposures. Insurers should be provided with adequate information on risk exposure, and large international brokers should be permitted to participate in the tendering process.



Direct damage to infrastructure leads to economic and social disruption, 1994.

*Chapter 5*

# Using New Financial Instruments to Transfer and Finance Risk

Dealing with the effects of natural catastrophes has proved extremely disruptive to the budgetary process in Mexico. What strategies can the Mexican government adopt to help it deal with these crises more effectively? How can effective disaster relief be provided without derailing other programs? This chapter examines the options available to the government for transferring and financing risk, suggests some steps to take to pursue these options, and makes recommendations for administering the Fund for Natural Disasters (FONDEN) more effectively.

## New Financial Instruments for Transferring Risk

Peak catastrophe risks throughout the world far exceed the capacity of the insurance and reinsurance industries to insure them. Available capacity falls far short of the estimated damages from even a single peak catastrophic event (such as a major earthquake on the New Madrid fault in the United States, which could cost up to $110 billion in direct losses). In such an event it is estimated that more than a third of the U.S. insurance industry would become insolvent, even after allowing for reinsurance of their exposures (Insurance Services Office 1999).

Recognizing the inability of the insurance industry to cover all catastrophic risks, insurers and corporations have sought to spread these risks to the capital markets by issuing catastrophe bonds and options and other similar instruments. The development of computer modeling of natural perils and the growing understanding of catastrophic risk among institutional investors is increasing market capacity of these new financial instruments (Froote 1998).

In industrial countries, where a high proportion of property is insured, much catastrophic risk is spread internationally through insurance and reinsurance. In developing countries a combination of low incomes and lack of awareness about insurance means that less than 10 percent of private property is typically insured. As a consequence, the global reinsurance market cannot be accessed. Catastrophe bonds may provide a means of circumventing the underdeveloped state of the insurance industry in many developing countries exposed to catastrophe risk.

Catastrophic risk transfer alternatives have been used for a variety of risks, including hurricane and earthquake risk in the United States and Japan, flood risk in most of the world, and storm risk in Europe. These tools could be extended to developing countries if the right structure were created to transfer risk and the right information provided to professional risk takers. The development of both appropriate institutional structures and proper modeling of the risk exposure are essential if these alternative risk transfer mechanisms are to be used in Mexico.

### *Catastrophe Bonds and Options*

Although the insurance risk exchanges have yet to develop a major presence, they are growing, with total risk transfer amounting to about $3 billion to date. The Chicago Board of Trade first launched catastrophe futures and options in December 1992. Since then the Catastrophe Exchange (CATEX) and the Bermuda Commodities Exchange have begun trading insurance risk. In 1999 the Chicago Mercantile Exchange introduced temperature-extreme derivatives, which had been trading over-the-counter among energy utilities in the United States. These derivatives are designed to enable energy utilities to smooth income when power usage is low because of mild winters or cool summers.

Act of God bonds were first issued in 1996. These bonds—which are often structured as reinsurance arrangements for legal and tax purposes—are nothing more than regular bonds issued with embedded contingent options that provide the right to withhold some or all of the principal and accrued interest in the event of a defined trigger event. Between 1996 and 1998 this market (including related instruments) issued more than $2.5 billion of paper to about 50 institutional investors. Spreads varied according to structure and exposure but averaged about 4 percent over the London interbank offer rate (LIBOR).

A catastrophe bond need not rely on measures of actual loss. The trigger could be an objective measure of the intensity of an event, such as an earthquake or hurricane. One such bond has been issued for Tokyo earthquake risk, which pays out according to location and magnitude, as measured by the Japanese Meteorological Agency. Countries could set up a catastrophe fund to issue such bonds, the proceeds of which would be held in escrow pending a trigger event.

No investor has yet lost money invested in these instruments. Some observers believe that the first real natural catastrophe will see the end of the market, as investors lose money and retreat from the market. This need not be the case if investors include participation in these instruments as part of a diversified portfolio. Indeed, investors have shown interest in the new instruments because the natural risks covered are typically uncorrelated with major financial indices, thereby providing new opportunities for risk diversification.

### *Contingent Credit*

Another instrument used to finance large catastrophic losses is contingent credit with long maturities. Under a contingent credit arrangement, the lender charges a fee, which is paid as long as the trigger event does not occur (the International Bank for Reconstruction and Development charges 0.75 percent). If an event does occur, the borrower can rapidly draw down funds. To be able to repay the credit, the borrower must have a sufficient stock of reserves or future premium income. If it does not, the government could assume the risk of repayment through the taxation base.

## Risk Transfer and the Fund for Natural Disasters

Funds earmarked for relief and reconstruction after catastrophe events in Mexico are maintained in FONDEN. The fund has three main strategic objectives:

- Complement the systems of civil protection and assistance to victims.
- Finance repairs of damage to infrastructure caused by disasters, without affecting the budgeted programs and projects of the federal administration.
- Promote state and municipal participation to create a partnership among the three levels of government to deal with the negative impact of extreme events.

FONDEN is composed of three separate funds. The infrastructure fund provides for the repair of uninsured infrastructure. The agriculture fund provides immediate assistance to restore the productivity of low-income (subsistence) farmers. The assistance fund provides relief to low-income victims of disasters.

Budgetary allocations for FONDEN have not been sufficient to cover the fund's obligations since 1996. In 1998, for example, FONDEN's budget was about $227 million, while its expenditures were expected to exceed $500 million. The shortfall is made up by diverting funds from other government budgets.

### *Transferring Risk through the Insurance Market*

One way that Mexico could transfer its disaster risk out of the country would be for the government to purchase catastrophe insurance. A hypothetical example demonstrates how this option would function. For purposes of illustration, assume that the government wants to be able to cover up to $500 million in infrastructure losses caused by hurricanes, floods, and earthquakes and that FONDEN is willing to absorb $25 million in losses per incident, up to a maximum of $50 million. FONDEN could purchase such coverage for, say, $48 million a year (depending on the pricing cycle). Doing so would put a ceiling of $98 million on its expenditures ($48 million in premiums plus $50 million in maximum uninsured losses). It would provide coverage to segments of the society that would not have had the resources to purchase insurance themselves, and it would obligate both FONDEN and the insurer to take actions to mitigate the level of risk.

### *Transferring Risk through the Capital Markets*

Another way in which FONDEN could transfer risk would be to issue a bond in the international capital markets with characteristics similar to reinsurance. The federal government could, for example, issue a $500 million bond to international investors, holding the proceeds of the bond in an escrow account. Funds held in escrow would be released to Mexico upon the occurrence of catastrophes that cause more than a given level of damage to infrastructure. If no disaster occurs, investors would retain the principal as well as the interest earned on the bond. If a catastrophic event occurs, funds advanced to Mexico under the bond would be partially forgiven; interest on the advanced amounts would be partially or totally forgiven.

Catastrophe bonds can be flexible and are designed to meet the particular needs of the insurer. Pricing of these instruments has been higher than the pricing of reinsurance, although it has been consistent with the average pricing of reinsurance during the 1990s.

Given the novelty of these instruments and the risks faced in Mexico, a bond guarantee might be necessary to attract investor interest in such instruments. The World Bank's guarantee facility might be deployed to provide credit enhancement and augment the attractiveness and security of catastrophe bonds. A partial risk guarantee would consist of a contract—signed by the government, the World Bank, and investors—that would commit the Bank to pay investors the interest or principal due in the event that the government could not do so. If the guarantee were paid out, it would become an obligation due from the government to the Bank. The lower interest that Mexico should offer on the bond as a result of the Bank guarantee would more than compensate for the modest guarantee fee charged by the Bank.

### *Financing Risk with Commercial Bank Credit Lines*

If the Mexican government cannot or prefers not to transfer risk, it can explore various options for financing that risk. Because the size and frequency of the natural catastrophes covered by FONDEN vary from year to year, annual funding requirements fluctuate widely. Since supplementary funding from the government cannot be requested during the year, FONDEN has relied on the ad hoc capture of funds allocated to other agencies to meet its current requirements. To reduce the uncertainty and disruption to the budgetary process, FONDEN could use its current and future budgetary funding allocations to finance extraordinary costs when disaster-related damages costs are high.

The most promising option would be to establish a line of credit with a financial institution, which would provide funds in the event that catastrophic events exceeded FONDEN's annual budgetary funding. Repayment of the credit line would take place over a long period of time (perhaps 12–15 years if multilateral funding were obtained). Although the government would have to pay a commitment fee for the credit line, access to the line would ensure an immediate source of funding, obviating the need to divert funds from other government agencies. Credit line arrangements—which have been used by insurance companies concerned about the impact on their cash flow of a major catastrophe event—are a useful tool because they involve no transfer of risk. The insurability of the risk is thus irrelevant.

## Using Alternative Risk Transfer Mechanisms to Deal with Uninsurable and Uninsured Properties

Because insurance coverage in Mexico is very limited, the government is faced with large fiscal obligations following natural disasters. Some public sector properties and infrastructure (such as utilities, certain roads, and water systems) can be insured at the state and municipal levels. Other assets, however, are uninsurable or are difficult for the insurance industry to evaluate and price. For these reasons, alternatives to insurance, such as risk-transfer and financing instruments, should be considered.

### *Transferring Risk Borne by the Public and Business Sectors*

The government should seek to adopt efficient risk management techniques, including loss control, mitigation, and risk transfer. Catastrophe bond and option contracts could be used to insure state and municipal assets and infrastructure (sewerage systems, uninsurable buildings) that may not attract the interest of the insurance industry (because of their unusual nature or lack of compliance

with building codes, for example) or may command too high a premium for local governments to afford. They could also be used to cover small and medium-size enterprises for which insurance is available but is too expensive for owners to purchase. The covering of such enterprises through a financial instrument would free the government from having to extend financial assistance following a natural disaster. Bond and option instruments could be used to cover medium-size cash crop farmers. (In principle, such farmers could be insured through the government's crop insurance program. In fact, however, such farmers remain uninsured.)

The government could potentially bypass the entire insurance loss evaluation process by using an investment instrument that triggers or limits certain payments to investors based on objective indicators. Indicators, such as earthquake tremors and hurricane wind speeds, can sometimes be transmitted to central satellite stations.

### *Transferring Risk Borne by the Agricultural Sector*

Many countries compensate farmers after natural disasters, almost always doing so out of current budgetary resources. The degree of formality of these compensation arrangements varies widely. In Belgium and France, for example, a separate national agricultural disaster fund compensates farmers. In Australia, Denmark, and Germany, compensation is distributed largely on an ad hoc basis. In the United States farmers are eligible for free catastrophe insurance (subject to a $50 administrative charge). Despite the low cost, however, up to 20 percent of farmers remain uncovered (politicians generally bail them out following disasters anyway).

As the damage done by natural disasters has grown, however, particularly in agricultural areas, governments have found themselves unable to cover the costs of compensation, and politicians have come to recognize that disasters can inflict long-term damage on the economic base. In a number of countries (Australia and Morocco, for example) governments are attempting to find ways to reduce their contingent liabilities, by transferring catastrophic crop risk using private sector mechanisms.

In Mexico a well-developed agricultural insurance system is available through Agroasemex, the state-owned agency set up to replace Anagsa in the late 1980s. Agroasemex operates on the basis of strict underwriting and claims adjustments that are verified by a large team of field technicians. Since 1990 Agroasemex has been able to place a relatively low-level stop loss program (75 percent loss ratio in excess of the first 75 percent loss ratio, that is, any losses in excess of 75 percent of the premium amount are paid by reinsurance up to a maximum of 150 percent of the premium). Mexico is experimenting with a number of other leading-edge ideas, including remote sensing of soil moisture content and the use of French-style cooperatives to reduce moral hazard and information asymmetry.

The main drawback of all such individual assessment approaches is that they are extremely expensive to administer and almost always require some form of government subsidy. New approaches to crop-related disasters in which payouts are related to objective measures of rainfall and soil moisture rather than to crop yield itself are being examined by a number of countries and by the World Bank. Such approaches are potentially much less expensive to administer and still leave an important role for the insurance sector.

## Recommendations

During the past decade the insurance and capital markets have developed several innovative techniques for transferring the risk associated with natural hazard events. The Mexican government should investigate how it could use these new products to make more efficient use of the assets it allocates following disasters. By transferring risk to the private sector or financing the costs of disaster-related damage, Mexico could reduce the disruption to the budget process caused by unanticipated expenditures. In order to do so, it will have to take several steps:

- Reconstitute FONDEN as a legal entity that is capable of transferring risk.
- Group together similar risks in funds, so that they can be aggregated, priced, and transferred separately. Allocate sufficient dedicated capital and premium-paying capacity to FONDEN to support its risk placements in the insurance or capital markets.
- Inventory all vital infrastructure, and estimate FONDEN's risk exposure. Catastrophe modeling—

which analyzes the frequency of hazard events, the severity of the events, and the vulnerability and value of assets that are the responsibility of FONDEN—could be used to make these estimates.

- Develop financial models that allow various policy options to be evaluated. Financial modeling based on the data developed in the catastrophe modeling would yield various options and prices for the transfer of risk.

Risk management could also be improved by changing the way FONDEN operates. Specific recommendations include the following:

- Refocus FONDEN's efforts by absorbing only those residual catastrophe risks that cannot be absorbed by third parties, encouraging economically worthwhile mitigation by the public sector, and fostering the development of private sector risk reduction and transfer mechanisms.
- Modify FONDEN's mandate so that it is permitted to disburse funds for research and training on mitigating risk before a disaster occurs. Funding for research and training would represent an addition to the annual budgets of executing agencies; the actual financing of mitigation programs would presumably be carried out as part of the public investment programs executed by the various government departments. Investment programs for mitigation works should be screened for economic viability in accordance with the standard cost-benefit criteria used to evaluate public investments.
- Consider linking the terms of FONDEN financing for reconstruction following a disaster to the extent to which mitigation measures had been implemented before the disaster (possibly through cost-sharing arrangements with states and municipalities).
- Clearly define the risks for which FONDEN bears responsibility, beginning with the infrastructure fund. Limit coverage to those infrastructure items that are essential to support the country's economic and social affairs following a natural disaster and those items that have already been insured for noncatastrophic risks. Limit agricultural coverage to farmers who are unable to afford private insurance; farmers who are able to afford private insurance should be obligated to purchase it. Welfare payments to subsistence farmers could be subsumed under the victims fund or paid through other social safety net programs.
- Establish guidelines to be followed by other government agencies in managing the risks they bear. FONDEN could, for example, specify the types and acceptable limits for insurance coverage for various types of infrastructure. It could also help federal, state, and local authorities purchase property insurance on a group basis.

Post-1985 earthquake home reconstruction in Mexico, 1987

*Chapter 6*

# Summary of Findings and Recommendations

Mexico is vulnerable to a variety of natural disasters, including earthquakes, hurricanes, and volcanoes. Despite the frequency with which these disasters strike, however, inadequate investment is made in mitigation efforts, and insufficient funds are set aside to pay for relief and reconstruction efforts. As a result, when a disaster occurs, the government is often forced to use funds that had been allocated to other programs, disrupting the operations of those programs. The effect is to derail important development efforts and possibly reduce growth.

The Mexican government could improve the way it manages its risks so that ongoing programs are not disrupted following a disaster. Doing so involves identifying the risks the country faces, mitigating the damage caused by those risks, and transferring the risk to other parties (namely, insurance companies and the capital markets).

## Identify Risk

Formulation of a risk management strategy must begin with the identification of risk. Mexico should identify the principal hazards it faces and assess the vulnerability of principal settled areas, infrastructure, and economic assets. The analysis should include estimates of the direct, indirect, and secondary impacts of natural disasters.

Adequate funding must be maintained for the risk identification efforts already under way. The research capacity of CENAPRED and the National Autonomous University of Mexico is excellent, but neither institution receives the budgetary attention it deserves. Given the quality of their work on identifying risk and mitigating damage from volcanoes and earthquakes, their mandate should be expanded to include hurricane and flood mitigation.

Mexico has a good core of institutional capability to manage natural disasters, led by the Ministry of the Interior and the Ministry of Environment, Natural Resources, and Fisheries. High-level coordination and strategic planning for disaster management need to be improved, however.

## Mitigate Risk

The damage caused by disasters can be reduced by changing perceptions and behavior so that all members of society place a high priority on safety in planning and development. This is important from a social and economic standpoint, since, in the absence of ample insurance penetration in the private sector, a large proportion of catastrophic risks are de facto borne by the government and society at large. All stakeholders must contribute to the creation of a culture of safety. Toward that end, the government should develop strategies for improving education about disaster mitigation, creating incentives, and adopting regulations that will encourage individuals and businesses to reduce the risks they face.

Information and education are key to raising awareness of risk and the importance of investing in mitigation measures. Active programs of dissemination, targeted professional education, and broad public education on disaster risk and mitigation should be developed and delivered throughout Mexico. Programs should include dissemination of information on natural hazard risk, mitigation, and insurance (possibly through a collaborative effort by the government and the insurance industry); the inclusion of disaster preparedness and mitigation materials in elementary and high school curricula; and special programs to target low-income communities, which are often worst hit by disasters.

The regulatory approach to encouraging disaster mitigation in Mexico requires a comprehensive reassessment of the formal land use and building regulatory processes. New approaches to land use management and building quality management must be developed that effectively contribute to public safety in the informal sector. Recognizing that most mitigation decisions are made at the community level, policymakers must allocate resources to increasing capacity and authority for risk management and disaster mitigation at the state and community levels.

While new and innovative approaches to regulation are explored, new initiatives should focus on creating positive incentives. Such incentives could include provision of community-level technical assistance for disaster mitigation, establishment of "low-risk districts" or historic centers that include tax incentives for those that invest in mitigation, granting of financial assistance for engineering analysis of risk, and establishment of certification programs, such as the Pan-American Health Organization program for health facilities. The private sector could consider donating engineering design assistance, providing it at low cost, or offering low-cost loans for mitigation efforts.

FONDEN's mandate should be modified so that it can provide funds for studies and training related to disaster mitigation before catastrophic events occur. Even if the government cannot or prefers not to modify that mandate, FONDEN can still play an important role in postdisaster mitigation in areas in which disasters are recurrent. Temporary employment programs established as part of the relief effort following a disaster could be used to implement mitigation measures, such as strengthening buildings in earthquake- and wind-prone areas, improving irrigation facilities in drought-prone areas, resettling communities away from hazardous sites, clearing stream beds and drainage channels, constructing flood protection, and reforesting damaged or destroyed areas.

Mitigation programs that require some financial input from beneficiaries through cost-recovery mechanisms would help educate the population about the risk and cost of disasters and the need to mitigate them. Such programs could be developed and overseen by CENAPRED and assisted by student mitigation teams. FONDEN could also require municipalities or states to participate in mitigation projects by conditioning assistance on cost-sharing. FONDEN's support to states should be conditioned on a state's commitment to reviewing and updating building and zoning codes and to carrying out comprehensive hazard assessments.

### Transfer Risk

Private sector insurance companies can be used to help Mexico deal more effectively with risk in the public sector. The public sector should purchase insurance through international brokers and risk transfer specialists; individual agencies should not be purchasing insurance on their own. More cost-effective coverage should be purchased by increasing the deductible level and purchasing higher levels of catastrophe coverage.

Regulation of the insurance industry should support greater penetration of insurance in Mexican society and greater access to the insurance mechanism for people and enterprises of modest means. Regulation should also encourage the broad provision of technical assistance for loss management and premium pricing to provide incentives for mitigation investment.

In order to increase insurance awareness and penetration among small and medium-size enterprises and the general population, affordable insurance products must be available to the public. Capacity could be increased and prices reduced in several ways:

- Catastrophic premium rates could be formally deregulated, with a maximum tariff set at the current level.
- The discontinued 10 percent compulsory surcharge on earthquake premiums could be reintroduced and extended to all catastrophe classes (including civil disturbances). These funds could be placed in a central pool managed by the Mexican Insurance Association, which would help to stabilize reinsurance costs and cover catastrophe-induced insolvency. Companies could continue to be required to accumulate catastrophic reserves up to an agreed-upon standard retention level.
- This industry-run pool could be required to offer catastrophe-only coverage, which would be distributed by insurance companies.
- In order to raise insurance awareness, the mandatory automobile liability insurance requirement, which

was postponed, should be implemented as soon as possible.
- The insurance industry, in cooperation with the government, should be encouraged to educate the public about insurance.
- The government should consider providing targeted incentives to expand insurance density.

### Reorganize FONDEN

Before the Mexican government can make use of risk transfer and risk-financing tools, it must modify the way FONDEN is organized. Changes should include the following:
- Refocus FONDEN's efforts by absorbing only those residual catastrophic risks that cannot be absorbed by third parties, encouraging economically worthwhile mitigation by the public sector and fostering the development of private sector risk reduction and transfer mechanisms.
- Clearly define the risks for which FONDEN bears responsibility, beginning with the infrastructure fund. Limit coverage to those infrastructure items that are essential to support the country's economic and social affairs following a natural disaster and those items that have already been insured for noncatastrophic risks. Limit agricultural coverage to farmers who are unable to afford private insurance; farmers who are able to afford private insurance should be obligated to purchase it. Welfare payments to subsistence farmers could be subsumed under the victims fund or paid through other social safety net programs. A similar approach of identifying those that can afford private insurance could be developed for the victim assistance fund.
- Reconstitute FONDEN as a legal entity that is capable of transferring risk.
- Inventory all vital infrastructure and estimate FONDEN's risk exposure. Catastrophe modeling—which analyzes the frequency of hazard events, the severity of the events, the vulnerability of assets that are the responsibility of FONDEN, and the value of those assets— could be used to make these estimates.
- Develop financial models that allow various policy options to be evaluated. Financial modeling based on the data developed in the catastrophe modeling would yield various options and prices for the transfer of risk.
- Group similar risks together in funds so that they can be aggregated, priced, and transferred separately. Allocate to FONDEN sufficient dedicated capital and premium-paying capacity to support its risk placements in the insurance or capital markets.
- Modify FONDEN's mandate so that it is permitted to disburse funds for studies and training on mitigating risk before a disaster occurs. Funding for studies and training would represent an addition to the annual budgets of executing agencies; the actual financing of mitigation works would presumably be carried out as part of the public investment programs executed by the various government departments through their normal budgetary allocations. Investment programs for mitigation works should be screened for economic viability in accordance with the standard cost-benefit criteria used to evaluate public investments.
- Consider linking the terms of FONDEN financing for reconstruction following a disaster to the extent to which mitigation measures had been implemented before the disaster (possibly through varying the cost-sharing arrangements with states and municipalities).
- Establish guidelines to be followed by other government agencies in managing the risks they bear. FONDEN could, for example, specify the types and acceptable limits for insurance coverage for various types of infrastructure. It could also help federal, state, and local authorities purchase property insurance on a group basis.

### The Role of the World Bank

The study has helped the World Bank define more clearly ways in which it could help developing countries manage disaster risk more effectively. Instruments that could be of value include the following:
- *Loans for investment in mitigation and reconstruction.* Loans could be provided to finance retrofitting plans (at schools, hospitals, public buildings) and reconstruction of infrastructure damaged by natural disasters. An important feature could be to link the terms

of reconstruction financing to the extent of mitigation carried out by the final beneficiaries of the financing. A technical assistance component could support capacity building for various aspects of disaster management. These could include data generation; risk assessment and modeling; development of disaster management systems and plans; redrafting of building codes and improvement of physical planning criteria and systems; development of retrofitting plans; development of schemes for new risk financing and transfer arrangements and instruments; and design of improved laws, regulations, and policies to support better risk management.

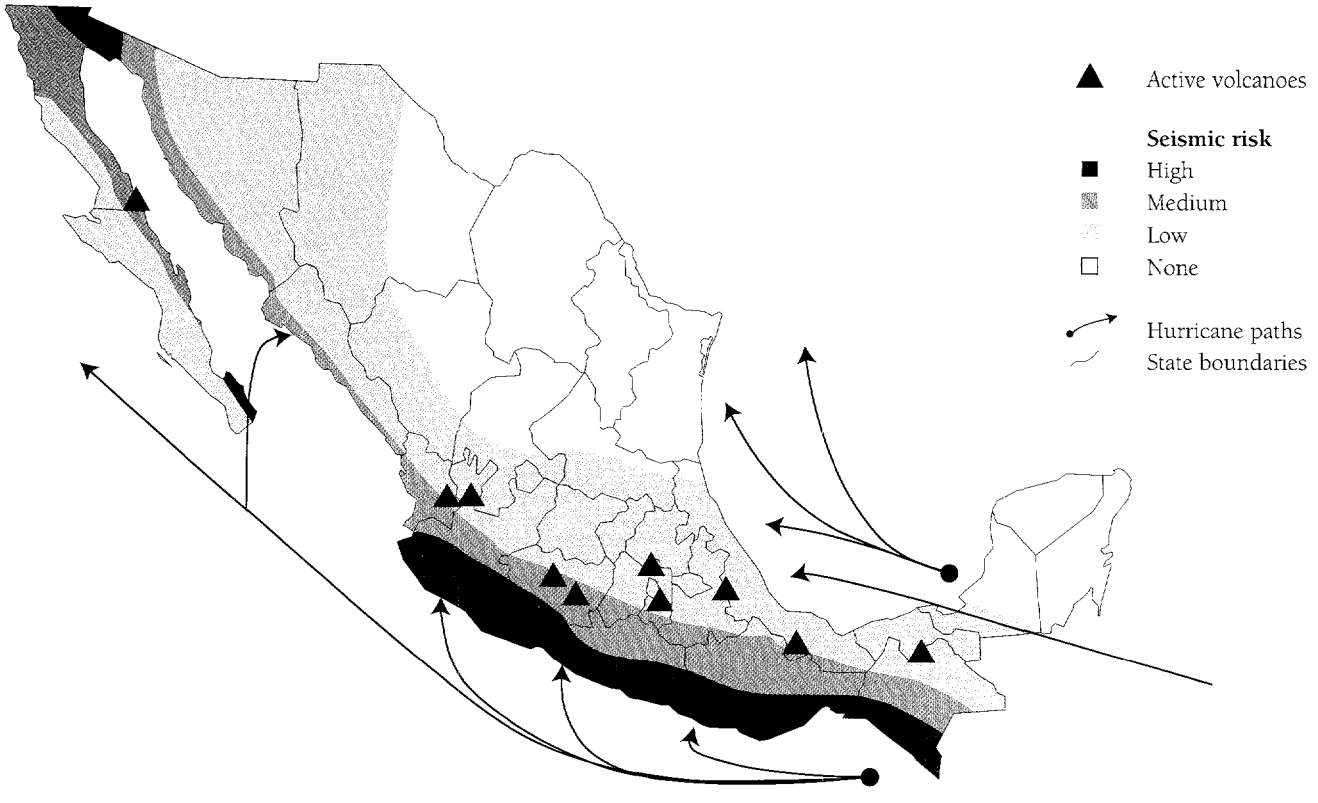
- *Contingent loans for reconstruction.* To make sure that funds are accessible immediately when disaster strikes, the Bank could establish a credit line that could be drawn upon under certain conditions. Establishing such a line would speed the delivery of funds during emergencies. The credit line agreement would specify the trigger events that would make Bank funds available. It would also include guidelines governing the use of funds (eligible expenditures; disbursement, procurement, and financial management arrangements; and on-lending terms to final beneficiaries, which could vary with the extent to which mitigation measures had been implemented before the disaster). Commitment fees would be paid before the loan was activated.
- *Contingent loans for risk financing.* Catastrophe risk is normally "packaged" into "layers" and financed or transferred through a variety of arrangements, including primary insurance, reinsurance, credit financing, and bond and derivative financing. The combination of instruments used will depend on specific circumstances, including the relative costs of the various instruments at the time the placements are made. The Bank could consider providing contingent loans to finance a credit layer in a risk management package.
- *Partial risk guarantees.* The Bank operates a guarantee program that supports private investment in borrowing countries by guaranteeing against risks associated with policy or contractual performance by the government. Under the program, the government counterguarantees the Bank guarantee by agreeing to repay the Bank for any payments it makes to investors under the terms of the guarantee. In principle, this program might provide credit enhancement for catastrophe bonds and commercial contingent credit lines, thereby improving their terms and attractiveness to investors.

This case study and future discussions with the Mexican government should help refine this menu of options so that it addresses Mexico's primary concerns. The effort should enhance the quality of the Bank's lending and nonlending activities in the increasingly important area of natural disaster risk management.

*Annex 1*

# Geographic Distribution of Major Hazards in Mexico

**Map A1** Active volcano risks and hurricane paths



*Annex 2*

# Estimated Cost of Disaster Events in Mexico, 1980–98

Mexico experienced dozens of disasters between 1980 and 1998 (table A1). About 9,515 people were killed in these events, which cost the economy about $12 billion in losses.

**Table A2 Estimated direct costs of disaster events in Mexico, 1980–98**

| *Year/event/location* | *Casualties and damage* | *Reported direct losses (millions of U.S. dollars)* |
|---|---|---|
| 1980 | | |
| Flood | | |
| Tijuana and Ensenada, Baja California | 3 people killed, 20 people missing, 6 towns destroyed, 30,000 victims | 87.0 |
| Gas plant fire | | |
| Xalostoc, State of Mexico | 4 people injured | 0.8 |
| Drought | | |
| Coahuila and Sinaloa | | 222.6 |
| Hurricane Allen | | |
| Matamoros | 25,000 people left homeless | 4.3 |
| 1981 | Information on losses not available | |
| 1982 | | |
| Eruption of Chichonal volcano | 42 people killed, 22,000 evacuated, 150,000 victims—including 17,000 Zoque Indians. Complete loss of cultivable land within 10 kilometer radius; partial loss of lands within 10–15 kilometer radius. Damage done to 4,000 hectares of banana crops, 15,000 hectares of corn, 905 hectares of bean crops, 10,000 hectares of coffee, and 17,000 hectares of cocoa. Eight airports temporarily shut down, access roads closed for weeks. Carpet of ash and volatile particles within 15 kilometer radius | 117.0 |
| Hurricane Paul | | |
| Sinaloa | 257,000 victims, 7,299 homes damaged. Complete loss of 7,334 hectares of soy crops, 2,300 hectares of corn, and 1,300 hectares of vegetables. Forty percent of 75,000 hectares of soy crops, 14,000 hectares of corn crops, and 13,400 hectares of vegetable crops damaged. Damage to industrial and commercial structures | 82.4 |
| Floods | | |
| Throughout the country | 8 people killed, 5 injured, 285,511 victims. Damage to homes, highways, electricity and telecommunications, and agriculture | 114.6 |

**Table A2 (continued)**

| *Year/event/location* | *Casualties and damage* | *Reported direct losses (millions of U.S. dollars)* |
|---|---|---|
| **1983** | Information on losses not available | |
| **1984** | | |
| Industrial explosion | | |
| San Juan Ixhuatepec | 1,000 people killed, 5,000 victims, 200 houses completely destroyed, 150 homes left uninhabitable | 26.3 |
| **1985** | | |
| Earthquake | | |
| Mexico City | 6,000 people killed, 30,000 injured, 150,000 victims, 30,000 homes destroyed, 60,000 damaged. Damage to all productive, health, and service sectors | 4,104.0[a] |
| Floods | | |
| Throughout the country | 43 people killed, 47 injured, 73,241 victims. Damage to housing, highways, electricity and telephone system, and agriculture | 39.4 |
| Torrential rains | | |
| Nayarit | 48,000 victims, 22 houses damaged, 3 highways affected. Complete loss of dozens of hectares of vegetables and grains | 16.4 |
| **1986** | | |
| Fire | | |
| Veracruz | | 1.5 |
| **1987** | | |
| Snowfall | Mexico City, States of Mexico and Hidalgo— 6 people killed. Damage to water infrastructure, electricity transformers, 1,300 hectares of crops, and vehicles (as a result of traffic accidents) | 0.3 |
| **1988** | | |
| Industrial explosion | | |
| Ixhuapan, Veracruz | 20 people killed, 15,000 left homeless, 18,000 barrels of oil burned | 0.3 |
| Forest fires | 500,000 hectares of forest burned | 1,250.0 |
| Drought in agricultural zones | | |
| Throughout the country | 542,000 hectares of crops completely destroyed, 439,000 hectares partially damaged | 168.4 |
| Hurricane Gilbert | | |
| Four states and Nuevo Leon | 225 people killed, 46 injured, 139,000 evacuated, 51,000 victims, 9,739 homes damaged; 364,000 hectares of agricultural land damaged. Buildings, roads, electricity lines, highways, crops, shipping, communications, and urban services also affected | 76.0 |
| Other hurricanes | | |
| Throughout the country | 417 people killed, 106 injured, 192,000 victims, 31,000 homes damaged; 1.35 million hectares of agricultural land completely destroyed, 1.73 million hectares partially damaged; 74,683 head of cattle lost | 597.6 |

*(table continues on next page)*

**Table A2 (continued)**

| *Year/event/location* | *Casualties and damage* | *Reported direct losses (millions of U.S. dollars)* |
|---|---|---|
| Frost | | |
| Tamaulipas, Nuevo León, Coahuila, Chihuahua, Veracruz, Puebla, and Tlaxcala | 50 percent of coffee crop, 250 tons of oranges, and 2,000 head of cattle lost | 0.6 |
| **1989** | 80,000 hectares of agricultural land damaged | 648.0 |
| Forest fire | | |
| Quintana Roo | | |
| **1990** | | |
| Frost | | |
| Tamaulipas,Veracruz, Baja California | 10,000 hectares of crops damaged in Tamaulipas | 1.2 |
| Hurricane Diana | | |
| Veracruz, Hidalgo, and Puebla | 139 people killed, 56 missing, 75,000 victims. Highways and train tracks blocked in 6 states; 40,000 hectares of agricultural land lost. | 90.7 |
| Flood | | |
| Chihuahua | 200 people killed, 5,000 victims, 700 houses damaged | 2.5 |
| Frosts | | |
| Nuevo León, Baja California, Durango, Coahuila, Sonora, Mexico, Tamaulipas, Veracruz, and Chihuahua | 52 people killed, 500 families affected | 0.1 |
| **1991** | | |
| Industrial explosion | 6 people killed, 329 injured | 150.0 |
| Veracruz | | |
| Floods (dam breaks) | | |
| Zacatecas | 5 people killed, 12,000 cut off from communication, 10,500 victims, 2 bridges destroyed | 0.7 |
| Winter storms | | |
| Baja California Sur, Sonora, Sinaloa, and Chihuahua | 153 communities flooded, 40,000 victims; 40 percent of streets in La Paz, Baja California, destroyed; 50,000 agriculture hectares completely lost, 25,000 pigs lost, 160 kilometers of irrigation canals destroyed, damage to bridges (road and railroad) and highways. | 16.8 |
| **1992** | | |
| Industrial explosion | | |
| Guadalajara | 212 people killed, 1,480 injured, 13,930 victims, 1,425 homes totally destroyed, 150 homes with minor damage; 450 businesses destroyed, contents of 802 households destroyed, 637 vehicles destroyed, 8 kilometers of streets destroyed, 300,000 cubic meters of urban area affected | 65.0 |
| Rain and snow | | |
| Sinaloa | Crops lost | 0.2 |
| Tornado | | |
| Reynosa | More than 3,000 homes flooded | 10.5 |
| Tornado | | |
| Comitán de Dominguez, Chiapas | 375 homes damaged | 1.3 |
| Hurricane Winifred | | |
| Manzanillo | 3,000 victims, 2,000 hectares of plantain crops damaged | 8.0 |

**Table A2 (continued)**

| *Year/event/location* | *Casualties and damage* | *Reported direct losses (millions of U.S. dollars)* |
|---|---|---|
| Winter storms | | |
| Nayarit | 64 people killed, 70 premises flooded, 100,000 people left homeless; 104,000 hectares of agriculture and several highways damaged | 78.0 |
| Hail storms | | |
| Ttlaxcala | 11 people injured, 2,000 families affected, 2,000 hectares of crops damaged or destroyed | 0.2 |
| Hail storms | | |
| Guerrero and Tlaxcala | 30,000 hectares of crops and orchids destroyed | 2.3 |
| Frost | | |
| Zacatecas | 350,000 hectares of agricultural land damaged; | 27.0 |
| Eruptions of Popocatépetl volcano (1993–98) | 5 people killed, 26,000 evacuated from 23 communities. Damage from falling ash to pastures and urban centers | 12.0 |
| Hurricane Gert | | |
| Veracruz, San Luis Potosi, Hidalgo, Guerrero, Tamaulipas, and Quintana Roo | 7 people killed, 50,000 victims, 5,000 homes flooded, 70,000 people cut off from communications | 18.1 |
| Winter storms | | |
| Baja California (January) | 20 people killed, 10,000 victims. Communications and agricultural zones severely damaged | 32.0 |
| Winter storms | | |
| Baja California (November) | 3 people killed, 10,000 victims. Interruption of public services, damage to bridges, highways, pipelines, and vessels | 63.4 |
| Frost | | |
| Tlaxcala | 1,000 hectares of crops damaged | 0.1 |
| **1994** | | |
| Drought | 10,000 head of cattle lost | 2.7 |
| Sonora | | |
| Drought | 3,000 head of cattle lost | 0.8 |
| Caborca and Sonora | | |
| Hail storms | | |
| Puebla | 1,100 hectares of crops damaged or destroyed | 0.3 |
| **1995** | | |
| Hurricane Ismael | | |
| Baja California peninsula, Sinaloa, and Jalisco | 56 people killed, dozens missing, 52 vessels damaged, 20 vessels sunk, 29 vessels disabled, 3 lost. Damage to infrastructure | 26.0 |
| Hurricane Opal | | |
| Campeche and Tabasco | 14 people killed, 26,874 victims, 35,229 homes damaged, 14,370 hectares of pastures damaged. Damage to hydraulic, road, communications, and electricity infrastructure | 124.7 |
| Earthquake | | |
| Guerrero and Oaxaca | 10,000 victims, 3,611 homes damaged—including 1,200 completely destroyed | 21.1 |
| Forest fires | | |
| Throughout the country | 127 victims, 18 homes damaged, 114,000 hectares of agricultural land damaged | 1.0 |

*(table continues on next page)*

**Table A2 (continued)**

| *Year/event/location* | *Casualties and damage* | *Reported direct losses (millions of U.S. dollars)* |
|---|---|---|
| Gas pipeline explosion | | |
| Tabasco | 12 people killed, 23 injured, 10 buildings damaged, telephone lines damaged | 4.0 |
| Drought | | |
| Chihuahua | 135,000 head of beef cattle lost | 36.7 |
| Drought | | |
| Durango, Tamaulipas, Hidalgo, and Puebla | 53,000 head of beef cattle lost | 14.4 |
| Forest fire | | |
| Cancún and Quintana Roo | 250 hectares of rain forest damaged | 1.0 |
| Storm | | |
| State of Mexico | 157 homes flooded | 0.5 |
| Drought | | |
| Sinaloa | 5,000 head of beef cattle lost | 1.4 |
| Other droughts | | |
| In agricultural zones throughout the country | 45,000 hectares of agricultural land totally lost, 31,000 partially damaged; 98,700 head of cattle lost | 40.4 |
| Other hydrometeorological events | | |
| Throughout the country | 282 people killed, 75 people injured, 75,969 homes damaged, 335,140 victims; 392,844 hectares of agricultural land destroyed, 340,609 hectares partially damaged; 106,165 head of cattle lost | 418.4 |
| **1996** | | |
| Frosts | | |
| Chihuahua, Coahuila, Tamaulipas, Durango, México, Nuevo León, Aguascalientes, Michoacán, Veracruz, San Luis Potosí, Guanajuato, Colima, Hidalgo, and Jalisco | 224 people killed, 70,250 hectares of crops damaged, 90 percent of banana crop in Colima lost. Highways temporarily closed | 5.3 |
| **1997** | | |
| Hurricane Pauline | | |
| Oaxaca and Guerrero | 228 people killed, hundreds injured, 202,000 victims in 1,025 communities, 54,000 homes destroyed; 179 drinking water systems destroyed, damage to telecommunications and electricity systems; 186 kilometers of highway and 2,210 kilometers of rural roads damaged | 447.8 |
| **1998** | | |
| Forest fires | | |
| Throughout the country | 200,000 hectares of land damaged | 1,620.0 |
| Forest fires | | |
| Nuevo León, Morelos, Puebla, Oaxaca, and Chiapas | 1,500 hectares of land damaged | 12.2 |
| Hail storms | | |
| Oaxaca and Tamaulipas | 480 homes damaged | 1.7 |
| Forest fire | | |
| Puebla and Tlaxcala | 180 hectares of woods and pasture damaged | 0.7 |
| Forest fire | | |
| Puebla and Oaxaca | 5,100 hectares damaged | 41.3 |
| Forest fire | | |
| Hidalgo, Veracruz, and Nuevo León | 4,700 hectares damaged | 38.1 |
| Forest fire | | |
| Guadalajara | 600 hectares damaged | 4.9 |

**Table A2 (continued)**

| *Year/event/location* | *Casualties and damage* | *Reported direct losses (millions of U.S. dollars)* |
|---|---|---|
| Forest fires | | |
| Veracruz, Coahuila, Nuevo León, Hidalgo, Michoacán, and San Luis Potosi | 6,000 people evacuated 16,080 hectares of land damaged | 130.2 |
| Forest fire | | |
| Tabasco | 50 hectares damaged | 0.4 |
| Forest fires | | |
| Coahuila and Guanajuato | 1,600 hectares damaged | 13.0 |
| Fire in the public market | | |
| Mexico City | 600 stalls destroyed | 12.0 |
| Forest fire | | |
| Federal District of Mexico | 200 hectares damaged | 1.6 |
| Torrential rains | | |
| Chiapas | 199 people killed, 28,753 initial victims, 700,000 people without electricity, 51 communities in 39 municipalities affected; 712 kilometers of paved roads and 3,600 kilometers of rural roads damaged, 22 bridges collapsed and 18 others damaged, 5 highways damaged | 602.7 |

*Note:* Figures are based only on data available for reported losses and do not represent a comprehensive economic assessment of all direct losses. Figures are based on dollar/peso conversion rate in the year the losses were incurred.

a. Includes indirect costs of $515 million.

*Source:* Bitrán Bitrán 1999.

*Annex 3*

# Examples of Catastrophe Funds and Catastrophe Risk Pooling Used in Other Countries

Several countries have established institutions whose main or sole objective is to fund the repair or replacement of losses caused by catastrophic events. In most cases these institutions work in close collaboration with the local insurance industry and, in some instances, international reinsurers. The government acts as the reinsurer of last resort when reserved funds are not sufficient to pay losses incurred. Most funds charge a flat rate that does not discriminate based on the level of exposure or vulnerability. None of the funds seeks to earn a profit.

## Spain

The Spanish government established the Consorcio de Compensación de Seguros in 1941 to provide soft financing to Spanish life insurance companies that were unable to meet their obligations. Shortly after the Consorcio was established, catastrophic fires engulfed the port city of Santander. In response to that crisis, the Consorcio changed its basic functions and became a subsidiary insurance company, providing catastrophe coverage that is either not provided by insurance policies or was provided by an insurance company that went bankrupt or became insolvent.

The Consorcio provides coverage for all catastrophic risks (earthquakes and tsunamis, floods, volcanic eruptions, atypical cyclonic storms, and other natural disasters). It also covers risks of political or social origin (terrorism, rebellion, mutiny, popular upheavals, and damage caused by the armed forces or the security forces in times of peace).

The Spanish system links the protection provided by the Consorcio with the different types of policies provide by private insurance companies (for example, fire, motor, railroad) provided that the individuals or property insured is located on Spanish territory. The amount of catastrophic coverage provided is equal to the amount of property insurance purchased by the insured. Only direct damages are covered by the Consorcio; indirect damages can be insured by private insurance companies. The Spanish government guarantees all the liabilities contracted by the Consorcio (the guarantee has never been invoked, however).

The Consorcio's basic principles and modus operandi are framed by the most recent modification to Law 21/1990 approved by the European Union. The law, which originally banned state monopolies, was changed when policymakers realized that some state monopolies could serve the public interest. Today the Consorcio is subject to laws that apply to private sector insurance companies.

The Consorcio's only source of revenue is the premiums it charges. Private insurance companies that underwrite the basic policies collect these premiums, which are then remitted to the Consorcio. The premiums are used both to create the necessary technical reserves and maintain the required solvency margin and to establish a special accumulative reserve fund. Profits are not earned, as all resources, including investment results, are added to the reserve fund.

The tariffs charged by the Consorcio are compensatory and do not reflect the degree of exposure to risk. Rates range from 0.092 per 1,000 for housing and offices to 0.25 per 1,000 for industrial risks. Public property tariffs range from 0.35 per 1,000 (for highways) to 2.0 per 1,000 (for port installations). Vehicles pay a flat fee.

Between 1980 and 1998 the Consorcio's loss ratio averaged about 93 percent, with losses from floods accounting for 86 percent of losses and losses from terrorism accounting for 10 percent. Claims are adjusted by a network of specialized technicians that is kept on stand-by.

Payments to policyholders are made by the insurance companies that underwrote the basic policies.

The Consorcio does not cover agricultural risks. Such risks are handled by a special system that the government coordinates through ENESA (Entidad Nacional de Seguros Agrarios—the National Agriculture Insurance Agency), which operates a pool, called AGROSEGUROS, made up of private insurance companies that wish to participate as coinsurers. If the resources provided by this pool are deemed insufficient, the Consorcio participates as reinsurer. Although the Consorcio has participated in the pool since 1984, its involvement in the fund has been steadily declining.

### France

In France national solidarity in confronting catastrophes is explicitly expressed in the preamble to the 1946 Constitution, which states, "The State affirms the solidarity and equality of all its citizens in facing the burdens that result from national calamities."

The Caisse Centrale de Reassurances (CCR) was established in 1946 as a public entity of commercial nature. In 1993 CCR became a stock company wholly owned by the state. It functions as a reinsurer, providing catastrophe reinsurance to local insurers, backed by an unlimited guarantee from the state for catastrophic risks affecting property located on French territory. The state determines the premium rates, franchises, and amounts to be reinsured. It is also responsible for declaring a natural catastrophe state of emergency and for developing and implementing risk prevention measures.

The natural catastrophe guarantee is provided automatically to all property insurance policies purchased in France on which an extra premium for catastrophe coverage is charged. Collection of these extra premiums, evaluation and adjustment of claims, and payments to policyholders are handled by private insurance companies. A uniform rate—ranging from 6 percent for motor vehicle coverage to 9 percent for property and loss of profit coverage—is used throughout the country. Application of a single rate, regardless of the level of exposure to risk, has been challenged, but the government has successfully defended its policy, invoking the solidarity principle.

The CCR competes successfully with national and foreign private reinsurers in the market, as local direct insurers are not required to purchase their reinsurance through the CCR. More than 90 percent of direct insurers work with the CCR. The CCR provides insurers with reinsurance plans that would be difficult to find anywhere else or would be very expensive. The contracts allow direct insurers to create and increase catastrophic loss reserves, which can make them less dependent on reinsurance in the long run.

For agricultural risks, CCR finances and operates the National Guarantee Fund for Agricultural Calamities, which provides protection for standing crops and livestock against frost, flooding, land slippage, storms, hurricanes, avalanches, droughts, atypical rains, epizootic diseases, and other risks. Coverage is provided only to property situated in continental France. It does not cover agricultural assets, such as machinery and buildings, that can be insured with private insurance. The fund's income comes from a parafiscal rate applied to the premiums generated by the basic insurance policies plus a state subsidy. Insurance companies underwrite basic policies, adjust losses, and effect payments, but no premiums are paid to them.

### Japan

Although Japan is exposed to many types of catastrophic events—including earthquakes, typhoons, floods, and volcanic eruptions—state involvement is limited to insuring dwellings against the risk of earthquakes. Risks in Japan are insured by private insurers; local reinsurers; the Japanese Earthquake Reinsurance Co. (JERCO), which is partially state owned; and the government, as a reinsurer of last resort with limited capacity. The system has not proven effective (as the response to the Kobe earthquake showed), and penetration of coverage (which is voluntary) is low.

### New Zealand

The Earthquake Commission of New Zealand operates much like the Consorcio of Spain. Its name notwithstanding, it offers coverage for a variety of catastrophic

risks. The state provides unlimited capacity whenever direct insurance reserves and reinsurance are exhausted. Coverage is available for family dwellings (including small businesses), personal property (excluding automobiles and works of art), and the land on which dwellings are situated. Commercial and industrial property is insured by private insurance, following withdrawal of the government from this sector.

### United States

The United States has probably the highest catastrophe risk exposure in the world, in terms of both frequency and severity. For various reasons (low penetration of insurance, inadequate capacity of private insurers, laws that impede the creation of catastrophe reserves, high expected losses), the federal government provides catastrophic flood insurance. The National Flood Insurance Program has been in operation since 1968 and has had mixed results.

Earthquakes in the United States have the potential to cause enormous damage. Since 1964 (following the Anchorage earthquake), a number of proposals have been made by governmental and private bodies on how to deal with the high level of risk posed by earthquakes. Failing to come up with an insurance solution, Congress passed the National Earthquake Hazards Reduction Act of 1977, which mandated the creation of a prevention and mitigation program to be applied by the Federal Emergency Management Agency (FEMA).

In 1987 a group of insurance companies established the Earthquake Project (later known as the Natural Disaster Coalition and the Project for the Law for Protection and Prevention of Natural Disasters). The project, which has yet to be approved by Congress, seeks to mitigate losses in zones with high catastrophic exposure by establishing more rigorous building standards, creating a federal catastrophe fund, and increasing reinsurance capacity in order to increase coverage. All of these actions would be implemented and controlled by FEMA.

Some states have also tried to deal with risk. In 1986 the California legislature passed a law requiring every insurer selling homeowners insurance to offer earthquake coverage. In 1991 the California Earthquake Recovery Fund was established to provide protection to homeowners. The program failed, however, because of high loss ratios. After the Northridge earthquake in 1994, insurers refused to provide coverage. In 1996 a set of laws was passed by the California legislature authorizing the formation of a new state agency, the California Earthquake Authority. That agency provides a limited form of earthquake insurance to homeowners, renters, and condominium owners. Seventy-two percent of insurers participate in the fund. Financing is done by layers of funding (reserves) and reinsurance. Financial performance has been worse than expected, because of high premium rates, low coverage, and the high cost of reinsurance.

In the wake of the enormous damage caused by Hurricane Andrew (which caused 10 Florida insurers to declare bankruptcy), the State of Florida established the State Hurricane Trust Fund in 1994. The fund acts as a reinsurer, absorbing 75 percent of the excess of losses incurred by insurance companies caused by hurricanes if those losses reach twice the premium volume collected by the insurer for that risk. The objective is to maintain coverage at accessible levels, especially for homeowners. The State of Hawaii established a similar fund, the Hurricane Relief Fund of Hawaii, following Hurricane Iniki.

*Annex 4*

# List of People Interviewed for Study and Participants in Workshop

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