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## ***Natural Hazards in the Caribbean***

### **Earthquakes**

Earthquakes are caused by sudden release of slowly accumulated strain energy along a fault in the earth's crust. Earthquakes and volcanoes occur most commonly at the collision zone between tectonic plates. Earthquakes represent a particularly severe threat due to the irregular time intervals between events, lack of adequate forecasting, and the hazards associated with these:

- Ground shaking is a direct hazard to any structure located near the earthquake's center. Structural failure takes many human lives in densely populated areas.
- Faulting, or breaches of the surface material, occurs as the separation of bedrock along lines of weakness.
- Landslides occur because of ground shaking in areas having relatively steep topography and poor slope stability.
- Liquefaction of gently sloping unconsolidated material can be triggered by ground shaking. Flows and lateral spreads (liquefaction phenomena) are among the most destructive geologic hazards.
- Subsidence or surface depressions result from the settling of loose or unconsolidated sediment. Subsidence occurs in waterlogged soils, fill, alluvium, and other materials that are prone to settle.
- Tsunamis or seismic sea waves, usually generated by seismic activity under the ocean floor, cause flooding in coastal areas and can affect areas thousands of kilometers from the earthquake center.

### **Volcanoes**

Volcanoes are perforations in the earth's crust through which molten rock and gases escape to the surface. Volcanic hazards stem from two classes of eruptions:

- Explosive eruptions which originate in the rapid dissolution and expansion of gas from the molten rock as it nears the earth's surface. Explosions pose a risk by scattering rock blocks, fragments, and lava at varying distances from the source.
- Effusive eruptions where material flow rather than explosions is the major hazard. Flows vary in nature (mud, ash, lava) and quantity and may originate from multiple sources. Flows are governed by gravity, surrounding topography, and material viscosity.

Hazards associated with volcanic eruptions include lava flows, falling ash and projectiles, mudflows, and toxic gases. Volcanic activity may also trigger other natural hazardous events including local tsunamis, deformation of the landscape, floods when lakes are breached or when streams and rivers are dammed, and tremor-provoked landslides.

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## **Landslides**

The term landslide includes slides, falls, and flows of unconsolidated materials. Landslides can be triggered by earthquakes, volcanic eruptions, soil saturated by heavy rains or groundwater rise, and river undercutting. Earthquake shaking of saturated soils creates particularly dangerous conditions. Although landslides are highly localized, they can be particularly hazardous due to their frequency of occurrence. Classes of landslide include:

- Rockfalls, which are characterized by free falling rocks from overlying cliffs. These often collect at the cliff base in the form of talus slopes which may pose an additional risk.
- Slides and avalanches, a displacement of overburden due to shear failure along a structural feature. If the displacement occurs in surface material without total deformation it is called a slump.
- Flows and lateral spreads, which occur in recent unconsolidated material associated with a shallow water table. Although associated with gentle topography, these liquefaction phenomena can travel significant distances from their origin.

The impact of these events depends on the specific nature of the landslide. Rockfalls are obvious dangers to life and property but, in general, they pose only a localized threat due to their limited areal influence. In contrast, slides, avalanches, flows, and lateral spreads, often having great areal extent, can result in massive loss of lives and property. Mudflows, associated with volcanic eruptions, can travel at great speed from their point of origin and are one of the most destructive volcanic hazards.

## **Flooding**

Two types of flooding can be distinguished: (1) land-borne floods, or river flooding caused by excessive run-off brought on by heavy rains, and (2) sea-borne floods, or coastal flooding, caused by storm surges, often exacerbated by storm run-off from the upper watershed. Tsunamis are a special type of sea-borne flood.

### **Coastal flooding**

Storm surges are an abnormal rise in sea water level associated with hurricanes and other storms at sea. Surges result from strong on-shore winds and/or intense low pressure cells and ocean storms. Water level is controlled by wind, atmospheric pressure, existing astronomical tide, waves and swell, local coastal topography and bathymetry, and the storm's proximity to the coast.

Most often, destruction by storm surge is attributable to:

- wave impact and the physical shock on objects associated with the passing of the wave front.

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- Hydrostatic/dynamic forces and the effects of water lifting and carrying objects. The most significant damage often results from the direct impact of waves on fixed structures. Indirect impacts include flooding and undermining of major infrastructure such as highways and railroads.

Flooding of deltas and other low-lying coastal areas is exacerbated by the influence of tidal action, storm waves, and frequent channel shifts.

### **River flooding**

Land-borne floods occur when the capacity of stream channels to conduct water is exceeded and water overflows banks. Floods are natural phenomena, and may be expected to occur at irregular intervals on all stream and rivers. Settlement of floodplain areas is a major cause of flood damage.

### **Tsunamis**

Tsunamis are long-period waves generated by disturbances such as earthquakes, volcanic activity, and undersea landslides. The crests of these waves can exceed heights of 25 meters on reaching shallow water. The unique characteristics of tsunamis (wave lengths commonly exceeding 100 km, deep-ocean velocities of up to 700 km/hour, and small crest heights in deep water) make their detection and monitoring difficult. Characteristics of coastal flooding caused by tsunamis are the same as those of storm surges.

### **Hurricanes**

Hurricanes are tropical depressions which develop into severe storms characterized by winds directed inward in a spiraling pattern toward the center. They are generated over warm ocean water at low latitudes and are particularly dangerous due to their destructive potential, large zone of influence, spontaneous generation, and erratic movement. Phenomena which are associated with hurricanes are:

- Winds exceeding 64 knots (74 mi/hr or 119 km/hr), the definition of hurricane force. Damage results from the wind's direct impact on fixed structures and from wind-borne objects.
- Heavy rainfall which commonly precedes and follows hurricanes for up to several days. The quantity of rainfall is dependent on the amount of moisture in the air, the speed of the hurricane's movement, and its size. On land, heavy rainfall can saturate soils and cause flooding because of excess runoff (land-borne flooding); it can cause landslides because of added weight and lubrication of surface material; and/or it can damage crops by weakening support for the roots.
- Storm surge (explained above), which, especially when combined with high tides, can easily flood low-lying areas that are not protected.

**Annual Average Number of People  
Reported Killed or Affected by Disasters**

**by Country, 1970-1994**

<b>Country</b>	<b>Killed</b>	<b>Affected</b>
Haiti	168	219,861
Dominican Republic	84	102,566
Puerto Rico	47	160
Guyana	36	10,859
Cuba	33	65,335
Jamaica	19	54,187
Suriname	7	N.A.
Bahamas	4	N.A.
Dominica	2	3,600
St. Lucia	2	2,944
Martinique	2	1,060
Anguilla	1	N.A.
Belize	1	3,731
Bermuda	1	N.A.
Trinidad & Tobago	0	2,000
Barbados	0	8
Antigua & Barbuda	0	3,000

*Source: World Disasters Report 1996*

<b>Country</b>	<b>Date</b>	<b>Hazards</b>	<b>Comment</b>
Anguilla	02/01/55 05/09/60	Hurricane Hurricane	Alice Donna
Antigua & Barbuda	01/09/50 04/09/60 26/09/66 08/10/74 11/83 16/03/85 17/09/89	Hurricane Hurricane Hurricane Earthquake Drought Earthquake Hurricane	Dog Donna Inez Major Extensive damage to agric sector 6.6 Richter Scale Hugo
Bahamas	26/07/26 26/09/29 29/09/35 14/09/45 18/10/63 09/65 03/10/66 08/92	Hurricane Hurricane Hurricane Hurricane Hurricane Hurricane Hurricane	Devastating Enormous damage In Bimini Heavy damage Flora Betsy Inez Andrew 4 killed
Barbados	22/09/55 10/70 03/08/80 10/83 25/10/84 10/09/31 28/09/55 31/09/61 09/74	Hurricane Floods Hurricane Flood Floods Hurricane Hurricane Hurricanes Hurricane	Janet Entire Island Allen Speightstown Widespread 1,500 killed Janet Hattie Carmen & Fifi
Belize	09/78 12/79 17/05/82	Floods Fire	Greta - 5 deaths, 6,000 affected Torr, rains Belize City
Bermuda	12/10/48 01/86 25/09/87	Hurricane Tornadoes Hurricane	Heavy damage 5 parishes Emily
British Virgin Islands	1932 23/05/69 07/09/70 04/83 11/84	Hurricane Flood Flood Flood & rains Tropical Storm	Tortola damaged 19" rain recorded Heavy damage Heavy damage

## **Major Disasters in the Caribbean: 1899—1989**

<b>Country</b>	<b>Date</b>	<b>Hazards</b>	<b>Comment</b>
Cuba	20/10/26	Hurricane	600 killed
	09/11/32	Hurricane	2,500 killed
	28/09/35	Storm Surge	Many fatalities
	18/10/44	Storm	--
	21/09/48	Hurricane	Heavy Damage
	05/10/48	Hurricane	--
	04/10/63	Hurricane	Alma
	06/06/66	Hurricane	Flora
	30/09/66	Hurricane	Inez
	13/10/68	Hurricane	Gladys
	19/02/76	Earthquake	--
	06/77	Floods	Eastern area
	11/02/78	Storm	Gale
	03/06/82	Hurricane	Alberto
	Feb/Mar/83	Rains/floods	10 weeks of Torrential rains
	25/05/85	Heavy rains	+ tornadoes
	18/11/85	Hurricane	Kate
	06/86	Floods	+ landslides
	08/87	Fire	--
	26/05/88	Flood	20 killed, 90,000 affected
28/05/90	Flood	6,000 affected	
06/02/92	Flood	9,127 affected	
25/05/92	Earthquake	7 Richter Scale,000 affected	
Dominica	04/03/03	Earthquake	--
	16/02/08	Earthquake	Slight damage
	04/02/35	Earthquake	--
	21/05/46	Earthquake	7.0 Richter scale
	25/09/63	Hurricane	Edith
	08/79	Hurricanes	David & Frederick
	09/10/84	Hurricane	--
	09/03/86	Earthquake	--
	9/89	Hurricane	Hugo
Dominican Republic	03/09/30	Hurricane	2,000 killed
	02/10/63	Hurricane	Flora
	08/64	Hurricane	Cleo
	04/65	Forest Fire	--
	29/09/66	Hurricane	Inez
	1968	Drought	Nationwide
	27/04/79	Floods	N/N-E areas
	08/79	Hurricanes	David & Frederick
	May 81	Floods	Heavy rains
	12/02/83	Forest fire	--
	29/05/86	--	--
	02/09/87	Hurricane	Emily
	08/88	Flood	1,191,150 affected

Country	Date	Hazards	Comment
Grenada	1955 03/09/63 27/04/90	Hurricane Hurricane Fire	Janet Flora --
Guadeloupe	12/09/28 11/08/56 06/10/63 22/08/64 27/09/66 20/08/70 30/08/76 16/03/85	Hurricane Hurricane Tropical Storm Hurricane Hurricane Tropical Storm Volcano Eruption Earthquake	Betsy Helena Cleo Inez Dorothy Mt. Soufriere 6.6 Richter scale
Guyana	07/71 18/11/78	Floods Accident	21,000 affected 900 killed, Jonestown Massacre
Haiti	12/11/09 12/08/15 21/10/35 27/10/52 12/10/54 03/10/63 14/11/63 24/08/64 29/09/64 1968 07/08/72 1974-75 1977 31/08/79 11/05/80 05/08/80 1980-81 20/05/85 16/05/86 01/06/86 03/06/86 Apr-Oct 86 23/10/86 10/07/87 12/87 11/09/88	Hurricane Hurricane Hurricanes Earthquake Hurricane Hurricane Floods Hurricane Hurricane Drought Fire Drought Drought Hurricane Fire Hurricane Drought Floods Fire Floods Floods Floods Fire/floods Floods Heavy rains Flood Hurricane	150 killed 1,600 killed Jeremie & Jacme 6 killed Hazel Flora 500 killed Cleo Inez 210,000 affected Port-au-Prince N/W Peninsula countrywide David 10,000 affected Allen S/W area 40,000 affected 3,300 homeless Extensive Damage Heavy rains + Emergency 100 homeless Extensive damage 3,000 affected Gilbert: 54 dead, 870000 affected

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Jamaica	10/08/03 14/01/07 04/11/09 12/11/12 23/11/37 18/11/40 20/08/44 17/08/51 03/10/63 1968 17/10/73 25/04/79 06/79 05/08/80 11/11/85 15/05/86 30/10/87 12/09/88 21/05/91	Hurricane Earthquake Flood Hurricane Flood Flood Hurricane Hurricane Hurricane Drought Tropical storm Floods Floods Hurricane Hurricane Floods Floods Hurricane Floods Floods Hurricane Flood	Heavy damage 1,200 killed 53 killed Heavy damage 111 killed 125 killed 26 dead Charlie Flora Nationwide Gilda Western area Widespread Allen Kate Islandwide Tropical Storm Gilbert (49 killed, 810,000 affected) 550,000 affected
Martinique	08/05/02 08/08/03 16/02/06 17/04/14 26/09/9 02/09/51 19/03/53 10/07/60 25/09/63 07/09/67 20/08/70 08/79 04/10/90	Volcano eruption Hurricane Earthquake Earthquake Earthquake Hurricane Earthquake Hurricane Hurricane Hurricane Tropical storm Hurricane Hurricane	Mt. Pelee 40,000 killed Heavy damage -- -- -- Crops destroyed Building damage Abby Edith Buelah Dorothy David Klaus 6 killed, 1,500 affected
Montserrat	28/08/24 12/09/28	Hurricane Hurricane	Heavy damage Heavy damage
Martinique	12/12/34 10/11/35 16/03/85 17/09/89	Earthquake Earthquake Earthquake Hurricane	Building damage Building damage 6.6 Richter scale Hugo
Netherland Antilles	Aug 1899 01/09/50 04/09/80	Hurricane Hurricane Hurricane	Heavy damage Dog Donna



<b>Country</b>	<b>Date</b>	<b>Hazards</b>	<b>Comment</b>
Puerto Rico	Aug 1899 06/09/10 11/10/18 24/10/18 23/07/26 13/09/28 10/09.31 08/32 12/08/56 08/60 1989	Hurricane Hurricane Earthquake Earthquake Earthquake Earthquake Earthquake Earthquake Earthquake Hurricane Hurricane	6,000 killed San Juan damaged Extensive damage Deaths/damages Deaths/damages Deaths/damages Deaths/damages Deaths/damages Deaths/damages Donna Hugo
St. Kitts (Saint Christopher) and Nevis	13/09/28 12/50 02/10/55 1984 16/03/85 05/87 17/09/89	Hurricane Earthquake Hurricane Floods Earthquake Flood Hurricane	Heavy damage Heavy damage Alice In Basseterre 6.6 Richter scale -- Hugo
St. Martaen/Saba	30/12/54 04/09/60	Hurricane Hurricane	Alice Donna
St. Lucia	16/02/06 21/05/46 19/03/53 10/07/60 25/09/63 07/09/67 03/08/80 08/83 08/09/86	Earthquake Earthquake Earthquake Hurricane Hurricane Tropical Storm Hurricane Storm Tropical Storm	Extensive damage Building damage Building damage Abby Edith Beulah Allen Gale force winds Danielle
Saint Vincent and the Grenadines	08/05/02 17/07/02 17/09/06 26/09/28 21/05/46 19/03/53 23/09/55 08/09/67 17/10/71 13/04/79 03/08/80 08/09/86 21/09/87	Volcanic Eruption Earthquake Earthquake Earthquake Earthquake Earthquake Hurricane Tropical Storm Volcanic Eruption Volcanic Eruption Hurricane Trop Storm/Flood Hurricane	Mt. Soufriere (1,565 killed) Buildings damaged -- -- -- Buildings damaged Janet Beulah Mt. Soufriere Mt. Soufriere Allen Darrielle Heavy damage Emily
Suriname	01/08/69	Floods	4,600 affected

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Trinidad & Tobago	31/01/04 26/03/15 24/02/18 04/12/54 27/06/33 30/09/63 14/08/74	Earthquake Earthquake Earthquake Earthquake Hurricane Hurricane Tropical Storm	Building damage Building damage Building damage Building damage Heavy damage Flora Alma
Turks and Caicos Islands	20/11/85 21/09/87	Hurricane Hurricane	Kate Emily
US Virgin Islands	Aug 1899 Aug 1899 01/10/01 22/08/09 14/07/16 21/08/16 09/10/16 28/08/24 12/09/28 10/09/31 26/09/32 07/05/60 01/03/69 05/70 10/70 1989	Hurricane Hurricane Hurricane Tropical Storm Hurricane Hurricane Hurricane Hurricane Hurricane Hurricane Hurricane Flood Flood Flood Flood Hurricane	Heavy damage and major flood surge Heavy damage to St. Thomas Damage to St. Croix Major flooding Damage to St. Croix Heavy damage Heavy damage Heavy damage Heavy damage Heavy damage Heavy damage Heavy damage Heavy damage to St. Thomas Heavy damage Heavy damage Extensive damage to St. Thomas Hugo

*Source: Disaster Information Kit for the Media (ver 05/95)* Data based on records available from:

1. OFDA Disaster History: “Significant Data On Major Disasters Worldwide, 1900 - present of June 87”
2. PCDPPP’S “Caribbean Disaster News,” issues Nod. 1-11 (1984-present)
3. PCDPPP Documentation Centre, 1988
4. UNDRO’s computerized list of situation/information reports (“sitrep.Prints”)
5. World Map of Natural Hazards, Muenchener Rueckversicherungs Gesellschaft, 1978