

## Instructions for Case Study

Following the passage of Hurricane Keith you have been asked to participate in a special task force that will be responsible for the reconstruction programme. The first meeting of the taskforce was held soon after the end of the emergency phase. At this point in time a description of impacts was available but a comprehensive damage assessment report was not available. One of the first tasks of the taskforce is to prepare such a comprehensive damage assessment.

A decision is made to use the ECLAC methodology to estimate the socio-economic effects of the disaster. Therefore the taskforce will need to focus on indirect and secondary costs as well as the effects of the disaster on national economic and social development and implications for economic, social and environmental policy.

In parallel, the taskforce has been asked to identify problems encountered, lessons learnt and identification of measures to reduce vulnerability to natural and man-made disasters.

Based on the partial description of the impacts you are being asked to:

- Identify direct, indirect and secondary impacts, damages and costs.
- Prioritize these types of impacts, damages and costs.
- Identify the kind of data you will need.
- Identify the sources of data.
- Identify possible problems.
- Identify shortcuts, which may have to be employed.
- Identify lessons learnt.
- Identify measures and possible projects which would contribute to reconstruction and vulnerability reduction.

It is strongly recommended that for each of the sectors you prepare draft summary and supporting worksheets.

## I. Introduction

### \* Description of the phenomenon and its effects

#### a) Storm description

Tropical Storm Keith began to intensify on 29 September 2000. Between Saturday 29 and Sunday 1, this system intensified from a tropical storm status to a category 4 hurricane. Over this period, central pressures dropped from 1 004 milibars (mb) to 942 mb, with a corresponding increase in sustained wind speed from 25 kilometres (km) to 115 km. During that period also, the hurricane remained almost stationary over the northern part of Belize, with the eye approximately over Ambergris Caye. A key feature of this hurricane was its rapid progression from a tropical depression to a category 1 hurricane in less than 24 hours and further rapid development to a category 4 hurricane in less than an additional 24 hours.

Because it was nearly stationary, this hurricane resulted in a record amount of rainfall on Belize. It is estimated that approximately 815 mm of rainfall fell in a 72-hour period between Saturday, 29 September and Monday, 1 October. This was one of the most extreme rainfall events that have been experienced in Belize in recent memory.

#### b) Impacts on cayes and mainland

The impacts of this hurricane varied considerably, depending on the location considered. At the keys (particularly Ambergris Caye and Caye Caulker or Cayo Hicaco), there was extensive damage from high winds, rainfall and storm surge on the leeward side of these islands. As a result of this, roofs were removed and extensive damage to property occurred. Because of the rapid intensification of this system from a tropical storm to a hurricane, there was limited time to carry out an effective evacuation from Ambergris Caye to the mainland.

On the mainland, the majority of the damage was confined to areas north of Dangriga. Extensive flooding was experienced, with roads being cut off and rivers subsequently flooding their banks. Belize City, for example, was cut off from access to or egress from it, as both main roads leading away from this city were under water. Further north,

the road to Orange Walk Town was accessible only to trucks, busses and SUVs, as flood waters cut off the main roadway. North of this town, there was extensive flooding of areas adjacent to the Rio Hondo, which resulted in loss of sugar cane crops and some livestock. In general, the damage on the mainland was restricted to some wind damage and extensive flood damage and hindrance in low-lying areas.

This hurricane clearly highlighted the areas of the country that are presently very vulnerable to extreme flooding. The lessons learnt from this experience must therefore be incorporated into the planning and decision making process.

These lessons provide valuable insights into adjustments in physical development policies, strategies and land use that may be required to help to reduce the country's vulnerability to future events. They also suggest the need for improving or fine tuning methods and approaches used in assessing vulnerability.

Damages pointed to vulnerability in the agricultural sector, where major losses to crops occurred and where livestock populations were adversely affected. The hurricane also caused extensive damage to transportation infrastructure (highways, streets, ports, etc.) and to utilities and telecommunications infrastructure (electricity, water, telephones, internet services).

Damage to housing highlighted the need for implementing building codes and land use standards that could help to reduce the costs associated with restoration and reconstruction of the housing sector after such events.

A major lesson from Hurricane Keith is the need for government agencies and corporations and private sector entities involved in land use and various other forms of physical and infrastructure planning to develop more effective measures for coordination in risk analysis and in vulnerability assessment and reduction.

**c) Population affected**

Of the four districts that were affected by Hurricane Keith, (Orange Walk, Cayo, Belize District, and Corozal) with a total population of over 125,000, more than 57,400 were affected. This represents 46 per cent of the inhabitants of these districts and 23 per cent of the national population. Worst hit were the people who lived on the Cayes, namely Ambergris and Caye Caulker, as all their inhabitants were affected. In these districts as many as 20 to 30 percent of the households have been classified as poor.

More than 5,000 persons were evacuated and 3,279 made homeless. Thirteen thousand persons were isolated due to the flooding and more that 57 thousand were affected due to the heavy rains and flooding. Ten lost their lives.

Female heads of households comprise anywhere from a low of 25 percent in Cayo to a high of 38.5 percent in Orange Walk of the poor households. Low-income groups have been among the most affected and factors such as the temporary setback in economic activities (particularly fishing and subsistence agriculture) and increased health risks have increased their vulnerability.

**d) Emergency actions**

The Government of Belize declared the Preliminary Phase during the early hours of 30 September, and by 9:00 am that day had declared Phase III or Red II, in compliance with the Disaster Management Plan developed in 1999 after Hurricane Keith hit the Central American region. A Hurricane Warning was declared for northern Belize, meanwhile the government of Mexico had posted hurricane warning for the coast of Yucatan from Cabo Catoche to the Border with Belize. This became necessary as Keith intensified and kept drifting on a westerly track towards Belize's northern coastal waters. By 6:00 pm minimal tropical storm force winds were already spreading over northern coastal areas of Belize.

Given the rapid development of Hurricane Keith from a tropical depression to a category 4 hurricane evacuation orders were not issued to the residents of Belize City nor the two Cayes that were severely affected. However, on Sunday, 1 October 2000, transportation was made available free of cost to those persons in Belize City who felt insecure in their homes and wished to seek shelter inland, namely in Belmopan and San Ignacio. Residents of some settlements along the coastline of the Corozal District were advised to seek higher ground.

## II. Social Sector

### a) Housing

Some 3,000 houses were either completely destroyed or suffered either partial or complete roof damage, particularly in the coastal areas hit by hurricane-force winds. Of these almost two thousand houses were completely destroyed. Others suffered damage as a result of flooding.

The most affected areas were San Pedro, Caye Caulker and Orange Walk.

**Table 4**  
**Belize: Location and Number of houses destroyed**  
**by Hurricane Keith**

District	Number
Total	1,988
San Pedro	406
Caye Caulker	275
Belize District (other than cayes)	65
Orange Walk	1,212
Cayo District	30
Corozal District	0

### b) Education

Schools suffered damage to their roofs and to their structures due to flooding. In all some 51 schools, 33 at the primary and 18 at the secondary level were damaged both in rural and urban areas.

Schools lost newly created computer laboratories, desks, chairs and educational materials, all of which will set back the educational programme of the Ministry of Education which is geared to improving the quality of education offered to its population.

Three libraries, two located in Belize city, the Leo Bradely Library and the North Front Street Library, and one in Belmopan, the Belmopan Library, suffered damage as a result of the rains and flooding.

Sporting facilities have suffered damage due not only to the hurricane but also as a result of their having been used as emergency distribution points and temporary deposits for diverse materials (electric cables, poles, etc.) Those most affected were located in Belize City, San Pedro on the Cayes, and in Orange Walk.

### **c) Health sector**

Health infrastructure. The main damages to the health infrastructure were reported to the National Hospital (Karl Heusner Memorial Hospital) and the Central Medical Laboratory and several clinics in Belize City, Belize rural, San Pedro (Ambergris Caye), Corozal and Orange Walk districts. It is estimated that 11 health centers lost their three-month medical supplies and basic equipment.

The Hospital remained functional throughout the storm. No serious damage was reported to equipment, although the immediate and longer-term effects of water seepage on the floor and ceiling tiles will undoubtedly be a problem.

The hurricane affected the Central Medical Laboratory and Blood Bank, as all reagents, blood units stock (50) and 100 per cent of supplies were lost due to electricity failure (the generator didn't work) and flooding. Also several pieces of furniture and equipment are malfunctioning or damaged following Hurricane Keith.

Epidemiological and environmental health issues. Water supply systems were greatly affected by Hurricane Keith. The islands and four districts were completely flooded resulting in dumpsites, sewer lagoons and excreta from latrines and septic tanks being washed into residential areas.

### III. Damage in Productive Sectors

#### a) Agriculture, livestock and fisheries sector

As a result of Hurricane Keith, the agriculture sector experienced major losses. Sugar, citrus and rice crops were affected in the districts of Corozal, Orange Walk, Belize and Cayo. The Orange Walk District was affected the most, accounting for 35 per cent of total estimated losses. It was mainly damages to the sugar cane crop. The citrus industry also experienced major losses in the Cayo District. In Blue Creek, which is the main producing area for rice, only 5 per cent of the crop could be harvested, the rest was lost due to the flooding.

The livestock sector suffered minimal direct damages compared to total stocks. Major losses in this sector were linked to damage to pastures and to secondary effects resulting from stress and loss of weight in cattle and poultry.

The fisheries sector experienced significant damages especially in the reduction of expected catch, due to silt accumulation. Most affected are areas of lobster production. This is expected to also reduce the annual catch for up to three years.

#### b) Tourism

Damage caused by Hurricane Keith. Direct damages. Sustained wind and storm surges brought by Hurricane Keith ravaged the northern Cayes of Belize, in particular Ambergris Caye, Caye Caulker, and Caye Chapel. Most of the hotels (62 in Ambergris Caye and 37 in Caye Caulker) and other tourist infrastructure and assets suffered damage with varying degrees of severity. Inland, fewer damages to the tourism sector were reported. An important Maya archaeological site, the ruins located in the Lamanai Nature Reserve reported damages caused by strong winds (fallen trees) and flooding. A crevice in the main pyramid structure damaged the cultural landmark.

The following damages were reported in the northern Cayes:

- Two hotels in Caye Caulker and one in Ambergris Caye were completely destroyed and several suffered structural damages.
- A great share of hotels suffered rood damages, usually leading to interior damages (ceilings and room furniture).
- Damages to equipment (water pumps, water heaters, washing machines, air conditioners).
- Landscaping damages: losses of trees and ornamental plants, litter.
- Damages to gift shops and restaurants.
- Damages to the golf course of Caye Chapel.
- Piers partially or totally destroyed.
- Seawalls destroyed in Caye Chapel and Caye Caulker.
- Property lost by beach erosion (included in environment damage assessment).
- Losses of boats mainly devoted to tourism activities.

#### **c) Industry and Commerce**

The damages caused by Hurricane Keith in industry and trade were less severe than in agriculture and tourism. Activities in the Corozal Free zone suffered minimal negative impact. Minor dislocations in production led to indirect damage resulting from loss of business for a period of three days. There were damages to the timber-processing sector in the Orange Walk District, affecting inventory, machinery and some buildings.

## **IV. Infrastructure**

#### **a) Transport**

Main highways direct damage. The storm affected the Western Highway and the Northern Highway. The Western Highway was affected by flooding and the road was underwater for a number of days and due to the continuous passage of vehicles erosion loosened the pavement surface and affected the base course. Culverts overflow and blockage contributed to the slow dispersion of the waters. Most of the damage was done by heavy traffic passing

over the soaked structure of the road. Additionally, at Roaring Creek Bridge, close to Belmopan, in the Belmopan-San Ignacio section, a major cut occurred due to the river's overflow, causing the road to remain under the water level for a number of days.

The Northern Highway was affected by flooding in the initial section close to Belize City and at Carmelita Toll, the New River overflowed and the highway was under water for some days. Culverts collapsed in many places along the lane.

With regard to the secondary network of a total of 1,515.8 miles of such roads, 740 of them were affected. Most damage occurred in culverts and fill erosion. Two bridges collapsed in low standard feeder roads. Fortunately they were located in an area where many alternatives may be used.

Additionally, streets in cities and villages suffered damage and interruptions that caused mostly damage to the surface and culverts.

#### **b) Telecommunications**

In Belize City also some lines fell down while in Belize-Rural, power failure caused most of the service's interruption. Flooding caused a manual shutdown of the exchange in Ladyville and in Mile 32-Cell site, two racks and two batteries were lost. Damage in Orange Walk City was minor, as in Blue Creek and Sartaneja. In many instances, emergency generator sets were used to provide energy to restore the service.

In San Pedro and Caye Caulker the BTL infrastructure was damaged. This affected all the services provided by them, which include, local, long distance, international, data, paging, Internet, and mobile communication. The damages primarily were due to the collapse of a 37.5-m self-supporting tower, provoked by intensive wind. The rain and flood affected the Exchange and Transmission equipment, while, rain, wind and flood also affected the overhead network and distribution point cases. Additionally ancillary equipment, such as, payphones, key systems, private automatic branch exchange, Wireless Local Loop, etc. also suffered intensive damage.

**c) Energy**

Electricity. The transmission and distribution lines suffered cuts and loss of poles. Some damages affected the generating system. The most affected areas were the islands of San Pedro, Caye Caulker's village and in Belize City. Interruptions in the service occurred during the storm, affecting approximately 22,000 customers.

Generation capacity was severely affected only in San Pedro and Caye Caulker. Furthermore in San Pedro and Caye Caulker the entire main and secondary distribution lines were affected in some way and many poles fell down or were broken. In San Pedro 9.4 per cent of the 34.5 KV transmission lines, 43.2 per cent of the main fallen and 32.7 per cent of the secondary distribution network were affected. In Caye Caulker the damages caused by poles were more severe, affecting 73 per cent of the main and 42 per cent of the secondary distribution network respectively. The damages on the network were caused by the extreme winds and flooding, while the damage in the power stations was due to the excessive rain and flooding.

**d) Water and sanitation**

In Corozal Town the damages were concentrated on the overhead storage tank, pumping station and cover material for the main transmission lines. In San Pedro Town the damages affected the secondary distribution lines and sewer collection system. In Orange Walk town, the intensive wind collapsed an overhead storage tank and flood affected the electrical system of the pumping station and main distribution lines.

In Belize City, damages were due to flood affecting the transmission lines and sewerage system. Belmopan and other five cities and town reported small damages on the distribution lines as a consequence of flooding.

## V. Effects on the Environment

The areas that were most heavily impacted are the northern cayes (primarily Ambergris Caye and Caye Caulker). In comparison, mainland Belize had minimal impact from the windstorm. It was flooding following the storm that caused havoc in low-lying areas along river basins and lagoons. Experts had indicated that full receding of the water to its normal level may last four months more. For example, Crooked Tree Wildlife Sanctuary was seriously flooded. In certain sections it appeared that the Belize River and the Sibun River had joined and become one body of water.

### a) Coastal erosion

Caye Chapel was severely impacted on its western coast as evidenced by the collapsing of almost its entire seawall. Specifically, the plastic sheet pile wall that has been used along the entire western length of this shoreline was destroyed. With this wall gone, the beach was severely eroded and the other carried offshore or up onto the golf course in the lee of the seawall. Observations made along this shoreline indicated that in some areas along this western coast, the shore had been eroded approximately 10-15 metres landward of the seawall. A total length of affected shoreline is estimated to be 2,800 metres.

In Caye Caulker the greatest erosion occurred at the “Split”, which had almost doubled in width, and had been deepened. In particular, the water depth is reported to have increased from 5 m to 8m, while the width of this feature appeared to have been more than doubled. Inspection of aerial photographs taken both before and after hurricane Keith indicated that there was significant damage to the plastic sheet pile wall, which previously lined the southern bank of the “Split”. A total shoreline loss of more than 11,000 m<sup>2</sup> has been estimated.

At Ambergris Caye, shoreline erosion was limited to the south-eastern coastline, where water came overland from the west, and eroded the shoreline over a distance of approximately 300-500m. This occurred at an area where the lagoon came inland, the width of the Caye was diminished and the buffering effect of the mangroves was reduced. A total affected area of approximately 600-100 m<sup>2</sup> was estimated.

**b) Damage to reef, mangrove and sea-grass bed ecosystems**

The entire waterbody within the Reef Lagoon from Robinson Point to North Ambergris Caye was extremely turbid during the immediately following the hurricane. This turbidity was observed to extend beyond the Belize Barrier Reef (BBR), some 30 to 50 metres eastward. The impacts of this tremendous amount of silt on the sections of the BBR will need to be assessed in order to determine its immediate, medium and long-term impacts. It is likely that sections of the BBR may suffer long-term damage from the smothering effect of the silt plume. The Coastal Zone Management Authority carried out an assessment of reef health following hurricane Keith. This was done on the back reef at Caye Caulker and all the corals were observed to have been bleached.

Sea-grass beds within the Reef Lagoon in this area have also been impacted by wave action, due to Hurricane Keith. Observations show that a large fraction of the sea-grass beds were smothering effects of the silt, as it is deposited on the seafloor. Large mats of uprooted sea-grass were observed floating between Caye Chapel and San Pedro Town.

Mangroves: all cayes suffered moderate to severe (40-80 per cent) mangrove leaf loss. Only few (about 5 per cent) mangrove trees were uprooted (most of these appeared to be isolated trees). In addition, the rich nutrients that were stored in the mangrove wetlands may have been released into the sea, with the potential medium or long-term negative impacts on the reef ecosystem. Additional sources of nutrients have also been contributed from the overflow of sewerage lagoons and septic tanks on these cayes.

**c) Impacts to wildlife**

Birds appeared to be the wildlife that suffered the greatest impacts as reported by the number of dead birds. In addition, birds continue to be affected on these cayes due to the loss of their habitats and feeding grounds. It was reported that the nesting and roosting sites of some of these birds on the atolls were also severely affected. For example, the habitats for the frigate and boobies at Half Moon Caye were heavily impacted.

**d) Impacts on water quality**

Contamination of coastal water with faecal coliform was believed to occur resulting from the overflow of sewerage lagoons and the inundation of septic tanks.

### **Belize population - 2000**

The total enumerated population of Belize as at Census Day 2000 was 240,204. Comparing this with the previous census count i.e. 189,392 enumerated as at May 12, 1991, the inter-censal growth rate is 2.7% per annum. This growth rate is approximately one percentage point higher than the growth between 1980 and 1991.

The Belize district continues to represent the largest proportional share of the total population i.e. 28%, but this has declined by two percentage points from its level of 30% in 1991. In the case of the Cayo district, which is again, the second largest populated district representing 22% of the total population, this district's share has increased by two percentage points from its level of 20% in 1991. With respect to the other four (4) districts, Orange Walk's share in 2000 (16%) remains the same as in 1991, while Corozal's declined by one percentage point i.e. from 15% in 1991 to 14% in 2000. Both southern districts share this one point, with Stann Creek gaining just under one half of a percentage point i.e. from 10% to 10.3% and Toledo gaining just over one half of a percentage point i.e. from 9% to 9.7%.

The Urban/Rural distribution of the population is of some significance, since Belize continues to have a larger rural population than urban. In 1991, the urban/rural ratio was 48:52. In 2000, this ratio remains the same indicating that 52% of our population live in the rural areas and 48% live in the towns. Of significance here however, is that whereas in 1991 the Cayo district accounted for the largest shift to the rural areas, in 2000 the Orange Walk district has taken over this role showing Orange Walk town accounting for an increase of over four (4) percentage points more than in 1991.

Aside from Belize City, Orange Walk Town has maintained its position as the largest urban center in the country. However, this lead now, is only by 223 persons over San Ignacio/Santa Elena. In 1991, the population of Orange Walk Town was larger than that of San Ignacio/Santa Elena by 2,634 persons.

The most populated village in the country is Trial Farm in the Orange Walk district with 3,443 persons. Second in population size is the village of Ladyville with 3,435. In 1991, Ladyville was the most populated with 1,871 persons, whereas Trial Farm had at the time 1,665 persons. Obviously, the growth rate of Trial Farm between the two censuses has been much higher at 207% while Ladyville grew by 84%. Other large villages in terms of population size are in Corozal, Little Belize, Sarteneja and Progresso with populations of 2,059, 1,648 and 1,165 persons respectively, and in the Orange Walk district, Guinea Grass, Shipyard and San Jose with populations of 2,510, 2,385

and 2,254 persons respectively. In the Cayo district, the villages with the largest population are: San Antonio (2,124), Valley of Peace (1,809) and Spanish Lookout (1,786). In Stann Creek, Independence/Mango Creek village stands out as the largest in terms of population with 2,929 persons, whereas in Toledo the village of Silver Creek is the largest with a population of 1,326.

### **The male/female breakdown of the population at the National level**

The census enumerated 121,278 males and 118,926 females. This converts to a sex ratio of 1.02 or for every 102 males, there are 100 females. This sex ratio follows the normal trend for most populations, which have not experienced any abnormal circumstances. This pattern is similar in most of the six districts, except in Orange Walk and Stann Creek where the sex ratios are 1.05 and 1.07 respectively.