Tonga Meteorological Service – Ministry of Civil Aviation

TROPICAL CYCLONE INFORMATION

INTRODUCTION

Tropical cyclones are known around the world by various names: hurricanes in the Atlantic and Caribbean, typhoons in the North-West Pacific, baguios in the Philippines, cordonazos in Mexico, tainos in Haiti and tropical cyclones in the South-West Pacific (including Tonga)

DEFINITION

A tropical cyclone is essentially a rotating storm in the tropical oceans. In the South West Pacific (including Tonga) it is defined as a circular system with clockwise rotating 10-minute average wind speeds in excess of 34 knots (1 KNOT = 1.85 KM/HR).

The life span of a tropical cyclone is, on average, about six to nine days until it enters land or re-curves into cooler latitudes, but this may vary from a few hours to as much as three to four weeks.

Tropical cyclones form in the oceans between 5 to 30 degrees north and south of the equator. They are found in all oceans of the world, with the probable exception of the South Atlantic and the South Pacific east of 140 deg. West longitude.

No two tropical cyclones follow the same track; some re-curve, some do not; some loop; some slow to a standstill and some will accelerate. The movement of a tropical cyclone is generally 12 knots or less. In the South West Pacific cyclones tend to move generally in the southeast direction.

TROPICAL CYCLONE INTENSITY CLASSISFICATION

Classification of tropical cyclones differs according to Region. In the South West Pacific (including Tonga) the classification is as follows:

Description	Speed Range (knots)
Tropical Depression	Less than 34
Tropical Cyclone	34+
Tropical Cyclone (Gale)	34 – 47
Tropical Cyclone (Storm)	48 – 63
Tropical Cyclone (Hurricane)	64+

WHAT CAUSES A TROPICAL CYCLONE

Cyclones are born in the hot, humid summer environment of the tropics (November to April in the South Pacific). As the sun warms the oceans, evaporation and conduction transfer heat to the atmosphere so rapidly that air and water temperatures differ by a very small amount. The water vapor generated by such evaporation is the fuel that drives a tropical cyclone, because as the vapor condenses into clouds and precipitation it pumps enormous amounts of heat into the cyclone. The fuel supply is controlled by the evaporation rate which explains why cyclones cannot develop when the ocean temperature is below 26°C.

Another ingredient that must be present for formation is the Coriolis force or spin (The Coriolis effect is the force caused by the earth's rotation that deflects a moving body to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.) This force is zero at the equator. This is why cyclones cannot form right on the equator. In the South Pacific, cyclones normally form between 5 and 15 degrees south.

In order for a cyclone to get going also there is a need for a jet stream (high velocity wind) to be present in the upper atmosphere. This is so it can remove the top layers at a rate as to allow more energy to be fed into the lower levels.

FREQUENCY AND DURATION

Tropical cyclones are a seasonal phenomenon (November to April in the South West Pacific) with an average frequency of 1 tropical cyclone per season in Tonga. The average number of tropical cyclones that affect the Southwest Pacific per season is 8-10.

EFFECTS OF A TROPICAL CYCLONE

PHYSICAL EFFECTS

STRONG WINDS

High winds are the most common and visual effects of cyclones. High winds usually cause damage to structures and vegetation (including agriculture).

FLOODING

High winds are, of course, only a part of the problems that are brought by cyclones. Devastating floods from extremely heavy rainfall often accompany tropical cyclones. Flash floods of great volume and short duration may result from the cyclone's rain, especially in hilly or mountainous terrain.

Flood flows frequently contain large concentrations of sediment and debris.

Tidal floods can also be caused by the combination of waves generated by cyclone winds and flood runoff resulting from the heavy rains that accompany cyclones. These floods may extend over large distances along a coastline. Their duration is usually short, being dependent upon the elevation of the tide, which rises and falls twice daily.

STORM SURGES

In many major tropical cyclone disasters, storm surge is frequently a key factor. As the cyclone approaches the coastal area, strong on-shore winds can cause a rise of several meters in sea level; the result is water crossing the coast and flooding large areas of the interior. The factors that combine to cause a storm surge are partly meteorological and partly hydrographic, including the state and nature of the tide and the topography of the sea bed in the vicinity of the coast. The following are some major factors contributing to a storm surge:

- A fall in atmospheric pressure over the sea surface: in the center of a tropical cyclone the atmospheric pressure is much less than outside the storm. For each one millibar difference in air pressure, the mean water level in the storm will rise approximately one centimeter. Since the difference in atmospheric pressure rarely exceeds 100 millibar, the maximum rise in mean sea level due to this effect is about one meter (three feet).
- The effect of wind: as the winds strengthen they will have more effect on the water, causing waves, swells, and storm surges. While the storm is some distance from the coast, however, countercurrents beneath the ocean surface may offset any tendency for the winds to cause a storm surge or a net rise in the level of the sea.
- The influence of the sea bed: as the storm approaches a coast, especially one in which the sea bed slopes gradually, friction at the bottom of the sea will interfere with the return water currents and the wind effect will pile up water along the shore. This combination of strong winds and a gently sloping sea bed can result in very high storm surges.
- A funneling effect: a semi enclosed bay in the path of the high water permits the storm's winds to pump additional water into the bay and trap it there for extended periods until the water level inside the bay is considerably higher than along the open coast.
- The angle and speed at which the storm approaches the coast: this also affects the height of the surge. In general, the greater the forward speed and the more nearly perpendicular the track is to the coast, the higher the surge will be. However, the storm surge can also be dangerous in a severe storm that is moving either parallel to the coast or moving forward very slowly.
- The tides: in some countries the semi-diurnal tide has amplitude of a few meters and shows some variation with the season of the year. In such regions there is a large difference in the maximum water height if the storm surge comes on the high tide rather than on the low tide. If landfall of a tropical cyclone coincides with the maximum of the "spring tides," the resulting surge can be devastating, particularly if in the normal "high tide" the water is almost high enough to cover portions of the coast.

Countries most vulnerable to storm surges are those that experience the more severe tropical cyclones and have low-lying land along the closed and/or semi-enclosed bays facing the ocean. It has been the scene of storm surges that have caused heavy loss of life and extensive damage in the countries whose coastlines have been affected. These countries have therefore established elaborate protective measures and warning systems for storm surge.

IMMEDIATE EFFECT

The most serious immediate consequence of cyclones is the loss of human lives. It is estimated that from 1960-1970, 17 major storms in various parts of the world killed about 350,000 people, most from drowning. The death rate is significantly higher where communications are poor and warning systems and evacuation plans are inadequate. Furthermore, the number of deaths will increase as population pressures force people to inhabit more vulnerable areas, such as low-lying agricultural areas or overcrowded urban slums.

The most dramatic impact of cyclones is the damage they cause to houses and other physical structures. In addition to damaging homes and buildings, cyclones destroy or damage critical facilities, supply lines, crops, and/or food stocks. They disrupt economic activities and create financial burdens. They may destroy or damage facilities that are critical not only for responding to disasters, but also for maintaining a safe environment and public order. Among these are communications installations; electrical generating and transmission facilities; water storage, purification, and pumping facilities; sewage treatment facilities; hospitals; police stations; and various other public and private buildings.

Cyclones disrupt agriculture and destroy crops. High winds destroy some standing crops, especially grains, and damage orchards and forests. Flooding from intense rains damages certain crops, especially tubers, and may cause excessive erosion. Storm surges scour and erode top soils; deposit salts on fields, and may increase salinity in subsurface water. Furthermore, access to markets for buying and selling agricultural produce may be impeded by damage to roads, bridges, railways, etc.

Cyclones disrupt economies. Consequences of the disaster include the loss of investments and jobs, for example, destruction of or damage to factories; production losses that result from the destruction of harvests or crops; the death of livestock; the closure of shops, small businesses, and industrial production units, etc. During the emergency, people must leave their jobs and devote their time to disaster-related activities such as search-and-rescue or caring for survivors. During this period, normal economic activities are severely curtailed even if the sources of employment are unaffected by the cyclone. Persons (such as subsistence farmers, urban squatters, fishermen, and others) who were participating only marginally in the economy before the cyclone will be affected most severely by the economic losses. After a cyclone, it is not uncommon for many small enterprises to fail.

In addition, the cost of relief and reconstruction creates a financial burden on the government. Increased expenditures for preventive and curative medicine, aid to the unemployed, and repair or replacement of housing are required, at a time when there is a decrease in public resources due to an overall decrease in economic activity and tax receipts.

LONG TERM EFFECTS

Cyclones also cause indirect and secondary effects that can have a far-reaching, long-term impact on a country. Fundamental changes may occur in the lifestyles of the people as well as in the basic direction in which the society had been moving prior to the disaster. Disaster-induced changes occur because disasters create a climate wherein changes in society (including land use, agricultural, economic, political, geographic and housing patterns) are more acceptable--or even demanded.

Cyclones can significantly retard the long-term economic growth of smaller countries like Tonga. Indirect and secondary effects on the local and national economy may include reduction in family income, decline in production, inflation, unemployment, and decline in national income.

In some cases, poorly-conceived relief efforts can recreate vulnerable conditions. For example, many relief agencies rush to initiate housing reconstruction projects after a cyclone. Yet many have no experience in the housing sector and do not know how to build safe houses. Scores of housing programs systematically rebuild each year thousands of structures that are more dangerous than the houses they replace.

Finally, relief and reconstruction efforts compete with development programs for available funds. In countries where cyclones occur frequently, they can create an enormous financial burden.

VULNERABLE COMMUNITIES

The vulnerability of a human settlement to a cyclone is determined by its siting, the probability that a cyclone will occur, and the degree to which its structures can be damaged by it. Buildings are considered vulnerable if they cannot withstand the forces of high winds. Generally those most vulnerable to cyclones are light-weight structures with wood frames, especially older buildings where wood has deteriorated and weakened the walls. Houses made of un reinforced or poorly-constructed concrete block are also vulnerable.

Urban and rural communities on low islands or in unprotected, low- lying coastal areas or river floodplains are considered vulnerable to cyclones. Furthermore, the degree of exposure of land and buildings will affect the velocity of the cyclone wind at ground level, with open country, seashore areas and rolling plains being the most vulnerable. Certain settlement patterns may create a "funnel effect" that increases the wind speed between buildings, leading to even greater damage.

HOW HIGH WINDS DAMAGE BUILDING

Contrary to popular belief, few houses are blown over. Instead, they are pulled apart by winds moving swiftly around and over the building. This lowers the pressure on the outside and creates suction on the walls and roof, effectively causing the equivalent of an explosion.

Whether or not a building will be able to resist the effects of wind is dependent not so much upon the materials that are used but the manner in which they are used. It is a common belief that heavier buildings, such as those made of concrete block, are safer, simply because the materials are stronger than other types of building materials. While it is true that a well-built and properly-engineered block house offers a better margin of safety than other types of buildings, safe housing can be and has been provided by a variety of other materials including wood, wattle- and-daub, and many others.

DAMAGE TO INFRASTRUCTURE

Damage to infrastructure can also be widespread. Towers and transmission lines may fail as a result of resonance from high winds. Large buildings may also be damaged by wind resonance, flying debris, or erosion that undermines their foundations, leading to weakening or even failure of the building. Transportation facilities such as causeways, airports, roads and ports are also vulnerable to damage by both high winds and flood waters.

DISASTER PREVENTION

Much of the potential impact of cyclones can be reduced or eliminated if certain precautions or mitigation measures are taken. The following are specific actions that can be taken to implement these improvements.

Regulatory Controls and Their Relative Effectiveness

Conventional land-use control measures regulate use, density and location as well as the rate of development and growth. Land-use planning and control for disaster prevention and mitigation purposes is designed to control land use so that low-risk activities can be placed in vulnerable areas.

In coastal areas exposed to cyclones and storm surges, zoning ordinances would regulate minimum building height, type of land- use according to the set-back for the shoreline and most vulnerable locations, and density occupancy of buildings. Land might be regulated so as to place residential development away from the coastline, reserving it for other uses.

Land-use control and regulation can be an effective tool for reducing vulnerability, but it is not a simple, universal cure. Controls must be relevant to local conditions, to the degree of physical hazard, to the existing local economy, and to the probable future socio-economic status of the area. Also involved are numerous human factors that have to do with the inhabitants' perceptions of the hazard they face and the available means of altering the incidence of damage. The established way of life, existing land-use and ownership patterns, and pace of social and economic change will determine to a greater or lesser extent what regulated uses are to be recommended.

Other needs or pressures are frequently so overwhelming that land- use policies for disaster prevention/mitigation are given little weight. Growth of population and land shortages have tended to push the poor further and further to marginal land such as ravines, steep slopes, or even riverbeds. Disaster prevention and mitigation controls may conflict with other interests such as employment and income opportunities.

For example, rapid urbanization in many developing countries has produced large concentrations of urban squatters who have settled on unoccupied land (both public and private) in unattractive or undesirable locations, including marshes and the low-lying land exposed to periodic or seasonal flooding, but where they are close to employment opportunities and services. Squatter settlements in low-lying flood-prone areas are often caused by the high cost of suitable alternative locations and the extremely high per capita costs of new infrastructure and services.

Traditional and transitional economic systems are highly sensitive to regulation, and the economic costs (measured by employment or employment growth losses) of uprooting, relocating or inhibiting development can be very high. Land-use controls that do not respond to the economic forces they attempt to channel will be less effective. The cost of policing a body of unpopular or unworkable (for the poor) rules and regulations may exceed the capacity of the government.

Land-use policies must be supported by corresponding social and economic policies. Thus the reservation of new urban land for housing, especially where low-income families are concerned, should be linked to transportation and employment opportunities, education and other social services.

Building Regulations

Building codes establish minimum standards of design, construction and materials in order to avoid structural collapse. But like formal land-use controls, strict building regulations are unrealistic (and almost always unenforceable) for the majority of homes that typically receive no engineering input and are made from locally available, inexpensive materials.

A workable alternative to rigid building codes are more flexible building performance standards. Establishment of these policies and standards should be based on the degree to which a certain level of performance is desired. For example, it is probably not cost-effective (nor technically feasible) to build every house so that it is completely disaster-proof; yet it is possible to ensure that all houses have an increased level of safety. A primary objective of the standards, therefore, would be to encourage the development of more disaster-resistant houses (i.e., with a substantially increased level of safety) rather than to require that all houses be built to a very high engineering standard. This means that any type or size of house may be built, and any material may be used to build a house-- whatever is appropriate to the economic situation of a homeowner- -as long as the final structure is cyclone resistant and as long as it does not endanger the lives or property of neighbors or passersby.

Various economic, land and construction incentives have been tried, with varying degrees of effectiveness in reducing vulnerability. Fiscal and financial incentives can be used to encourage proper, rational development in less vulnerable areas. They can also be used to avoid the undesirable location of infrastructure facilities, haphazard or irrational uses of land, over-developed land, and congestion of people and activities. Fiscal and financial incentives might include subsidies and loans to landowners who comply with urban and land-use regulation designed to reduce disaster risk. Taxes that penalize inappropriate use of land or construction are most relevant to the modern or developed sectors of national economies. The marginal (low-income) or traditional sectors are largely outside the tax system; therefore, "positive" incentives in the form of housing and land subsidies are likely to be more effective and politically more acceptable.

Positive incentives comprise various kinds of grants or low- interest loans for construction or for the purchase of building materials to encourage new development on low-risk land. The subsidies have to be sufficient to outweigh other concerns, such as access to transport, proximity to work, etc., that are factors in perpetuating unplanned development in high-risk zones.

Public development of urban infrastructure can be an effective measure to encourage development in safe areas. Governments have traditionally provided roads, sewer systems, water facilities and other public utilities, and often the actual construction of housing or sites and services. This is an excellent opportunity for guiding growth away from hazardous lands and for managing the impact of natural hazards. As a development strategy, the provision of infrastructure may be used to curtail development by prohibiting public utilities, such as sewer and water facilities, from being extended to disaster-prone areas. If services must be provided in vulnerable areas, water supply networks, sewers and septic tanks should be located on lower-risk areas so as to minimize health hazards.[15]

Measures to Reduce Economic Losses

Measures to reduce agricultural losses may include building Ferro-cement or other appropriate strong grain silos to help protect harvests until they are sold; changing cropping patterns, if possible, to avoid exposing crops during their most vulnerable stages (i.e. harvesting) to periods of high risk (e.g., the flooding season); and introducing alternative crops or crop strains that are more flood and wind resistant.

Measures to reduce losses to energy facilities include using power grids that allow continuation of service to areas not damaged; diversification of generating capacity (i.e., oil, gas, coal, etc.); and development of alternative energy sources (wind power, solar, biogas, etc.).

Public Awareness

Perhaps the biggest obstacle to vulnerability reduction is the lack of awareness of the existence of a disaster threat and of basic disaster mitigation and preparedness measures that can provide substantial and permanent benefits without necessarily causing governments or individual’s additional expenditure. Systematic methods are necessary to inform people about the threat of disasters. Public awareness programs must explain some very basic and frequently misunderstood issues on the nature of the disaster risks--the anticipated hazard, the type of disaster impact, and the vulnerable condition to which the local population is exposed.

Disaster Preparedness and Response

Several important activities are necessary during the pre- disaster period. The following are the most important measures that governments, communities or voluntary agencies need to institute to be ready for the advent of a cyclone:

- developing a disaster preparedness plan to sequence the activities and responsibilities of each participant
- developing an effective forecasting system;
- developing warning and evacuation procedures for people threatened by floods
- training for first aid and trauma care, and maintaining stocks of necessary medical supplies
- Establishing an emergency communication system as well as public service messages regarding evacuation, health, safety, and security.

The occurrence of a disaster is a critical time and the response must be quick and complete. Specific initial and secondary responses are listed below by the group responsible for them.

The initial response by local authorities after a cyclone includes:

- evacuation
- search-and-rescue
- medical assistance
- disaster assessment
- provision of short-term food and water
- water purification
- epidemiological surveillance
- Provision of temporary lodging and, depending upon the climate, blankets.

The initial response by foreign aid organizations includes:

- cash
- assistance in reopening roads
- re-establishing communications contact with remote areas
- disaster assessment
- Assistance with water purification.

The secondary response by local authorities after a cyclone includes:

- repair and/or reconstruction of infrastructure, housing and public buildings
- creation of jobs
- Assistance to agricultural recovery (loans, seeds, farm equipment, animals) as well as to small businesses, fishermen, etc.

The secondary response by foreign agencies includes:

- repair and/or reconstruction of housing;
- creation of jobs
- provision of credit
- technical assistance
- Assistance to recovery of agriculture, small businesses and institutions.

The many conclusions drawn and lessons learned from past cyclones can be used to mitigate and better respond to future occurrences. Some of the most helpful are listed below for easy reference.

- Outbreaks of cholera do not follow cyclones. Cholera must previously be endemic to a community.
- Waterborne diseases do not increase as a result of cyclones.
- Massive food aid is rarely required after a cyclone.
- Used clothing is almost never needed. It is usually culturally inappropriate. Though accepted by disaster victims, it is almost never worn.
- Blankets can be useful, but if they are needed they can be found locally and do not need to be imported.
- Assistance by outsiders is most effective in the reconstruction period, not the emergency phase
- Most needs are met by the victims themselves or their local governments.
- In general, victims do not respond to disasters with abnormal behavior. Cyclones do not incite panic, hysteria or rioting.
- Cyclone relief and reconstruction programs should be integrated with long-term development programs.
- When properly executed, reconstruction assistance can provide a strong stimulus to recovery and a base for future development work.
- Reconstruction programs should seek to reduce vulnerability to future disaster.
- Re-establishment of the local economy, income security and agriculture are usually more important to cyclone victims than material assistance.
- Churches, schools and other large buildings that are often designated as cyclone shelters are usually not safe. The number of deaths attributed to destroyed or flooded shelters is alarming. Most experts agree that the best alternative is adequate warning and evacuation of the threatened areas.