Preparedness

Most people living in areas at risk from tropical storms are aware of the potential dangers. This is through education and public awareness campaigns, using posters, radio and television to warn people of the dangers and provide instructions about what to do before, during and after a tropical storm event. This can involve making minor structural improvements to buildings (e.g. stronger doors and windows), preparing emergency supplies and planning evacuation routes. Property can also be insured against storm damage.

In Florida, USA, evacuation routes and cyclone shelters are clearly signposted. Individual families are encouraged to make a plan and have provisions ready in case they need to act quickly. There is no question that mass evacuation programmes have been immensely important throughout the world in saving lives.

It is now possible to use satellites and other technology such as radar to identify and track tropical storms. Computer models based on historical data enable scientists to predict the likely course or track of an individual storm. In the USA and the Caribbean a 'Hurricane Watch' is issued for those areas of land where hurricane-force winds are a serious possibility within 36 hours. This will be upgraded to a 'Hurricane Warning' when landfall is expected in the next 24 hours or less.

Look at Figure **2**. It shows the early track of Hurricane Gustav as it passed through the Caribbean in August 2008. Notice that a 'cone' of prediction has been plotted to show the area most likely to be affected by the hurricane. This results in warnings being issued to the general public and to civil authorities to enable them to act accordingly and prevent injury and loss of life.

The National Hurricane Centre in Miami uses a computerised model called SLOSH (Sea, Lake and Overland Surges from Hurricanes) to estimate storm surge heights and waves. It uses historical data and takes into account storm characteristics and shoreline features (water depth, bridges, bay configurations, etc.) to estimate the height and extent of a storm surge associated with a predicted hurricane. Data is uploaded every six hours and the model is refined accordingly. The prediction is accurate to +/− 20 per cent. Therefore, if a 2 m surge is predicted, the actual surge will be between 1.6 m and 2.4 m.

Preparedness, mitigation, prevention, adaptation

There are several approaches that can be adopted to reduce the impact of a natural hazard.

- Preparedness – increasing people's awareness of the potential hazards associated with storms, wildfires, etc. and through their actions minimise the likely impact of the hazard.
- Mitigation – actions aimed at reducing the severity of an event and lessening its impact, which can involve direct intervention or post-event support in the form of aid and insurance.
- Prevention – actions aimed at preventing large-scale events from starting (if possible), for example wildfires.
- Adaptation – accepting that natural events are inevitable and adapting our behaviour accordingly.

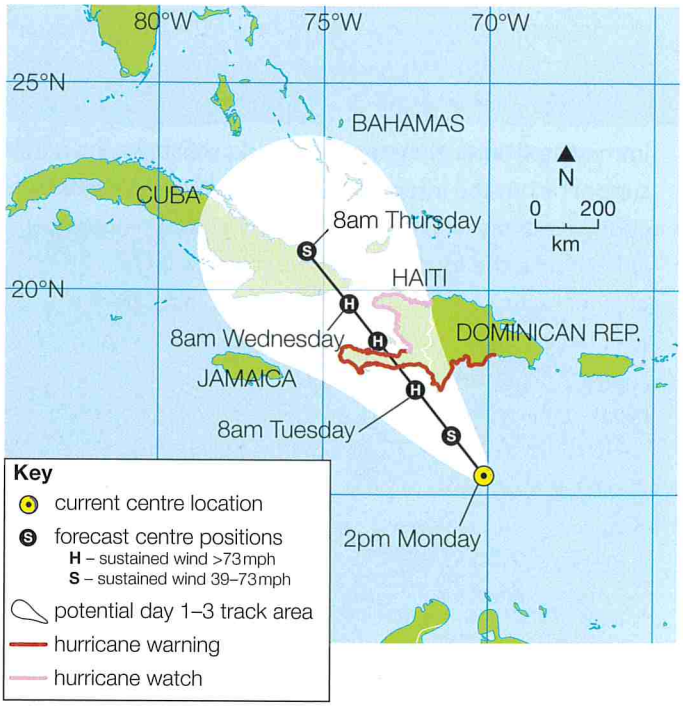


Figure 2 *The track of Hurricane Gustav, August 2008*

Mitigation

Mitigation can involve a range of measures, including structural intervention, disaster aid and insurance cover.

Structural responses

It is possible to offer some protection from storm surges by soft engineering schemes (planting trees and building up beaches) or hard engineering, such as constructing sea walls (Figure **3**). There is an increasing recognition of the importance of coral reefs in acting as a buffer in reducing storm surges. It is therefore important, for several reasons, to maintain the healthy reef ecosystems that fringe many tropical coastlines (see 6.10).

In South Carolina, USA, the South Carolina Department of Insurance administers the Safe Homes Program, which provides grant money to local homeowners to make their property more resilient to hurricane and wind damage. The principle behind the initiative is that less damage will result in fewer insurance claims and lower premiums. Increasing resilience includes reinforcing gable ends, strengthening roofs and installing stronger doors and windows.

Figure 3 *Sea wall flood defence at Corpus Christi, Texas*

Disaster aid

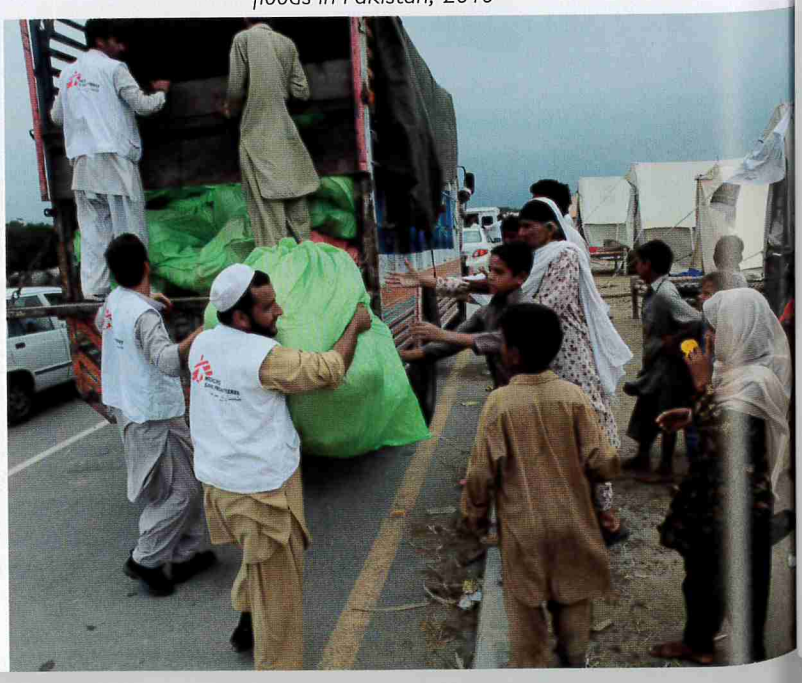
Disaster aid can take two forms:

- immediate humanitarian relief in the form of search and rescue, food, water, medicine and shelter
- longer-term reconstructional aid that seeks to support recovery and reconstruction.

The first stage in any impending disaster is for the government to declare a state of emergency, as this often triggers federal/state support both financially and also in terms of mobilising armed forces and emergency services.

Immediately after disaster has struck, most governments seek support from the international community, particularly neighbouring countries and those with historical, political or economic links. Disaster aid can take the form of expert personnel (e.g. engineers, doctors, search and rescue), transport (e.g. helicopters) or relief supplies (e.g. food, water, shelter) (Figure **4**). Aid can also come from trading blocs such as the EU or from international bodies such as the World Bank or the United Nations. Charities and other NGOs also provide valuable support, often reflecting generous donations from members of the public.

Figure 4 *Médecins sans Frontières workers distributing aid following the floods in Pakistan, 2010*



Longer-term aid may come from a variety of sources and could take the form of either a loan to help a country rebuild or direct help, for example, involving charities working within stricken countries.

Disaster aid played an important part in both case studies (see 5.18).

Insurance

Insurance cover is widely used to mitigate the effects of tropical storms, particularly in HICs. In the USA, people living in hurricane-prone areas are encouraged to take out insurance against wind damage and to follow certain building codes and regulations, for example on windows and doors. The fact that some car insurance policies only cover damage to windscreens and not side windows can result in apparent bizarre behaviour prior to a storm as residents seek to park their cars in the direction of the oncoming storm!

There are huge social issues regarding insurance – the rich can afford the high premiums, whereas the poorest in society cannot. Many of the poorest people in New Orleans who were most severely affected by Hurricane Katrina in 2005 did not have insurance; they remained behind in the city to safeguard their property, refusing to be evacuated to safety. This serves to illustrate how behavioural responses are determined to some extent by potential economic losses (Figure **5**).

Prevention

In the past, scientists have attempted to use cloud seeding (dropping crystals into clouds to cause rain) in order to dissipate tropical storms and make them less powerful. However, this has not worked and scientists now focus on forecasting, together with mitigation and adaptation, in reducing the impacts of tropical storms.

While a tropical storm cannot be prevented as such, it is possible, to some extent, to mitigate some of its effects. For example, sea walls can be constructed to protect coastal developments from storm surges and river flood defences can help to protect property and land from flooding (Figure **6**). However, with low-return tropical storm probabilities for many coastal areas, such approaches can be seen as financially extravagant, with behavioural responses involving forecasting, evacuation and insurance being the more favoured options.

Protecting Galveston, Texas, USA

In 1900 a devastating storm surge killed up to 12000 people in the coastal city of Galveston, Texas, USA. In response to this event, the city authorities embarked on an ambitious plan to prevent such a tragedy occurring in the future. A 5 km sea wall was constructed to a height of 5 m to form an effective barrier against the sea. In addition, dredged sand was used to actually raise over 2000 buildings, some by as much as 5 m! In 2009 plans were put forward to extend the sea wall and install floodgates to cope with predicted rising sea levels and the increased threat posed by a storm surge.

Figure 5 *New Orleans residents needed persuading to evacuate prior to Hurricane Katrina*

Figure 6 *Sea wall in Havana, Cuba protecting the city from storm surge*

Adaptation

Adapting to the threat posed by tropical storms is for many people around the world the most realistic option. Tropical storms cannot be prevented so people simply have to learn to live with the threat and do what they can to minimise the risks. Clearly, to some extent adaptation can also involve elements of preparedness and mitigation.

A good example of adaptation involves land-use zoning that aims to reduce the vulnerability of people and property at the coast. Most commonly this allows only low-value land uses (e.g. recreation) to occupy the coastal strip. In parts of north-eastern Florida, coastal properties are raised above the ground on stilts and have non-residential functions on the ground floor, such as a garage or storage area (Figure **7**). This shows how people have adapted the functionality of their houses to accommodate the threat posed by storm surges. Storm surge elevation markers help to give an indication of which buildings are at risk when a storm warning is issued (Figure **8**).

Following the devastation of the Australian city of Darwin in 1974, when Cyclone Tracy destroyed 94 per cent of the houses and left 40 000 people homeless, the city authorities recognised the need to adapt to the problem of strong winds when rebuilding the city. The use of improved wind-resistant structures in building design was mandatory, which has proved to be effective in reducing losses. Regular inspection and maintenance programmes help to ensure the effectiveness of this approach.

Figure 7 *Adaptation to coastal flooding, Cedar Key, Florida, USA*

Figure 8 *A hurricane storm surge elevation marker on Tybee Island near Savannah, Georgia, USA*