grammes aimed at . . . proper disposal of solid wastes and the control of toxic chemicals."

Further discussion of the legislation relating to industrial chemicals and hazardous wastes can be found in the chapter *Health Legislation and Policy.*

Food Contamination

Chemical and biological food contamination continues to be a serious problem in the Americas, including the Caribbean. Measures aimed at food safety and control are needed to ensure the health and well-being of the population. These measures should take into consideration the region's increasing dependence on imported foods, which sometimes do not meet the safety requirements of the country of origin.

Although several governments have initiated actions aimed at improving their food protection activities, the limited resources assigned to protection programmes have not allowed for much progress. Food safety and control is made difficult in all of the Caribbean countries by the fragmentation of efforts among a number of ministries and their technical units. In some countries, overall responsibility for ensuring safety and control of both domestic and imported foodstuffs has been assigned to the Ministry of Health. In others, this responsibility is shared among the ministries of health, agriculture, commerce, and industry. The implementation of effective food protection and safety programmes must include not only government agencies but also the food industry (producers, importers, and processers) and informed consumers. In addition, most countries need to update and harmonize their food legislation.[48]

In rural areas, control of hygienic conditions during food distribution is very difficult, and in many urban areas sanitary monitoring is deficient or lacking, leading to biological contamination of food.

Food poisoning cases are often not reported in the Caribbean. However, it has been observed recently in many countries that hotels are reporting cases of food poisoning to the health authorities more frequently, owing to the hotel industry's growing concern about the impact of this problem. There is a need for more equipment for holding prepared food at the proper temperature, better training of food handlers, and increased vigilance.

The number of cases of foodborne illness reported in a country is related to the effectiveness of its surveillance system. Ten countries in the Caribbean reported ciguatera poisoning between 1992 and 1994. In the latter year, 774 cases were reported. The number of cases of foodborne illness (excluding typhoid, cholera, gastroenteritis in children under 5 years, and ciguatera) in 14 countries in 1994 was 1,331, with three countries each having more than 300 cases. In 1992 there were 1,261 cases.[49] In Trinidad and Tobago in 1992 there was an outbreak of salmonella food poisoning in the psychiatric hospital, resulting in 346 cases and 10 deaths. The implicated food item was a drink containing raw eggs.[50] Storage of conchs in polluted seawater in the Bahamas has recently been identified as the source of an outbreak of illness caused by *Vibrio parahaemoliticus*. Such incidents are likely to recur unless storage methods are improved.

Lack of adequate controls in the mass processing of poultry and beef has led to cases of campylobacteriosis and salmonellosis. Stricter regulations are needed governing the use of antibiotics in animal feed. In both Anguilla[20] and the British Virgin Islands,[19] private slaughtering of animals has also been signalled as a source of concern, and Montserrat has highlighted the lack of food hygiene regulations as a potential problem area.[41] In Guyana, the problems caused by poor food conservation and protection facilities are compounded by poorly equipped and understaffed laboratories for food chemistry and microbiology.[6]

The intensive use of agricultural chemicals, coupled with poor application practices, has led to concern about food contamination by residues of organochlorine insecticides and certain herbicides. A case of accidental contamination of flour imported into Jamaica in 1976, in which parathion poisoning resulted in several deaths, has been well documented. The contamination is thought to have occurred during the international transport of the flour to Jamaica.

Pesticides

The threat posed by exposure to pesticides—through direct contact, as residues in food, or in contaminated drinking water—varies with the protection measures taken and the type of pesticide involved. Pesticides can cause acute poisoning and death, chronic conditions affecting the skin and lungs, neurological sequelae, and even teratogenic and mutagenic effects. Moreover, arsenical pesticides are known to be carcinogenic to humans.[51] Organochlorine pesticides degrade very slowly and tend to accumulate in soil and groundwater, the food chain, and also in fatty tissue, frequently causing elevated levels of these substances to be found in mother's milk.[51]

The most urgent problem in the Caribbean related to pesticide use pertains to acute poisonings of work-

ers and others exposed to these substances.[7] However, information on the extent of the problem is inadequate in most countries. Data available for Trinidad and Tobago with regard to substances used, poisonings in the exposed population, and biological monitoring indicate that most poisonings occur in workers 15 to 29 years of age and are associated with exposure to organophosphate insecticides and carbamates. Most of the deaths are due to nonoccupational exposure, often self-inflicted, and are linked to organophosphate insecticides and dipyridilium herbicides (paraquat). For example, in 1984, of the 762 poisonings treated at Trinidad and Tobago's three main hospitals, 245 were caused by pesticides. There were 120 deaths among the 245 cases, 90% of these deaths were attributed to suicide.[7] (See also "Part III: Injuries, Poisonings, and Their External Causes," in the chapter *Epidemiological Overview of Morbidity and Mortality.*)

Many farmers get no guidance from agricultural authorities or pesticide vendors regarding the safe use of these substances. A study conducted in Saint Lucia to document the prevalence of suboptimal safety practices among workers using pesticides[52] noted that although the groups surveyed were familiar with the fact that pesticides are toxic, their knowledge did not always translate into the adoption of safety precautions. The study uncovered a number of deficiencies in the training, knowledge, and safety practices of pesticide users on small and large farms in Saint Lucia; these findings could be considered typical for many islands in the Caribbean. An additional problem in the Caribbean is that health personnel sometimes have little training in diagnosing and treating pesticide poisonings. Efforts are being made to address these deficiencies.

Pesticides are no longer as effective for crop protection as they were in the past, owing to the increasing number of insect pests and weeds that are developing resistance to chemicals. There is a substantial risk that pesticides will be applied more frequently, at higher concentrations, and in mixtures in order to compensate for their lack of effectiveness. Aside from the associated increased risk to human health, these practices will result in mounting expenditures for pest control.[51]

Vector-borne Diseases

Except on Hispaniola (Haiti and the Dominican Republic), where the disease is endemic, malaria is no longer a major public health concern in the islands of the Caribbean, although the continued presence of important anopheline vectors on several islands provides a potential for outbreaks. In contrast, malaria is a public health priority in the continental countries of Belize, Guyana, and Suriname, as well as in their neighbouring countries in Central and South America. In Guyana, the annual parasite incidence has exceeded that of all other countries in the Americas during most of the 1990s.

Bancroftian filariasis has largely disappeared from the Caribbean region, the major exceptions being Haiti and Guyana. This decline in prevalence can be attributed to improvements in general sanitation in urban areas, which have helped to eliminate important larval habitats of the main vector, the mosquito *Culex quinquefasciatus*.

Undoubtedly the most important vector-borne disease affecting the region at present is dengue. Dengue-like illness has been reported in the Americas for over 200 years. Until the 1960s, most dengue outbreaks occurred at intervals of a decade or more, but since then the intervals have shortened. The first laboratory-confirmed epidemic affected the Caribbean basin in 1963–1964, although prior to that (in 1953–1954) dengue virus had been isolated in Trinidad and Tobago in a nonepidemic situation. Classical dengue and its more serious clinical sequelae, dengue haemorrhagic fever and dengue shock syndrome, are becoming an increasingly serious public health threat in the region. In 1995, information from the Caribbean Epidemiology Centre (CAREC) confirmed that dengue virus was circulating in 16 CAREC member countries. There were epidemics in Barbados, Dominica, and Jamaica, with associated deaths in Barbados and Jamaica.[53] Epidemics are extremely costly in terms of patient care, hospitalization of the most serious cases, and emergency vector control efforts. In addition, epidemics can lead to social and economic disruption for individuals, families, and national economies, especially those based on tourism.

Presently, three of the four dengue virus serotypes are circulating in the Caribbean; the fourth began spreading through Central America in 1995 and seems likely to reach the Caribbean in the near future. The increasing frequency with which dengue haemorrhagic fever and dengue shock syndrome are occurring appears to be associated with the circulation of multiple serotypes.[54]

The hemispheric *Aedes aegypti* eradication campaign successfully eliminated this dengue vector from most of the mainland countries of the Americas during the 1950s and 1960s but was less successful in the Caribbean. Nevertheless, the risk of transmission of dengue (and also of yellow fever, which was transmit-

ted in urban areas by the same mosquito before an effective vaccine became available) was greatly diminished, and the disease appeared to no longer pose a serious health threat. However, with reduced public health expenditures during a period of economic decline, virtually all the countries in the hemisphere became reinfested. Vector densities increased dramatically in the 1970s and 1980s, and there was an associated increase in dengue transmission.

The main breeding habitat of the dengue vector consists of receptacles in the household environment that collect and hold rainwater, including water storage drums, houseplant pots, discarded tyres, and other containers and debris. The traditional vector control programmes of the Caribbean were largely dependent on chemical control through routine larviciding and adulticiding on an island-wide basis. They were organized as vertical programmes, which in most instances are no longer affordable or manageable. Current policy is aimed at developing integrated programmes, using insecticides along with biological control and, especially, breeding source reduction. Community participation is seen as an essential component of this strategy. The involvement of all parts of the health sector, other government agencies, and nongovernmental organizations is also crucial. In the longer term, provision of an adequate and reliable supply of water to all households, improved management of solid waste, and increased awareness and changed behaviours in the general populace are most likely to contribute to a lasting reduction in vector densities.[55,56]

An integrated programme for the control of *Aedes aegypti* in the English-speaking Caribbean countries has been in operation since 1992 with support from the Government of Italy. It relies on a primary health care approach through community participation and health education. The strategy addresses community concerns relating to not only *Aedes aegypti* (the main target) but also other insect vectors, pests, and rodents. So far, 15 countries are participating [57]

Future Directions

In the Caribbean region, as in other parts of the world, there is mounting awareness and concern on the part of governments and communities about the need for the preservation of the environment and the restoration of areas where environmental degradation has commenced. Even when the linkage is not explicitly made, the connection between quality of the environment and human health is obvious.

The field of environmental health goes beyond the traditional regard for cleanliness and sanitation associated with public health at the beginning of the 20th century. It seeks to ensure that people live, work, and enjoy recreation without risk to their health, and that future generations may also do so. Concern for environmental quality has been identified as one of the major trends that is shaping tourism development in the world as a whole, but that concern must be manifested not only by addressing factors that make the destinations safe for tourists but also by paying equal attention to the well-being of the local population.[58]

The steady growth of tourism has provided most of the prosperity that the Caribbean region has experienced. However, there are examples of adverse environmental impacts that already threaten the tourism sector. At the same time, economic exigencies exert a strong pull on governments to rapidly expand tourism. If the Caribbean region is to maintain its preeminence as a tourist destination, there is a need to adopt a tourism development model that is more environmentally friendly and sustainable, so that future generations of Caribbean people will continue to enjoy their heritage.

Environmental health is becoming a priority in sustainable development. The fragile environmental balance of the small islands of the Caribbean and the formerly pristine land masses of the mainland countries bordering the Caribbean Sea has been disturbed. In the areas near some coastal mangrove swamps and tropical forests, the imbalance already endangers the population, exposing large numbers to flooding, landslides, and a contaminated water supply. To prevent the proliferation of such threats, governments and private investors should be required to assess the impact of development projects not only on the environment but on health. There is an urgent need to assemble resources to prevent further deterioration by strengthening existing institutions capable of scientific monitoring, establishing networks within and between countries for measuring levels of pollution, taking action to prevent further degradation, and providing the technical evidence which will allow for successful legal action under existing environmental laws.

PART II: DISASTER MANAGEMENT

Risk in the Caribbean

Not all violent manifestations of nature—earthquakes, volcanic eruptions, hurricanes, floods—neces-

sarily cause disasters. When a disaster does occur, it is not always the exclusive result of the natural hazard itself. What human beings do, or what they fail to do, is a key factor.

A hazard is a phenomenon which, when it manifests itself in a given area over a specific period of time, has the potential to cause severe social disruption, trauma, property damage, and loss of life. The potential impact of a hazard is normally expressed in terms of its magnitude or intensity, and scales describing these properties have been developed for different types of hazards.

Natural hazards of all types exist in the Caribbean basin.* The common ones can be classified by their origin as geological (including earthquakes, tsunamis, volcanoes, and some landslides) and hydrometeorological (including hurricanes, tropical storms, floods, rain-related landslides, and drought). In addition to natural hazards, there is also risk from technological hazards, i.e., those posed by accidents resulting from human activities.

People have always coexisted with natural hazards. What has changed, particularly in the last century, is the extent of the impact hazards have when they hit populated areas. The disaster is the human consequences of the hazard. However, the very same natural hazard, be it a volcanic eruption or a hurricane, can bring about very different effects depending on the vulnerability of the community.

The vulnerability of a building, a population, or a country is measured by how susceptible to harm or loss it is in the face of a specific hazard. For example, a building is at risk during an earthquake when (1) the earthquake (hazard) is strong enough to damage or destroy the building, and (2) seismic-resistant construction techniques were not used (vulnerability) in the design and construction of the building. Consequently, the degree of risk to which a country, a population, or a structure is exposed when confronted with the effects of a hazard depends on both the hazard itself and vulnerability.

*In this section, "Caribbean basin" refers to the area bounded by the islands which fringe the Caribbean Sea, from Cuba in the northwest to Trinidad in the southeast, and by the Caribbean coast of Central and South America. The Bahamas and Bermuda are also included. Twenty-two countries and territories in this geographical area—Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Turks and Caicos Islands—participate in PAHO's Caribbean Emergency Preparedness and Disaster Relief Coordination Programme, based at the Caribbean Programme Coordination Office in Barbados.

Risk is not an abstract concept; it is concrete and measurable. Many countries have designed maps to illustrate their degree of risk. These maps not only mark the areas with the highest probability of occurrence of an event of a certain magnitude, but also point out vulnerable infrastructure in those areas.

Hydrometeorological Hazards

Hurricanes and Tropical Storms

A hurricane is a low-pressure, large-scale weather system ("cyclone") which derives its energy from the latent heat of condensation of water vapor over warm tropical seas. To be classified as a hurricane, a cyclonic storm must have a minimum sustained wind speed of 116 kilometers per hour (km/h) or 74 miles per hour (mi/h). In order to develop, a hurricane requires a sea temperature of at least 26 °C maintained for several days and a large expanse of sea surface (about 400 km, or 200 mi, in diameter) from which to draw energy. A fully developed hurricane may have a diameter ranging from 150 to 1,000 km.[59] More than 4,000 tropical storms have occurred in the last 500 years in the Caribbean, half of which have become hurricanes. This amounts to an average of four hurricanes within the region every year.

The most devastating of all recorded hurricanes occurred between 10 and 16 October 1780. Nearly 20,000 people perished as the storm hit virtually every island, passing from Tobago in the southeast through the Leeward Islands and across to Hispaniola. The death toll was 4,500 in Barbados, 9,000 in Martinique, and 4,500 in St. Eustatius.[59]

According to the Organization of American States (OAS), between 1960 and 1989 hurricanes killed and injured 28,000 persons, altered the lives of another 6 million, and destroyed property valued at close to US$ 16 billion in the Caribbean basin alone.[60] Individual islands are exceedingly vulnerable because of their small size and fragile economies. The destruction caused by hurricanes Gilbert in 1988, Hugo in 1989, and Luis and Marilyn in 1995 to housing, public buildings, and crops is ample testimony to this vulnerability. For example, in Jamaica, 95% of all health care facilities suffered damage as a result of Hurricane Gilbert. The cost of emergency repairs was estimated at US$ 13 million, 55% of which was spent on secondary health care facilities.[61] The cost of restoring these facilities has exacerbated the country's economic difficulties. Even though grants and loans are available for this purpose, the outlay of capital funds

on physical structures in the service sectors of the Commonwealth Caribbean invariably increases recurrent expenditures and produces no additional revenue.[62]

In September 1979, Hurricane David devastated the economy of Dominica. Although this hurricane may be considered a disaster of modest proportions because it caused few fatalities, it left 80% of the population homeless.

The year 1995 proved to be the second most active hurricane season in recent history, producing 19 tropical storms. Hurricanes Luis and Marilyn—which caused severe damage to Anguilla, Antigua and Barbuda, Dominica, Montserrat, Saint Kitts and Nevis, Saint Martin, and Saint Thomas—struck just a week apart.

Tropical storms (wind speeds of 61–115 km/h or 40–73 mi/h) can also prove damaging. Recent examples are Tropical Storm Bret (1993), which caused extensive property damage in Trinidad and Tobago, and Tropical Storm Debby (1994), which devastated Saint Lucia's economically important banana crop.

Floods

Floods are perhaps the most frequent and among the most ruinous types of natural disasters, but they almost never receive the same immediate publicity as an earthquake or hurricane. Almost every country in the Caribbean has been affected by floods, but very little information on their impact is available.

Most of the floods occur as a result of storms during hurricane season (from June to November). Many of the storms that cause floods are not hurricanes but rather tropical depressions or tropical waves. In 1994, Tropical Storm Debby and Hurricane Gordon caused extensive flooding and landslides on several Caribbean islands. The effects of Gordon killed more than 1,100 people in Haiti, showing the dangerous potential of excessive rainfall.

Landslides

The impact of a landslide depends on the specific nature of the event and its origin For example, landslides of hillsides or mountain slopes obviously constitute a hazard to human beings and property, but, in general, they cause damage in a limited geographical area. By contrast, volcano-triggered slides, avalanches, mudflows, and lateral blasts can affect larger areas and cause greater loss of life and property.

Landslides caused by strong rains and flooding are the most common type in the Caribbean. Human activity, particularly deforestation of watersheds and construction of buildings on unstable soil in deforested areas, can result in or aggravate the risk of these landslides considerably. Practically all the hurricanes and tropical storms causing heavy rainfall in the Caribbean have triggered landslides. The risk of landslides is intensified by the mountainous topography of many of the islands, making Dominica, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent, and Trinidad especially vulnerable. Grenada has also experienced large rock falls, in one instance killing the passengers of a bus.

Geological Hazards

Earthquakes

Over the past 300 years, around 40 destructive earthquakes have occurred in the Greater and Lesser Antilles, as well as innumerable low-magnitude quakes. An earthquake's magnitude, or strength, is determined by the amount of tectonic plate movement that occurs and is commonly described using the Richter scale. Its intensity, in contrast, is a measure of the effects it has at a specific site, and the 12-degree Modified Mercalli (MM) intensity scale is frequently used as an indicator.

Wide areas of the Caribbean were seriously affected by an earthquake in 1843 (an estimated 7.8–8.0 on the Richter scale, MM intensity IX) that was centred in the northeastern Caribbean. Heavy damage occurred in Antigua (40 people were killed and English Harbour sank), Montserrat (16 killed), and Guadeloupe, Dominica, and Saint Kitts, where landslides and liquefaction of the soils resulted. In this century, MM IX earthquakes (intense enough to cause panic and generalized serious damage to property and other infrastructure) have affected Jamaica in 1907, Puerto Rico in 1918, and Hispaniola in 1946.[59]

While practically the entire Caribbean is at risk for earthquakes, there are varying degrees of risk for each of the islands. Based on the known effects at past events, the expected length of time between earthquakes of a given MM intensity can be calculated, but the values given must be properly interpreted For example, in Barbados the mean return period for an MM VII (moderate intensity) earthquake is estimated at 50 to 70 years according to available data, but the actual number of years between occurrences of that intensity may be much shorter or much longer

Volcanoes

Fourteen volcanoes in the Caribbean region have been active in the last 10,000 years. In 1902, two major volcanic eruptions occurred almost simultaneously. The tragedy began with the explosion of Mount Pelee in Martinique, resulting in the discharge of a dense emulsion of incandescent lava and boiling gases that ran downhill to the port of St. Pierre. Nearly 30,000 persons were suffocated. Twenty-four hours later, the Soufriere Volcano on the neighboring island of Saint Vincent, 150 km away, erupted in a similar manner, causing the death of 1,500 people. Mount Pelee was active again in 1929–1932, while Soufriere erupted mostly recently in 1979, causing no fatalities but resulting in extensive damage and making communication impossible between the northern and southern parts of the island of Saint Vincent.

The Soufriere Hills Volcano in southeast Montserrat became active in mid-July 1995 for the first time in the historical period. Its activity intensified in April 1996 and continued unabated as of April 1997.[63] A multinational team of scientists stationed in Montserrat has monitored activity of the volcano and provided information to decision-makers.

Everyday activities on the island have suffered significant disruption, especially in the south where both the volcano and the capital, Plymouth, are located. Two-thirds of the island's population and the necessary social services were moved to the north for periods longer than one month on two occasions in 1995 when the volcano's activity increased to such a level that it threatened the safety of the population. In April 1996, the southern part of the island was evacuated once again and the area remains very hazardous. Ash falls have been a major problem, and the population has been advised to wear dust masks.[63]

Even though volcanic eruptions are rare events, site selection of structures must take into account local volcanic hazards, especially since the environs of volcanoes tend to be endowed with extremely fertile soil and are therefore attractive areas for population settlements.

Tsunamis

Tsunamis are caused by earthquakes, volcanic activity, and landslides on the sea floor which generate enormous waves (tidal waves). Because of the length, depth, and velocity of these waves they are difficult to detect and to monitor. About 80% of tsunamis occur in the Pacific Ocean, but there have been significant events in the Caribbean as well. In 1692, 3,000 people were killed by an earthquake and tsunami at Port Royal, Jamaica. Tsunamis resulting from an earthquake off the Virgin Islands in 1867 and the 1918 Puerto Rico earthquake did extensive damage. Tsunamis present a significant threat to island populations living near the shoreline and to coastal inhabitants of countries like Guyana and Suriname, whose coastal areas are below sea level.[60] Tidal waves may also be generated by storms.

Technological Accidents

The Caribbean has been undergoing rapid development in the last 20 years, installing new industries, landing larger aircraft, and using larger quantities of chemicals in agricultural production. These changes, added to the dramatic increase in both the number and size of new construction projects, are exposing the region to a level of risk never experienced before.

The potential consequences of transportation accidents have been magnified by the large numbers of passengers involved. The increase in the number and size of airplanes and cruise ships arriving daily in the Caribbean raises the risk of a high number of casualties that cannot be managed by existing health resources.

The region's new industries entail the production, handling, storage, use, and transport of a broad range of chemical products, many of which can harm the environment and people. Their production is usually restricted to the more heavily industrialized countries such as Guyana, Jamaica, and Trinidad and Tobago, but they are used throughout the region.

Considering the potential damage which accidental exposure to toxic chemicals can cause to human health and the environment, it is essential that all Caribbean countries develop mechanisms for effectively coping with such accidents. Fortunately, no catastrophic accidents have occurred yet in the Caribbean region, but governments will have to confront these potential hazards and try to establish effective plans and precautions. Two recent examples of technological accidents serve to illustrate the dangers.

Chemical Plant Fire in Barbados

In December 1993 an explosion occurred at 6:00 p.m. in a chemical plant where pesticides, deodorants, and plastics were manufactured. At the time of the explosion and immediately after, it was reported that the

disaster management authorities were not informed about the types of compounds and chemicals in use at the plant. The Fire Services did not use water to suppress the fire, which was allowed to burn itself out under surveillance. As a precautionary measure, an area within a one-half mile radius downwind of the site was evacuated. Ten persons were moved to a shelter. Six persons were taken to hospital with symptoms of chest pain and throat irritation; one was detained, while the other five were treated and discharged.

The PAHO Disaster Response Team was activated and a full assessment of the potential hazard was made. The Canadian Transport Emergency Centre (CANUTEC)* was contacted immediately, and relevant information on clinical symptoms and treatment was relayed to the local authorities.

Cyanide Release in Guyana

As a result of a failure in the tailing pond dam in a gold-mining operation, an estimated 3.2 million cubic meters of process water containing 30 parts per million (ppm) total cyanide was released into the Omai Creek over a period of 113 hours in August 1995. The Omai Creek is a tributary of the Essequibo River. The process water contained both copper (below 1 ppm) and ferrous compounds of cyanide. Over a stretch of one mile, this creek was completely poisoned, killing all aquatic life. Due to rapid dilution and breakdown of cyanide in the Essequibo, no acute poisoning of people occurred, nor was there evidence of fish kills or deaths of animals in the river.

The average flow of the river at that time was 14.4 million cubic meters per hour. At the first town downstream (75 miles away), the dilution was calculated to be 1:320, reducing the cyanide level to 0.094 ppm (the WHO limit for drinking water is 0.07 ppm). The Government of Guyana reacted on the basis of a "worst-case" situation and warned inhabitants not to drink the river water or eat fish from the river. Communities were supplied with water from other sources by the mining company. Medical supplies were requested to treat possible cases of poisoning, and the company agreed to provide them. The reports from the area as of 1 September 1995 did not reveal any ill effects on the health of the population.

PAHO staff, government officials, and independent experts visited the area and took their own samples in order to verify the water quality findings. Operations at the mine were initially shut down, but the Government allowed them to resume in February 1996.

The fact that the cyanide spill occurred during the rainy season, when the volume of water in the river was high, prevented it from becoming a major disaster. As Caribbean society continues to become more industrialized, risk will increase if no measures are implemented, simultaneously with development, to reduce the vulnerability of the population, structures, and environment in the region.

Disaster Management in the Caribbean

History

Ways to cope with the hazards inherent to life in the Caribbean basin have been integrated into the culture. For example, the gable-shaped roofs of the traditional houses take into account possible extensive wind load. The shape of these houses was influenced not only by economic factors but also by the simple observations of several generations of residents that these structures were resistant to disasters.

Nevertheless, with the exception of isolated protective measures, such as the "curtain" of trees planted at the edge of St. John's, the capital of Antigua and Barbuda, in order to protect it from the wind, much of the region maintains a fatalistic attitude, accepting hurricanes and other hazards as unavoidable "acts of God." Changing this attitude requires that these phenomena be viewed as destructive natural forces whose impacts can be alleviated by implementing certain disaster management measures.

Since 1979 such a change in attitude about natural hazards has taken place in the Caribbean, triggered by the eruption of the Soufriere Volcano on Saint Vincent and the devastation of Dominica by Hurricane David. These events convinced the highest levels of authority in the Caribbean countries that measures had to be taken to reduce disaster impact in the region. In the aftermath of the disasters of 1979, the United Nations Disaster Relief Organization (now the United Nations Department of Humanitarian Affairs—DHA), together with the Secretariat of CARICOM, the International Federation of Red Cross and Red Crescent Societies, and PAHO/WHO, and with support from bilateral agencies, established the Pan-Caribbean Disaster Preparedness Project Originally conceived as a short-term project focused on preparedness, it ex-

*A Canadian organization providing specialized information on toxic hazards, their control, and the prevention and treatment of poisoning. The advice of CANUTEC is available on a 24-hour basis internationally.

tended its scope (and its name) to include disaster prevention and operated for nine years. This external initiative served as a precursor to a true regional approach, the Caribbean Disaster Emergency Response Agency (CDERA),[60] discussed below in the section on "Response Mechanisms."

Definitions

Disaster management relates to the process of programme planning, preparation for, and response to disasters It includes regular review and evaluation of plans and response mechanisms, and involves prevention, mitigation, and preparedness, defined as follows:[64]

- *Prevention* includes those measures designed to provide complete protection from natural disasters by controlling the effects of natural phenomena.
- *Mitigation* means to act before a disaster occurs to minimize human and material losses. In most instances it is only possible to reduce (mitigate) the impact of a disaster on life or property, rather than prevent it.
- *Preparedness* consists of activities carried out before a disaster strikes aimed at strengthening the capacity for rescue, relief, and rehabilitation. It is a necessary supplement to prevention, which is not a realistic alternative, and mitigation, which, by definition, is incomplete.

Disaster Programme Structure

Until recently, countries sponsored activities related to disaster preparedness but seldom followed up on them. To improve results in that area, some countries (such as the British Virgin Islands) have established a programme with specific objectives and expected results. The activities in these countries are no longer isolated but rather form part of a structure. The results of each meeting, workshop, simulation exercise, etc., are used in subsequent activities. These countries are building on lessons learned and are able to better mobilize their scarce national resources.

Recognition of the complex range of activities in the disaster management field has stimulated countries to establish disaster management programmes, headed by a national disaster coordinator. As a result of continuous efforts, each of the Caribbean basin countries now has a health disaster coordinator. He or she is a staff member of the Ministry of Health who usually works part-time in disaster activities, although some countries have either a full-time disaster management post or a separate disaster management agency.* The trend in the Greater Antilles is towards the establishment of a full-time disaster coordinator position. However, the limited human resources available in the Lesser Antilles will not allow those countries to designate full-time disaster coordinators in the near future. An increasing role for regional organizations such as the OECS is envisioned.

While most Caribbean countries have expenses linked to disaster management activities, very few have specific budgets set aside for disaster management purposes. One exception is Jamaica, where such a budget was established in 1994. The permanent secretaries and the disaster coordinators who attended the June 1994 Health Disaster Coordinator Meeting recommended that all countries establish a small disaster preparedness budget.

Disaster Mitigation

In the 1990s the concept of mitigating the consequences of disasters has taken hold in the Caribbean countries, as elsewhere in the world. An area of particular importance is ensuring that hospitals continue to function following a disaster. To this end, the health sector has been in the forefront of promoting safe building standards, the CARICOM Ministers of Health having sponsored the preparation of the Caribbean Uniform Building Code (CUBiC).[65]

Just as environmental impact assessments are routinely required when a new construction venture is planned, disaster impact assessment studies should be performed to identify the measures needed to reduce disaster vulnerability to an acceptable level. These studies would also review the response capacity of the system in place at the national or regional level and propose amendments if needed.

Vulnerability of Health Facilities. Vulnerability analyses have been carried out on several hospitals in the region, including the Victoria Hospital in Saint Lucia and the Glendon Hospital in Montserrat. After Hurricane Gilbert, Jamaica went a step further by retrofitting the most affected hospitals.[66] In countries

*For example, the National Emergency Management Agency (NEMA) in Trinidad and Tobago, the Central Emergency Relief Organization (CERO) in Barbados, and the Organization for Disaster Preparedness and Emergency Management (ODPEM) in Jamaica.

such as Belize and Saint Vincent and the Grenadines, the hazards which could affect these institutions were taken into account during the design stage.

It is estimated that no more than 5% of existing institutions will be rebuilt within the next five years. In general, the ministries of health and their governments are conscious of the importance of preserving existing capital by making these institutions less vulnerable to disasters. There is increasing recognition that the vulnerability of a building can be reduced progressively. Components such as doors, windows, and roofs, which have a shorter life than the main structure, can be replaced as needed with stronger and more securely fixed products at relatively small incremental costs.[65] However, this exercise demands excellent coordination within the Ministry of Health (among hospital administrators, engineers, and maintenance personnel) and in ministries of public works and of planning.

There is still a need to better identify simple measures which could be implemented at a reasonable cost by the hospital administrator or the ministry of health to reduce vulnerability. The major obstacle is that results from this type of work will only be obvious over the long term.

Vulnerability of Water Facilities. The water supply is among the systems that are most vital and also most vulnerable to the impact of hazards. Water supply is also dependent on power supply. In 1994, the Board of Directors of the Caribbean Basin Water Programme requested that the topic of disaster mitigation be included on their 1995 agenda, which evidences new interest among water authorities in this field.

Disaster Preparedness

National Health Sector Plan. Disaster plans exist in every Caribbean country and territory in the health sector and at the national level. Nevertheless, only a few countries have carried out the essential activity of testing their disaster response plans. The plans frequently fail to clearly identify the specific responsibilities of national agencies, and they are not evaluated regularly by means of drills. Some countries are now discussing the institutionalization of such exercises.

The health sector is usually perceived as being synonymous with the Ministry of Health. There are, however, several institutions or departments directly related to health care which are not under the direction of the Ministry of Health, for example, ambulance services or first-aid centres provided by institutions, private sector corporations, and nongovernmental organizations. Several countries recently began identifying the authority who should oversee the health sector as a whole. The issue is particularly critical in the Lesser Antilles in the event of large numbers of casualties. The national disaster offices are in the process of being designated as the overall managers of the mass casualty disaster plan and would have the authority to mobilize resources under the specific and direct advice of the most senior health official available.

The health disaster coordinator and the national disaster coordinator are often persons at a senior level with substantial leadership experience. This arrangement should facilitate and solidify the relationship between institutions and hence increase the efficiency of the disaster response system by strengthening the cohesion among key response agencies. In most cases, the health disaster coordinator and the national disaster coordinator meet regularly.

Water and Sewerage Sector. Water and sewerage agencies also have difficulties in testing their disaster plans and upgrading them regularly. The threat of the outbreak of cholera in the region has, however, stimulated a very positive reaction from water authorities For example, water quality has been more carefully monitored and chlorination has increased in several places. Difficulties with water distribution in the period following Tropical Storm Debby in Saint Lucia provided evidence of the fragility of the existing system in the event of disasters. On the other hand, countries like Dominica and Saint Vincent and the Grenadines had procedures to quickly supply neighbouring countries with water.

Industry. In the area of the Point Lisas Industrial Estate in Trinidad, there is a concentration of heavy industries, including petrochemical and steel plants, as well as a port facility. A disaster plan for the area has been prepared and is operated by the Trinidad and Tobago Emergency Mutual Aid Scheme, which is a consortium of all of the industries concerned, together with water, electricity, and health authorities, under the chairmanship of the Chief Fire Officer. In the event of a disaster, all industrial resources will be pooled. There is a yearly drill that includes all participants. The plan has recently been reviewed by a committee chaired by the Director of the National Emergency Management Agency.

Health Facilities. Some health facilities have had disaster plans since 1985, but updating of the plans has been irregular. These plans are multisectoral, but

there are frequently conflicting interests in the mobilization of resources, for example, when a fire station has to both extinguish a fire and provide ambulance services with too few human resources.

District Plans. The existing district disaster plans are frequently based on the available health infrastructure in the area, as is the case in Dominica. In some other countries, the police take leadership of the local government in disaster situations. Local community action, based on previous plans, has been shown to be a valuable resource in disaster response.

"Tradewinds." The Regional Security Services (RSS), in coordination with other defence forces and agencies operating in the CARICOM countries, request on an almost yearly basis that a country volunteer to test its national response procedures during a nationwide drill and simulation exercise. This exercise, known as Tradewinds, usually helps the country appreciate the need to simplify and make their response system more precise. The Ministry of Health is one of the greatest beneficiaries of this exercise, which allows for testing of the health sector plan.

Response Mechanisms

At the Regional Level

In the aftermath of hurricanes Gilbert in 1988 and Hugo in 1989, a meeting of CARICOM Heads of Government called on the region to increase its level of organization and cooperation in disaster response. In 1991 CARICOM created the Caribbean Disaster and Emergency Response Agency (CDERA), which is headquartered in Barbados. This regional agency has the following main objectives: to provide emergency relief to any affected participating state; to provide reliable information to governmental and nongovernmental organizations regarding the effects of a disaster; to mobilize and coordinate the supply and delivery of disaster relief to an affected country; to mitigate or eliminate the immediate consequences of natural disasters; and to promote and establish sustainable disaster response capabilities among countries.[60]

CDERA now has several cooperation agreements with other disaster response agencies, including the Caribbean Carriers and Defence Force, among others. PAHO cooperates with CDERA, providing technical advice and assisting the ministries of health of CDERA member countries. The Organization of Eastern Caribbean States has also taken on an increasing role in the disaster management area by nominating a disaster coordinator based in Saint Lucia, who works in collaboration with CDERA.

Improvement of response mechanisms is also taking place among nongovernmental entities. Private companies such as CARILEC (the Association of Caribbean Electrical Companies) and NGOs such as the Red Cross and the Caribbean Council of Churches have developed mutual assistance procedures.

There have also been changes in the way the UN system approaches disasters in the region since the beginning of the Disaster Management Training Programme, a UNDP and DHA joint initiative launched in 1990 to train UN staff. The project emphasizes training in high-risk countries, such as Barbados, the Dominican Republic, and Jamaica. This initiative has boosted cooperation among UN agencies and the donor community. For example, following procedures agreed upon by the group of international agencies with the potential to provide assistance in case of disaster, the UN Resident Coordinator regularly convenes an interagency meeting—at least three times a year—for the purpose of reviewing postdisaster assistance procedures. PAHO participates to assist in the assessment of needs and the coordination of international health assistance.

At the National Level

There are arrangements at the national level to efficiently manage limited existing resources. These procedures are usually integrated into the national disaster preparedness plans. The main limitation of the existing disaster plans is that there is no clear distinction between preparedness activities and operational/response instructions It is rare to find a response plan limited to a precise guide of procedures to be followed in emergency situations, as one might find, for example, in defence force operational manuals. In a number of cases, the contingency and response plans could be improved by being limited to precise instructions and a checklist. The roles of the national and health sector disaster committees need to be reviewed. Other considerations should be dealt with by preparedness or mitigation committees.

Another problem with these plans is that few countries have recognized that the number of persons in the response committees has to be reduced to a minimum. After recent experiences, Saint Lucia has taken steps to reduce the size of its National Disaster Committee. The same type of small decision committee will be implemented in other ministries and institutions.

Supply Management in the Aftermath of a Disaster

In the aftermath of a sudden disaster, the arrival of unsolicited relief supplies can overwhelm national relief authorities. Storage space and means of transportation for supplies are scarce, and technical information on the types and quantities of incoming supplies is often unavailable. The resulting difficulties in utilizing donated goods give donors and the mass media a negative impression of national relief authorities.

To help the countries of the Americas better manage all relief supplies (not just health supplies), PAHO developed a methodology and computer software known as SUMA (for the *SU*pply *MA*nagement Project). Since it was first tested in 1990, SUMA has proved to be a flexible tool for sorting and inventorying large amounts of relief supplies in a short period of time.[67] This computerized system makes it possible to keep national authorities informed of the source, types, and quantities of supplies that arrive following disasters. Its flexibility allows for rapid adaptation to a country's special needs. The system has been put to the test in the Bahamas in the wake of Hurricane Andrew, in Haiti after Tropical Storm Gordon, in Saint Lucia after Tropical Storm Debby, and on several islands after hurricanes Luis and Marilyn. In the Caribbean nearly 300 volunteers, who come primarily from the civil defence and health sectors, have been trained to serve on SUMA teams either in their own or in neighbouring countries.

Disaster Management Regulations and Procedures

In several countries discussions are ongoing on the preparation of draft regulations, norms, and procedures to provide disaster coordinators in the region with the authority they need. At present, most of their authority is derived almost exclusively from personal influence and contacts rather than through their position in the system. There are exceptions to this situation, however, such as the civil defence in Cuba, which has a precise delegation of authority.

Well-established procedures facilitate all facets of disaster management: mitigation, preparedness, and response However, the adoption of procedures that are accepted and implemented by everybody is relatively difficult to achieve, particularly in countries where the line of authority is not clearly established. For example, guidelines may exist pertaining to the water system or simulation exercises and drills, but they are seldom incorporated into the countries' disaster management procedures manuals.

In many countries the only existing legislation on disaster management is that providing emergency powers to the Governor General in case of disaster. Such legislation, which was enacted in the 1960s when most Caribbean countries were not yet independent, is obsolete. Efforts have been made in the Dominican Republic, Jamaica, and Saint Lucia to ensure that adequate legislation is introduced to delegate more authority to the chairperson of the response committee and the disaster coordinator in order to boost the efficiency of disaster management.

Disaster Management Training

In recent years, disaster management training has been integrated into some of the public health, medical, and nursing curricula at the University of the West Indies (UWI). The UWI Faculty of Medical Sciences at the Cave Hill Campus in Barbados, in association with PAHO, the Queen Elizabeth Hospital, and the Barbados Defence Force, organizes an annual intensive course on medical management for disaster situations. The three-week course includes theoretical and practical training in mass casualty management. It may be taken as part of the four-year Doctor of Medicine degree in Emergency Medicine, or participants may attend only the disaster module of the D.M. programme and receive a certificate in disaster medicine after successfully passing the final exams.

The curriculum of the Master of Public Health degree at the UWI Mona Campus in Jamaica has for several years included a module on disaster management, which introduces students to the concept of hazards, vulnerability, risk, emergency management, mass casualty management, and disaster relief, preparedness, and mitigation. Furthermore, during the module the students can test their acquired knowledge in a simulation exercise which starts with response to an immediate postdisaster situation and ends with the elaboration of a health disaster preparedness programme.

The UWI St. Augustine Campus in Trinidad is considering the addition of a fourth year to the curriculum of the Faculty of Engineering that would include disaster mitigation issues.

Conclusion

The world of disaster management has been transformed in the last six years by the introduction of new

concepts (prevention/mitigation), by the adjustment of some ideas about disaster response, and by the increasing number of players in that field. The establishment of precise procedures that are updated regularly is the key to achieving definitive improvement in disaster management. The establishment of testing and certification mechanisms for disaster plans is also essential.

Advances in technology and science can help to protect human lives, property, and activities from disaster. It is hence the daily choices made by the population and institutions which either increase or decrease the actual vulnerability of Caribbean societies to hazards, both natural and manmade. The main challenge for the region is to ensure that all levels of society are better aware of their vulnerability to hazards in order to identify the level of risk that they are willing to accept. It is towards that goal that ministries of health must orient their activities.

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