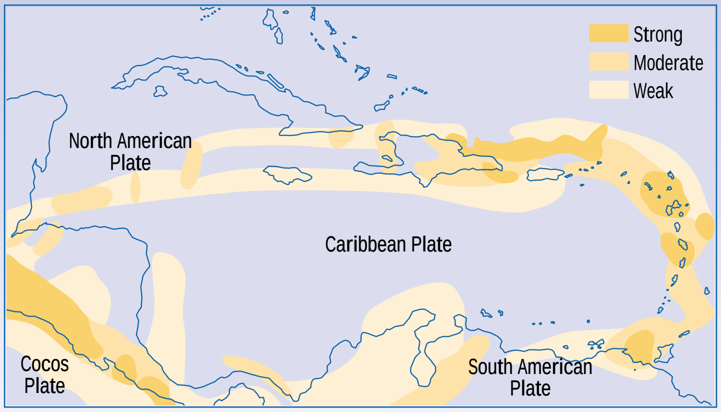
Natural and man-made disasters

The distinctive geological feature of the Caribbean is the Caribbean Plate, which underlies most of the Caribbean Sea (Figure 1.12). The movement of this plate relative to the surrounding crustal plates creates a halo of earthquakes and other tectonic activities which reveal the shape of the plate and the geological processes occurring around its periphery. Stresses along the eastern part of the northern boundary of the Caribbean Plate have caused uplift and subsidence,

Figure 1.12: Caribbean tectonic plate



Source: from Dillon *et al*. (1998)

including the sediment blocks seen at Mona Island between Hispaniola and Puerto Rico and the karst formations along the north coast of Puerto Rico. The volcanic activity of the islands of the eastern Caribbean is caused by subducting Caribbean Plate material melting to form magma which then folds back on itself and wells up through the volcanic islands of the zone (Dillon *et al.* 1988). The environmental effect of all of this seismic and tectonic activity is to create a relatively high risk of earthquake, volcanic and tsunamic activity throughout the insular Caribbean, on top of the already abundant risk of hurricanes and floods.

Disasters are so frequent and so all-encompassing that they are one of the main causes of environmental degradation in the region. The typical pattern of environmental breakdown in the Caribbean is not a steady, even progression: it is the gradual accumulation of small injuries and changes which increasingly compromises the ability of natural systems to respond, but which result in no immediate deterioration in system functioning until the area is hammered by a major disaster. Then, the host systems are unable to recover, and the previous condition is rapidly succeeded by a new regime or ecosystem that is less resilient, less diverse, and less able to provide environmental services such as water purification or sediment trapping.

Most of the islands of the Caribbean lie within the hurricane belt and are vulnerable to frequent damage from seasonally intense weather systems. The distribution of natural hazards such as earthquakes, volcanic eruptions, floods and landslides in the region is a result of the islands' common geologic-tectonic-geophysical framework, and their geographic location within the plate boundary zones of the Caribbean. In the last decade a considerable amount of attention has been given to disaster preparedness, assessment and mitigation in the insular Caribbean, as it is realized that lack of forward planning and failure to address disaster preparedness and mitigation have resulted in massive economic, social and ecological costs.

Since 1983 there have been many major natural disasters in the region – including a succession of major hurricanes (see section 'Shallow-water ecosystems', Box 1.5 and below); the eruption of the Soufriere Hills Volcano in Montserrat (1997), the Piparo Mud Volcano eruption in Trinidad in 1997, and severe drought conditions in Cuba and Jamaica attributed to El Niño (1997–1998).

Hurricane Georges is estimated to have reached a peak intensity of 250 km/h (Category 4) and a minimum central pressure of 937 mb while located about 675 kilometres east of Guadeloupe in the Lesser Antilles. Georges' first of many landfalls occurred at Antigua in the Leeward Islands after moving near or over several other islands including the US Virgin Islands. It then hit Puerto Rico with estimated maximum winds of 185 km/h. Georges weakened very little while over Puerto Rico and was even stronger when it made landfall in the Dominican Republic with estimated maximum winds of 190 km/h. Georges weakened after crossing the mountainous terrain of Hispaniola and made landfall in eastern Cuba with estimated maximum winds of 120 km/h. Georges caused one death and damage estimated at US$5.1 billion.

Hurricane Mitch, the strongest October hurricane ever recorded, formed as a revolving storm in the south-west Caribbean Sea about 580 kilometres south of Kingston, Jamaica, late on 21 October. Three days later it had developed into a major hurricane which began to intensify rapidly. In about 24 hours its central pressure dropped 52 mb – to 924 mb by the afternoon of 25 October. Further strengthening took place and the central pressure reached a minimum of 905 mb about 65 kilometres south-east of Swan Island on the afternoon of 26 October. This is the fourth-lowest atmospheric pressure recorded in an Atlantic hurricane this century (tied with hurricane Camille in 1969), and is the lowest pressure ever observed in an October hurricane in the Atlantic basin. At its peak, the maximum winds were estimated to be 290 km/h – a strong Category Five hurricane. The estimated death toll from Mitch could be as high as 11 000.

The environmental effects of natural and man-made disasters are multiple and complex. Some of the major

Box 1.5: The 1998 hurricane season

The 1998 hurricane season will be remembered as being one of the deadliest in the region's history, and for having the strongest October hurricane on record. It was a very active season with 14 named tropical storms, of which 10 became hurricanes. Three of these were major hurricanes – Category Three, Four or Five on the Saffir/Simpson Hurricane scale. The four-year period 1995–1998 had a total of 33 hurricanes – an all-time record.

Tropical cyclones claimed an estimated 11 629 lives in 1998 – 11 000 of them claimed by Hurricane Mitch in Central America and the Caribbean. Damage runs to many billions of US dollars.

On 25 September 1998 there were four Atlantic hurricanes in progress at once – the first time such an event was observed since 1893.

Summary table

Name	Class	Dates	Maximum wind (km/h)	Minimum pressure (mb)	Damage (US$ millions)	Deaths
Alex	Tropical storm	27 July–2 August	96	1000		
Bonnie	Hurricane	19 August–30 August	185	954	720	3
Charley	Tropical storm	21 August–24 August	113	1000	50	20
Danielle	Hurricane	24 August–3 September	169	960		
Earl	Hurricane	31 August–3 September	161	985	79	3
Frances	Tropical storm	8 September–13 September	105	990	500	1
Georges	Hurricane	15 September–1 October	249	937	5100	602
Hermione	Tropical storm	17 September–20 September	72	999		
Ivan	Hurricane	19 September–27 September	145	975		
Jeanne	Hurricane	21 September–1 October	169	969		
Karl	Hurricane	23 September–28 September	169	970		
Lisa	Hurricane	5 October–9 October	121	995		
Mitch	Hurricane	22 October–5 November	290	905		11 000(1)
Nicole	Hurricane	24 November– 1 December	137	979		

(1) Preliminary estimate

Source: National Weather Service, Miami, Florida

problems experienced in the Caribbean (Potter, Towle and Brower 1995) are:

- physical destruction of resources which are unable to recover because of anthropogenic-induced stresses: principal sources of this destruction include fire, landslides, landslide flooding and flooding from coastal waves;
- destruction of habitats by emergency response operations in the immediate aftermath of a major disaster: coastal areas of small islands are most susceptible here as emergency responses require access to the land, which may have been interrupted by coastal roads being cut off;
- poisoning of resources by pollutants released by the disaster: oil spills, sewage releases, and chemical spills from warehouse and port areas are the major sources of problems here;
- enormous quantities of waste generated by post-disaster clean-up and reconstruction, usually at a time when on-island transportation is slow and difficult: solid and hazardous waste disposal vacilities throughout the region are in a precarious condition, and the consequences include illegal dumping, overwhelming of existing dumps, introduction of toxics to dumps, rupture of existing sealing mechanisms in dumps, and frequently the use of refuse to infill damaged natural areas, especially coastal wetlands such as mangroves and salt ponds.

There are at least three different levels at which disasters threaten the environmental systems of Caribbean islands, and the smaller the island, the more acutely these effects are felt. They are:

- the disaster event itself;
- the impacts of the detritus of the disaster (and its disposal), and
- the acceleration of human impact trends, such as encouraging the in-filling of temporarily damaged natural areas, the replacement of indigenous species and systems with exotic species, and the hardening of shorelines and steep hillsides during reconstruction.

To a great degree, the damage that results from natural disasters is a function of decisions made, activities undertaken and technologies utilized during the process of development. A number of key issues have been identified which illustrate the range of priority concerns.

- lack of disaster preparedness, including zoning of susceptibility in development planning;
- poor mitigation mechanisms for dealing with oil spills and other environmental disasters;
- lack of, or inadequate, building code legislation;
- limited use or knowledge of appropriate building codes and guidelines;
- inadequate administrative arrangements and human resources for the enforcement of building codes;
- unavailability of suitable insurance policies for low-income households, and
- inadequate support systems for affected communities.

At the national level, early warning systems for hurricanes and tropical storms are effective, and the media publicize, well in advance, information on precautionary measures. A number of countries have national disaster response co-ordinating agencies that have mandates to provide precise assessments of damage, and to provide the necessary assistance. There are also disaster-specific institutions such as the Seismic Unit at the University of the West Indies, which monitors earthquakes in the region, and the Montserrat Volcano Observatory (MVO) which monitors the Soufriere Hills Volcano.

Climate change

Climate change represents a threat to the Caribbean region because of the vulnerability of small island ecological and socio-economic systems to climate change, including the impact of sea-level rise. Although climate change is of global concern, there are a number of issues that need to be addressed for the Caribbean. These include:

- the magnitude and rate of climate change in the Caribbean Basin;
- the relative sensitivities of and impacts on ecological and socio-economic systems;
- identification and implementation of viable response options, and
- an effective role for countries of the Caribbean in carrying out regional and international actions.

The majority of capital cities, towns and settlements in the Caribbean have developed in the coastal zone and are susceptible to sea-level rise and its associated impact on living conditions, infrastructure and the economy. Also important are the levels of emission of greenhouse gases in the Caribbean Basin and the comparison of climate trends with model projections of what should have happened with greenhouse gas and aerosol changes to date. It was noted in the International Panel on Climate Change Second Assessment Report that there has been a regional increase in the frequency of some severe events. The report also concluded that there were inadequate data to determine whether consistent global changes in extreme events have occurred over the last century. However, climate models continue to predict more severe climate-related disasters such as storms and floods. It is clear that environmental effects of climate change could include:

- destruction of coral reefs by a combination of inhibited growth from heat stress, over-washing from sea level rise, and increased wave energy from storms. This in turn will expose many coastlines to direct wave action, never before experienced.
- inundation of coastal settlements with multiple impacts on natural systems, including multiple pollution incidents, stemming from sea level rise, increased storm precipitation, and frequency.
- loss of fertile coastal nursery areas in the few remaining fringing mangroves as these are drowned by sea level rise compounded by hardened shorelines immediately inland of these fringes.
- loss of the few remaining salt ponds.
- loss of soft shorelines (especially beaches and mangroves) to construction activities designed to harden other portions of the coast.

Climate change in the Caribbean region will affect the agriculture and water resource sectors, and ecosystems in tidal zones, and fisheries. There are also potential health impacts related to higher temperatures and resultant heat-stress morbidity and mortality, as well as the potential for spread of tropical disease vectors that are temperature limited. Caribbean public health programmes therefore need to be on guard against diseases such as malaria, schistosomiasis, river blindness, dengue, yellow fever and cholera.

Box 1.6: Coral bleaching

The year 1998 was a difficult time for the world's coral reefs due to abnormally high sea surface temperatures. These warm water temperatures caused widespread coral bleaching. The coral animals, polyps, have tiny symbiotic algae called zooxanthellae living inside their tissues. High water temperatures, and sometimes other environmental conditions such as pollution, cause the zooxanthellae to leave the coral. Because the brownish or yellowish colour exhibited by a coral colony is due to the presence of algae in the animal tissues, a bleached coral, devoid of algae, appears white. Bleached coral is still alive, but because it is not receiving the energy it normally would from the tight symbiotic association with the algae, it is not as healthy. Bleached corals do not grow very much, if at all, and usually do not reproduce. If the sea water temperature returns to normal before too much time has passed, the algae will re-colonize the coral animal and the colony will probably recover. However, some coral colonies may die due to bleaching events.

Severe and widely reported coral bleaching took place in the Caribbean region between June and November of 1998. This period was one of higher than average sea surface temperatures. The figure below is a sea surface temperature anomaly, or 'hot spot' map derived from NOAA AVHRR (Advanced Very High Resolution Radiometer) satellite data on 29 September 1998. The coloured areas indicate regions where sea surface temperatures were higher than normal. It has been speculated that coral bleaching is a response to global climate change. There are still not enough data available to assess whether this is the case: however, recent widespread bleaching events world-wide are a cause of concern to reef scientists.

Source: NOAA/NESDIS