CHAPTER II

TROPICAL CYCLONES AND ASSOCIATED STORM SURGES

Introduction

In recent decades people throughout the world have become increasingly alarmed by reports indicating that natural disasters are becoming more and more devastating. To a large degree this is because they are affecting ever larger concentrations of population, and increasing physical developments are more at risk. By their severity, size, frequency of occurrence and vulnerability of the extensive areas they affect, tropical cyclones and associated phenomena are among the worst natural hazards causing sudden-onset disasters. They bring strong winds and torrential rainfall and associated storm surges, floods, tornadoes and landslides. Every year several of them cause social and economic setbacks, loss of life, human suffering, destruction of property, environmental degradation and severe disruption of normal activities. Such impacts, when beyond the ability of a society to cope using its own resources, are classified as disasters. The worst of these disasters are widely reported by the media.

People are not currently able to prevent the occurrence of tropical cyclones. On the other hand, substantial progress has been made in understanding their scientific aspects and in society's ability to warn those threatened by their impacts. Measures have been identified which can substantially reduce their harmful effects. A particularly important aspect of this phenomenon, as distinct from most other natural hazards, is the worldwide availability of organized warning systems as a basis for preventive action, e.g. evacuation.

Thus lack of understanding of the dangers posed and of actions that can be taken — a fatalistic attitude and complacency — can become more potent foes than inadequacies in the ability of society to cope with the threats posed by tropical cyclones.

In an attempt to alter attitudes and change reactions to natural disasters, the United Nations General Assembly designated the 1990s as the International Decade for Natural Disaster Reduction (IDNDR) during which, for the first time, a globally concerted effort would be made to reduce the disasters caused specifically by tropical cyclones, floods, landslides and storm surges, as well as other natural hazards. Information on the IDNDR as it relates to tropical cyclones is given by the World Meteorological Organization (WMO) (1990) and complementary information is contained in Smith (1989).

In this chapter, emphasis will be placed on describing the nature of tropical cyclones and associated phenomena, their impact, the warning systems and the reduction of and response to the disasters cyclones cause, as related to tourist interests.

The nature of tropical cyclones and associated storm surges

Tropical cyclone formation, development and decay

There are always clusters of clouds over the tropical and sub-tropical oceans around the globe. When one of these clusters occurs simultaneously and at the same location with several other prerequisite conditions — which are not individually rare events — a tropical cyclone will form. The conditions for cyclone formation and development include sea-surface temperatures above 26° Celsius, high relative humidity from the surface upwards to about six kilometres, spiralling inflow of winds at low level and divergent outflow winds aloft (see Figure 1). About 80 tropical cyclones form annually, mostly during the summer or autumn months, over the ocean areas as shown in Figure 2. Thus there is a seasonal aspect to tropical cyclones. On average, the lifespan of a tropical cyclone is of the order of a week to 10 days.

Tropical cyclone structure and terminology

A tropical cyclone is the generic term for a wind storm of tropical origin with an organized rainfall pattern. When it becomes mature or intense it covers an area some hundreds of kilometres in diameter, with warm temperatures and very low atmospheric pressure at its centre, where an "eye" will form. The "eye" will be a relatively cloud-free or rain-free area of light winds with a diameter of a few tens of kilometres, surrounded by a wall of clouds, torrential rainfall and the strongest winds. As the cyclone intensifies and sustained wind speeds exceed 118 kilometres per hour (33 metres per second), it will be called a hurricane in the western hemisphere and South Pacific, a typhoon in the western North Pacific and a severe tropical cyclone or just a tropical cyclone in other regions. A picture of a tropical cyclone as photographed from outer space by a meteorological satellite is shown in Figure 3, while schematic diagrams showing the wind and other features are given in Figures 4 and 5. Tropical cyclones differ in origin, structure and other respects from extra-tropical cyclones, winter storms and monsoon storms.

Tropical cyclone motion

In broad terms it may be said that tropical cyclones move in the direction and at the speed of the environmental winds or steering current, at speeds of up to a few tens of kilometres per hour. Some frequent tracks are indicated in Figure 2. However, when the steering current is light or changing, the cyclones may move erratically, with tracks showing sudden changes in direction or even loops (see Figure 6). The speed and direction of motion of a cyclone should not be confused with its wind speed. The cyclone's direction of motion determines its track, while its speed determines the length of time before its centre reaches a location along its path (see Figure 4). Its wind speed indicates its potential for doing wind damage.

Identification

The assignment of names or other identification to cyclones greatly facilitates communication in the warning system and also in describing past events. This is elucidated by WMO (1993). Briefly, by regional agreement, people's names are used in the western and southern hemispheres while sequential numbers, denoting also the year of occurrence, and letters to indicate the area of formation, are used elsewhere. Additionally, some countries give local names to cyclones.

Impact

Not all tropical cyclones move on shore to land areas, but several of those that do cause disasters of varying severity in tourist areas. The most costly damage occurs in vulnerable areas with substantial developments and the greatest loss of life takes place at the community level in countries where mitigation arrangements are weakest. The following examples are given to show the extent — albeit in a much wider area than tourism — to which severe tropical cyclones have caused major disasters in vulnerable areas. To take two extreme cases; a single tropical cyclone killed about 300 000 people in Bangladesh in November 1970, and in 1992 hurricane Andrew caused over US$ 25 000 million damage in the United States. Other recent examples include cyclone Alibera in 1990, which wrecked virtually all the buildings in Mananjary, Madagascar, while typhoon 9025 took 500 lives and caused losses of more than US$ 350 million in the Philippines. Demolition of a building and extensive damage to a city by severe cyclones and associated phenomena are illustrated in Figures 7 and 8. For tourism the major concerns are the threat of loss of life and the destruction of tourism plant and infrastructures. Much of the environmental degradation, such as beach erosion and destruction of flora and fauna caused by tropical cyclones, is also of direct concern to tourism interests.

The length of time during which a location which is directly hit by a tropical cyclone (that is, the "eye" of the cyclone passes over that location) will suffer from strong winds and adverse sea conditions may vary from a few hours to more than a day. Heavy rainfall may continue for several days.

The destructive forces

The classifications of tropical cyclone intensity around the globe are all directly related to wind speed. In most regions, a wind speed reaching 62 kilometres per hour (17 metres per second), or more is a necessary condition for a weather system to be called a tropical cyclone. There is no specific upper limit to wind speed. Much damage can be done by strong winds (see Figure 8). The wind force is related to the square of the wind speed. if the wind becomes twice as strong, its potential for doing damage becomes four times greater. The Saffir Simpson hurricane scale which is used in the United States and which describes the effects of hurricanes of different intensities is given in Table 1.

The disasters attributed to tropical cyclones are caused not only by wind but also by torrential rainfall, lightning and the associated phenomena: storm surges, floods, tornadoes and landslides. Indeed, as a cause of death, wind ranks third, behind storm surges and floods.

Storm surges. Everyone is familiar with the fact that strong winds create high waves over the open oceans and also, but to a lesser extent, over coastal waters. Some of the highest ocean waves are generated by tropical cyclones. In severe cyclones waves of 10 metres are not unusual and, less frequently, wave heights may exceed 15 metres. In addition, factors such as very strong on-shore cyclone winds, a gently sloping ocean floor profile along the coast, and extremely low barometric pressure near the centre of the cyclone, can combine to produce a storm surge, which is a rapid rise in sea-surface level near the area of strongest wind as it approaches the coastline. In areas where the astronomical tide range is large, the storm tide will be much larger if the surge occurs at the time of high tide. Such was the case with the Bangladesh cyclone of April 1992, which produced a record-breaking storm tide of about seven metres. Storm tides may also be aggravated by other factors such as occurrence in an estuarine region at the same time as a river flood, or in a bay.

The storm tide and the superimposed waves may flood beaches and coastal areas and even spread some distance inland if the topography allows. Some small islands and escape routes may be completely submerged. Historically, the greatest loss of life from tropical cyclones has occurred from storm tides in low-lying coastal areas. Figure 7 shows a picture of an apartment building before the impact of a storm tide and another of the remnants afterwards. It is reiterated that storm tides and sea action can pose the greatest threat to life for tourists in low-lying coastal areas. It is therefore of vital importance that official tropical cyclone warnings, particularly those related to storm surges and official advice on evacuation be heeded.

Other associated phenomena.

The heavy rainfalls in tropical cyclones frequently cause floods or flash floods when the cyclone moves over land. The total rainfall at a location in its path is usually greater for slow-moving cyclones, as the rainfall duration is longer. Tornadoes occur most frequently in the midwest United States in spring and early summer. However, many tornadoes have been generated in association with tropical cyclones, particularly in the southern United States and some neighbouring areas. A tornado usually appears as a funnel-shaped extension from the parent cloud to the ground, where its path may be only about half a kilometre wide and some kilometres long. However, its whirling winds at speeds of some hundreds of kilometres per hour can cause almost complete destruction along its path. The greatest risk of tornadoes associated with tropical cyclones occurs when the cyclone is making landfall. Landslides associated with tropical cyclones result from the high rainfall amounts.

Trends

Statistics on the climatology of tropical cyclones have shown an increase in the annual number forming. The Intergovernmental Panel on Climate Change has recorded the view that these increases are predominantly artificial, however, and result from better monitoring procedures; furthermore, available records do not suggest that a change to more intense cyclones are a result of climate change.

There are occasionally large variations from year to year and even from decade to decade in the numbers of tropical cyclones and in their preferred paths in specific regions. These departures from the averages have been shown in some regions to be fluctuations related to specific meteorological parameters. Periods with fewer numbers of tropical cyclones than the average may

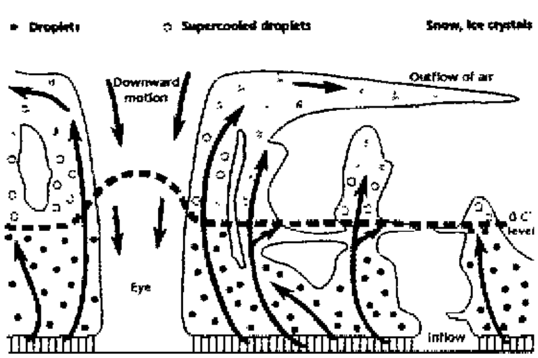

Figure 1 — Schematic cross-section of wind flow in a tropical cyclone — looking horizontally.

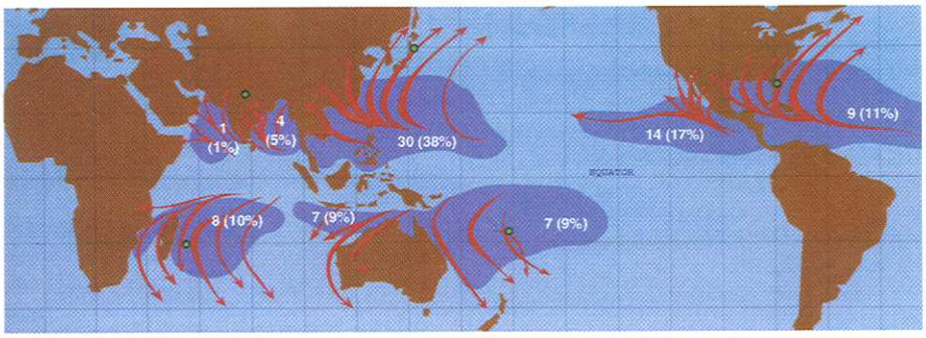

Figure 2 — Frequent tracks and annual average numbers of tropical cyclones.

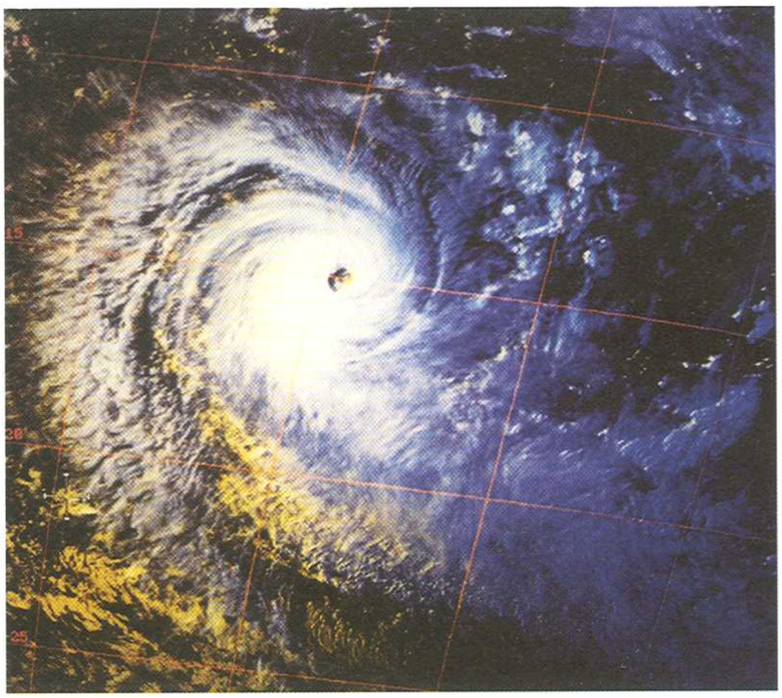

Figure 3 — Imagery from a Japanese geostationary meteorological satellite of two typhoons in the northern hemisphere. White areas are clouds spiralling anti-clockwise inwards to the eye (black dot).