Photo: Courtesy of Bustamante, DNPAC

Hazard map created as part of the Tsunami Risk Mitigation Project in Tumaco, Colombia.

use or urge structural strengthening of buildings. A vulnerability analysis is performed during this first stage, and is complemented by information on population and infrastructure.

Geographical Information Systems (GIS) are a relatively new form of information technology. This system requires a large initial investment in computer hardware, software, and training for managers and users; however, it facilitates data management, allowing flexible updating of maps and the immediate incorporation of information from aerial photography and data obtained by satellites. Whereas with manual map making, correcting inaccuracies and updating used to take hours, the versatile GIS performs these operations in virtually no time.

After geographical information is collected, GIS becomes a tool for forecasting trends in urban growth and locating areas and infrastructure at risk, thus producing useful visual aids for planning rational land use. However, the impressive technology and attractive maps should be considered only as powerful tools, not as ends in themselves. GIS has two drawbacks: first, the initial investment, operation, and maintenance of the equipment may outstrip the budgets of the institutions that use them. Second, mechanisms for updating information should be established from the start, but many institutions do not have the infrastructure to meet this demand.

The Bahamas, Barbados, the British Virgin Islands, Costa Rica, Jamaica, Mexico, Peru, Saint Lucia, and Trinidad and Tobago are among the countries in the Region with experience in preparing natural hazards maps. Examples of projects at the local level include the UNDP project in Medellín, Colombia; the "Infographic" Atlas of Quito, Ecuador (see Box 6.4); and the volcanic-hazard maps developed by Ecuador's Geophysical Institute of the Polytechnic School. CEPREDENAC's database on hazards in Central America, and the OAS projects to diagnose and reduce sectoral vulnerability also deserve special mention.

Costa Rica's Integrated Emergency Information System is an example of the

Box 6.4

HAZARD MAPS GUIDE URBAN PLANNING IN ECUADOR

The Constitutional Resolution that declared Quito a Metropolitan District in 1978 marked the beginning of a project to plan the future development of the nation's capital. A central element of the project was the work of Ecuador's Chapter of the Instituto Panamericano de Geografía e Historia (Pan American Institute of Geography and History—IPGH), the Military Geographic Institute of Ecuador, the Municipality of Quito, and the French Institute of Scientific Research for Development (ORSTOM) in producing the "Infographic Atlas" of Quito. This document has maps with scales ranging from 1:1,000 to 1:50,000 showing detailed geographic, demographic, and socioeconomic aspects of Quito. The atlas includes a chapter on the natural hazards to which this city of more than two million is exposed. The importance of this atlas is demonstrated by the fact that its maps have been incorporated, by law, into Quito's urban planning.

Source: Instituto Geográfico Militar (Ecuador), 1992.

use made of GIS to manage the phases of the disaster cycle, including prevention and mitigation. This system includes graphics that interact with a database to strengthen two central elements of the planning process: the country's "Atlas of Natural and Manmade Hazards" and the "Inventory of Strategic Resources for Disaster Preparedness, Response, and Rehabilitation". The summary, "Restrictions on Land Use," complements the atlas with legal, geological, hydrometeorological, technological, and engineering references and recommendations for local government authorities and the public at large.

The Fundación de Asesoría para la Prevención del Riesgo Sísmico (Foundation for the Prevention of Seismic Risk—FUNDAPRIS; formerly known as CEAPRIS) in Venezuela has gained valuable experience in developing zoning maps of geological hazards. These maps help to formulate state emergency plans and regulate the granting of construction permits based on land-use restrictions. Its disaster-mitigation activities at the local level include education and training, construction and urban development, and management of emergencies.

In the Caribbean, the British Virgin Islands have a new national physical development plan. The section on the Anegada area contains important information and conclusions on the island's natural hazards—the areas endangered by hurricanes, floods, seismic movements, soil liquefaction, and water pollution. The territory's Office of Disaster Preparedness provided information on hazards and disasters which has been incorporated into the plan. The project has the backing of the United Nations Center for Human Settlements (HABITAT).

Disaster scenarios are included in Colombia's comprehensive program for risk mitigation. As part of this program, two activities related to risk maps deserve to be singled out: the preparation of the tsunami hazard map in Tumaco, and the preparation of the volcanic hazard map for Ibagué. For these two activities, scientists, politicians, and community groups successfully worked together to implement the measures planned.

The "Tumaco Tsunami Risk Mitigation Project" illustrates a project for which a recent disaster was not the catalyst;

rather the process began with the possibility that such a disaster could occur. In addition to mapping the hazards, the Tsunami Detection and Alert Network has been expanded; a comprehensive relocation and housing improvement project is being undertaken, and the private sector is backing and spurring economic and social development in the region.

The UN Department of Humanitarian Affairs promotes the idea of drafting natural hazard maps in several countries of the Region as the first step in a comprehensive disaster management program For example, DHA supports Argentina in formulating and implementing a national disaster mitigation program emphasizing emergencies arising from volcanic eruptions and technological disasters The initial phase of this project focuses on one of the 42 potentially dangerous active volcanoes in the country to estimate hazards, develop monitoring procedures, and encourage community preparedness. The experience will subsequently be repeated with the remaining volcanoes.

In Peru, UN/DHA and the Canadian International Development Agency (CIDA) have carried out and financed a disaster mitigation program, with the Instituto Nacional de Defensa Civil (National Institute of Civil Defense—INDECI). It consists of the following components: a study of seismic, volcanic, and flood risk in the city of Arequipa; a study of seismic and tsunami risk along the southern coast, and the organization of the national disaster mitigation databank One aim of the project is to draft hazard maps to formulate and implement emergency plans which will be incorporated into the urban plans of the localities studied.

In 1987, the Civil Defense of Ecuador and the National Polytechnic School with support from OFDA/USAID and UN/DHA, developed a project to evaluate natural hazards and integrate their implications into community protection planning. One of the results of this effort was the publication of hazard maps for active and inactive volcanoes. On the basis of these maps it has been possible to:

- Analyze potential socioeconomic impact;
- Estimate the vulnerability of threatened areas;
- Monitor the active volcanoes on a permanent basis;
- Improve Civil Defense response plans

In summary, to mitigate the effects of natural disasters it is necessary, first, to be familiar with the hazard and, second, to locate it geographically in order to analyze the vulnerability and prepare risk maps. On the basis of these maps:

- Legal measures can be taken for design and planned development of urban areas;
- New buildings can be designed taking into consideration identified risks,
- Existing buildings can be reinforced and upgraded;
- Civil engineering works can be constructed to limit the destructive effects of disasters;
- Decisions can be made (in extreme cases) to totally or partially relocate human settlements as a preventive measure.

These examples of the use of risk maps show that maps should not be ends in themselves but tools for planning the orderly growth of cities and for developing institutional and community preparedness activities. In addition, although the technical and financial cooperation of donor institutions and countries is neces-

Box 6.5

THE CARIBBEAN UNIFIED BUILDING CODE (CUBiC)

An informal meeting of engineers from several Caribbean countries in 1968 led to the establishment of what is known as the Council of Caribbean Engineering Organizations (CCEO) One of their goals was to develop building codes.

With a view to standardizing code criteria, several meetings were held in Jamaica between 1970 and 1974, with a final conference in Trinidad in 1978 devoted entirely to the discussion and presentation of studies on seismic activity in the Caribbean and on earthquake-resistant designs. This conference gave rise to a CCEO committee to prepare guidelines that engineers could use until a formal code was published.

With initial support from USAID and CARICOM, the Caribbean Uniform Building Code (CUBiC) was finally proposed in 1985 Its application, however, has not been made obligatory in any of the countries, although the governments of Bahamas, Bermuda, Turks and Caicos Islands, and the French Departments are considering its implementation. HABITAT is promoting the adaptation of CUBiC to the particular conditions of each country or territory in the eastern Caribbean.

The initiative to formulate a regional code is advantageous, since it provides a reference document geared to actual conditions, both in the characterization of hazards and with regard to construction technologies, and can be adapted to each country CUBiC has not enjoyed wide acceptance, however, due to the unfounded fear that the cost of implementation may be high. Its success depends on having resources for inspection and enforcement and on legal support for these measures

Source Gibbs 1992 PAHO/WHO

sary to promote mitigation programs in their initial phases, to continue and attain objectives requires maturity and commitment on the part of those receiving this support.

DISASTER MITIGATION AND THE ENVIRONMENT

The recent trend toward lessening the adverse impact of development on the environment, promoted by the World Conferences on the Environment (held in 1972 in Stockholm and in 1992 in Rio de Janeiro), has awakened planners to consider natural hazards when they assess social and economic development projects. The commitments made by the majority of the world's countries in Agenda 21 of the "Earth Summit" in Rio de Janeiro include the proper management of forests and options for combating the degradation of soil, air, and water, as well as the need to eradicate poverty in order to achieve sustainable development. Accordingly, many of the solutions adopted in Agenda 21 are part of the same strategy of mitigating and preventing disasters

Even though many countries of the Region have formulated environmental agendas or laws, few include actions to reduce vulnerability to natural hazards. However, two positive examples include the law creating Colombia's Ministry of Environment and Honduras' Law on the Environment enacted in 1993. They both promote municipal decentralization as a major component in controlling and executing policies for environmental protection, natural resources management and, finally, measures to reduce the effects of disasters. Although there are many such laws, most countries have trouble enforcing them and monitoring compliance.

The trend now is for administrators and planners who are involved in disaster management to include an environmental impact analysis in development projects. Unfortunately, "environmentalists" rarely relate environmental deterioration to increased vulnerability to natural hazards.

MITIGATING THE EFFECTS OF DISASTER ON INFRASTRUCTURE

To mitigate the effects of natural disasters, the most common actions are those involving modifications to existing structures. Most of the countries of the Region are making efforts—within their limited budgets and occasionally with the technical and financial support of international agencies and other donors—to adapt building codes to local conditions; to reinforce existing buildings, especially critical facilities (such as hospitals, schools, drinking water supply, and electric systems); and to undertake prevention projects. In some of these projects, the community has played a decisive role in pressing for the most urgent measures.

Existing buildings are the main concern. Nevertheless, if during the planning of a project, special design and construction requirements were established with legal and institutional backing to enforce them, and if the project were built on an appropriate site, there would be no need for costly retrofitting assuming that maintenance is sustained. Experience demonstrates that the economic impact of losses due to structural damage from disasters leads to overseas borrowing and delays in normal development programs, in addition to the immeasurable cost in human lives. For this reason, scientists and technicians in most countries of the Region need to formulate and apply building codes—especially in the case of earthquakes—that will insure that a building can withstand the impact of natural phenomena with an acceptable and predetermined level of damage. Due to the lower costs of wind resistant reinforcement, engineers and other technicians recognize that during hurricanes, buildings should not suffer from damages other than those caused by flying objects.

The main obstacle to the effectiveness of building codes as a tool for disaster mitigation is their enforcement. Some countries of the Region do not have their own standards; they merely adapt European or United States parameters that are not geared to local conditions. Others, such as Colombia, Costa Rica, Mexico, and some Caribbean countries (see Box 6.5) have developed their own excellent codes, but they do not fully achieve their goals because they are not legally binding or because they are not enforced.

Even though many countries of the Region have formulated environmental agendas or laws, few include actions to reduce vulnerability to natural hazards.

In the case of hospitals and other critical facilities, functional rather than structural collapse is most often the principal effect of a disaster. The solution to this problem lies in preventive maintenance programs. Maintenance not only slows deterioration but also ensures that utilities (water, gas, electricity) and nonstructural components (facades, ceilings, fixtures, etc.) resist the disaster impact. Moreover, the cost is not onerous if considered as another item in the normal operating budget of a building (see Box 6.6).

There is a deep-rooted myth that to make a building hurricane- or earthquake-resistant means making a greater initial investment unjustified by the likelihood that a disaster will occur. In the case of large-scale projects, this increase in the initial cost, estimated at 4% to 10% in light of experiences in the Region (studies by the U.S. Federal Emergency

Box 6.6

STRUCTURAL REINFORCEMENT OF THE HOSPITALS OF THE COSTA RICAN SOCIAL SECURITY FUND

Photo Cruz

Costa Rica, a small country of slightly more than 50,000 square km has suffered several high-magnitude earthquakes in this century that have caused heavy economic and social losses.

The Costa Rican Social Security Fund (CCSS), which provides universal health care coverage, is responsible for the operation of the nation's most sophisticated hospitals. The effects of several earthquakes in Costa Rica and in neighboring countries in the 1980s on health care infrastructure, led to efforts to reduce vulnerability of hospital buildings. This trend culminated in a decision in late 1986 by the CCSS to authorize vulnerability studies and plans for reinforcing unsafe buildings belonging to the institution. Conditions at the Mexico and Children's Hospitals were assessed first, and subsequently at the Monsignor Sanabria and Ciudad Neily Hospitals and the central CCSS offices. The reinforcement of all these buildings was completed in 1988, before a period of intense seismic activity between 1990 and 1991.

In contrast the Tony Facio Hospital, which lies near the epicenter of the April 1991 earthquake (7.4 magnitude on the Richter scale), had not been a priority in the initial evaluations because it was located in an area where seismic risk was presumed not to be high. As a result, it suffered major damage and had to be evacuated.

The best lesson learned from Costa Rica's experience with reinforcing vital buildings, such as hospitals, was that mitigating the effects of earthquakes should begin before any disaster occurs. The success of this approach was evident when the strong earthquakes of 1990 and 1991 occurred. Had actions not been taken, the Tony Facio Hospital would not have been the only one damaged by the quake.

Source: M. Cruz, 1992

Management Agency estimate the increase at only 0.5% to 2%), is not an unnecessary expenditure since the cost of replacing these buildings is significantly greater, not to mention the human and social losses caused by their destruction. International financial institutions can promote protection from natural hazards as a variable in the formulation of investment proposals. Priorities in the countries of Latin America and the Caribbean in this regard are to:

- Make a hazard analysis of future construction sites compulsory;
- Require that designs produce buildings that can withstand natural disasters as conditions for the granting of a loan.

The financial institutions would thus promote effective disaster mitigation and protect investments.

However, the bulk of losses of human life and damage to structures from disasters occurs through damage to dwellings. For example, the 1991 earthquake in Costa Rica totally destroyed a few buildings, seriously damaged the communication and drinking water supply systems, started a fire in the country's most important oil refinery, and caused substantial indirect losses. However, the most significant damage was in the housing sector—some 5,000 units were affected. A similar pattern of damage was seen in the earthquakes in El Salvador and Guatemala.

This pattern is common in most disasters, especially among segments of the population that, owing to social and economic limitations, construct their dwellings without appropriate professional supervision and on land not suited for residential use. For this reason, research is being conducted on the materials and methods of "native" construction, not only to improve designs but also to reinforce existing dwellings (see Box 6.7). The numerous examples in the Region include the experiences of CENAPRED in Mexico and CISMID in Peru; the National Bamboo Project, under the Housing Ministry of Costa Rica; and experiments in building with bamboo and reed in Panama and Colombia. In addition, research is underway on the improved use of adobe, *quincha* (construction using cane or sticks and mud), and *taquezal* (blocks consisting of mud and organic materials) in Nicaragua, Guatemala, and Peru.

In Jamaica and other countries of the Caribbean, a pilot project was conducted with typical dwellings to assess first their response to hurricanes and subsequently to promote scientifically designed anchorings and connections. The project received technical and financial support from the International Development Research Center (IDRC) of Canada, the Faculty of Engi-

Box 6.7

REINFORCEMENT OF ADOBE DWELLINGS: IT SAVES LIVES

Photo: de Ville de Goyet, PAHO/WHO

The Centro Regional de Sismología para América del Sur (South American Regional Center for Seismology—CERESIS), located in Lima, Peru, is conducting a project to overhaul existing adobe dwellings to mitigate the damages sustained to these buildings during earthquakes.

Although research has been done worldwide to develop new technologies for adobe use in seismic-resistant buildings, these new technologies cannot be applied to reinforce older housing. Most adobe dwellings were constructed without technical advice, and because of limitations inherent in the material—the massive and fragile walls, defects of configuration, inadequate joints, and problems in the foundation, they usually collapse in earthquakes.

For this reason, CERESIS proposed establishing simple, low-cost procedures to improve the condition of existing dwellings, taking into account the type of soil on which they were built and their size and shape, so that they can withstand earthquakes, or at least remain standing until the occupants can vacate them.

The main objective of this project is to teach communities reinforcement methods, and then motivate them to improve the dwellings themselves, without external technical or financial support.

Source: CERESIS, 1994

Box 6.8

PARAGUAY: THE PROBLEM OF FREQUENT FLOODING


Photo I. Calle

The Paraguay River's greatest floods occur approximately every 5 to 10 years. In intervening years however, major floods can occur along specific stretches of the river's basin, the variable rainy seasons in the upper and lower river basin produce this uneven flooding. For example, serious floods in the upper basin have affected cities such as Fuerte Olimpo, Puerto Casado, and Concepción, while in the middle and lower basins the river barely rose. Conversely, there has been flooding in the middle or lower basin that affected major towns such as Asunción, Alberdi, and Pilar, while the upper basin saw nothing that could be considered abnormal

The behavior of the Paraná River is less predictable, and its flow is determined to a great degree by the fact that there are 18 hydroelectric plants built on its tributaries and on the Paraná River itself

The damage caused by flooding in Paraguay is considerable, which means that people must be relocated and infrastructure built for basic services: water, sewage disposal, vector control, food hygiene, and waste disposal. In addition, because flooding occurs at the coldest time of the year, the victims need blankets and temporary shelter, obtained mainly from international donations and governmental funds at an estimated cost of US$150,000 per flood

The city of Asunción, whose population is hit hardest by annual flooding, has made plans to build a wall around the city, and storm waters will be pumped toward the Paraguay River during periods of rain. The government invested approximately US$5.2 million to construct dikes for riverbank protection in the cities of Concepción in the north and Pilar in the south (both on the Paraguay River) and to build 150 km of embankments along several routes commonly affected by the flooding of the Paraguay River. These embankments will reduce the vulnerability of more than 400 km of roads connecting riverine towns that tend to be isolated from the rest of the country when major access routes are flooded

There are still no laws restricting the use of areas prone to flooding

Source: PAHO/WHO

neering of the University of the West Indies, and a Jamaican NGO, the Center for the Development of Research in Construction. This project is linked to similar activities that the OAS and the Regional Office of OFDA/USAID for Housing and Urban Development in the Caribbean are sponsoring, such as a project to inspect electric power grids and other infrastructure, map areas susceptible to natural hazards, cooperate with insurance companies to improve risk management, and improve building codes.

The purpose of research and experiments with construction technologies and materials is similar to that of developing hazard maps; that is to say, they are a means, not an end to a mitigation program. The need to convey all findings of these studies to communities, in easy-to-understand language so that they can be applied and become effective tools for reducing the impact of natural disasters, is imperative.

The city of Santiago de los Caballeros, Dominican Republic, is located in an area of high seismic activity that is also exposed to heavy rains from hurricanes affecting the Caribbean. In 1989, vulnerability analysis was conducted on both the water supply and sanitation systems which were susceptible to extensive rupture and damage because of inadequate maintenance programs, structural flaws, and improperly used piping materials. Corrections to the systems have been carried out in part, but an indirect and even more important consequence has been the government's decision to reinforce and modernize drinking water supply systems in the entire country.

Aside from modifications to existing infrastructure and special designs for new projects, measures can be taken to directly influence the impact of natural disasters. A wide range of engineering works to prevent disasters is available, depending on technical feasibility and cost-benefit ratio considerations. Investments in disaster prevention projects are readily justified in areas frequently hit by disasters; thus, it is not surprising that the control of hydrometeorological disasters through engineering is one of the most common preventive measures taken.

At certain times of the year, reports of flooding in susceptible areas are common. If we compare these reports year after year, we see that the damage is practically the same. . .until some political body decides to tackle the problem by building control devices (see Box 6.8).

The wide range of flood protection works runs from traditional dikes and retaining walls to river channel modifications. The design of such works, in addition to the high cost, often poses challenges to hydraulic and structural engineers. However, in many cases, the real solution to the problem is not possible since it would require the enforcement of a strict land-use policy that prohibits construction on or the use of this land for purposes other than the preservation of the rivers. The solution thus entails relocating human settlements and other structures, which could turn out to be not only more expensive but politically detrimental as well. A happy medium needs be found.

Owing to scientific and technological advances in the countries of the Region, innovative engineering solutions have been implemented to control the impact of flooding. In the city of Manizales, Colombia, ingenious, effective ideas are practiced to control landslides (see Box 6.9). There are also valuable examples of low-cost prevention works constructed with the participation of the communities.

Box 6.9

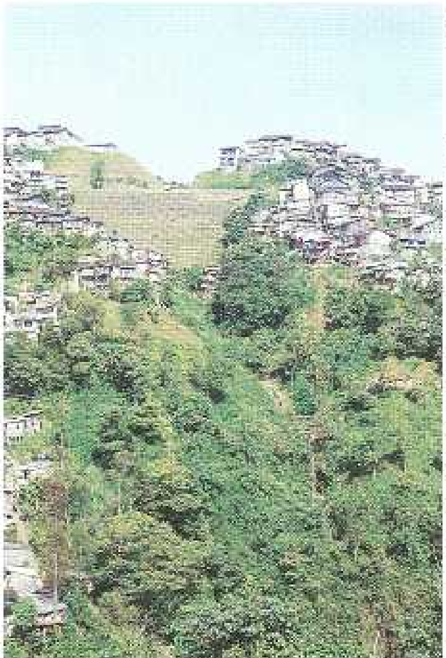

Photo: Marin Valdes/IDNDR

MANIZALES: MORE THAN MAPS FOR MITIGATION

Manizales Colombia has been struck repeatedly by landslides, caused by the instability of the slopes on which the city is built, as well as by intense seismic activity. To mitigate these conditions, local and national authorities, scientists and specialists at universities and private companies, and the community joined efforts and resources to implement safety measures within the framework of a project known as "Comprehensive Management of Disaster Prevention and Response Activities."

Phase II of the Project included a hazard study, preliminary mapping of dynamic characteristics of the soil, a building vulnerability study, and relocation programs for at-risk dwellings. In addition, the entity restructured as CORPOCALDAS working with the Mayor's Office, developed a program for slope protection which is currently financed with national and local funds. This program includes the restoration of plant cover, drainage systems, and other engineering works. The latter projects go beyond the traditional retaining walls and gabions, displaying an originality that has served as an example for specialists in other regions and countries facing the same problem.

In 1993 the Municipal Council of Manizales created a Municipal Fund for Calamities equivalent to 1% of the city's tax revenues. It also granted a real estate tax exemption to property owners who make structural modifications and take steps to conserve the architectural heritage of the city by reducing its vulnerability. These urban development policies are based on the results of the municipal project known as the Comprehensive Plan for Disaster Prevention and Response of Manizales (PADEM).

Sources: UN/DHA, PAHO/WHO, PADEM, IDNDR Regional Office

Among them is the program to improve the lower channel of the Juan Díaz River in Panama, which had public and private support and which, by preventing annual flooding in that area, offered a viable solution for other communities.

In summary, there are two direct ways of mitigating the effects of violent natural phenomena: first, know the threat, (for example, through maps or land-use regulations); second, respond appropriately to vulnerable elements (for example, by properly designing infrastructure projects or by reinforcing buildings). To take such action, the actors in the process must be aware of the consequences of disasters and have the technical and scientific knowledge and the motivation to propose solutions.

THE ACTORS—GATHERING AND APPLYING KNOWLEDGE

The challenge of the IDNDR in Latin America and the Caribbean is to apply the knowledge that has been accumulated and developed in the Region. The institutions of higher learning in the health sector have opened their doors to initiatives from agencies like PAHO/WHO to make emergencies and disasters an integral part of their curricula.

In disciplines such as engineering and the applied sciences, the study of natural disasters is approached from a rigorous analytical perspective, sometimes ignoring socioeconomic considerations. The contribution of this research to the improved knowledge of natural hazards

Photo facing page: Vizcarra PAHO/WHO