THE USE OF NOWCASTING TECHNOLOGY FOR NATURAL HAZARD MITIGATION: THE JAMAICAN EXPERIENCE

By

Norman Harris, Mines and Geology Division, Jamaica

1.0. INTRODUCTION

1.1 Geographical Setting

Jamaica is located in the north Caribbean region between latitude 18 36' N 175'S and longitude 76 15'E 78 22' W. As a result of its location, the island is in the path of tropical storms and hurricanes. Geologically, it lies within the Caribbean Plate in a seismically active region (Figure 1). The island often experiences high annual precipitation, high magnitude rainfall from various types of tropical storms whose winds often reach hurricane forces (Technical Report i.e., Halcrow South Coast Development).

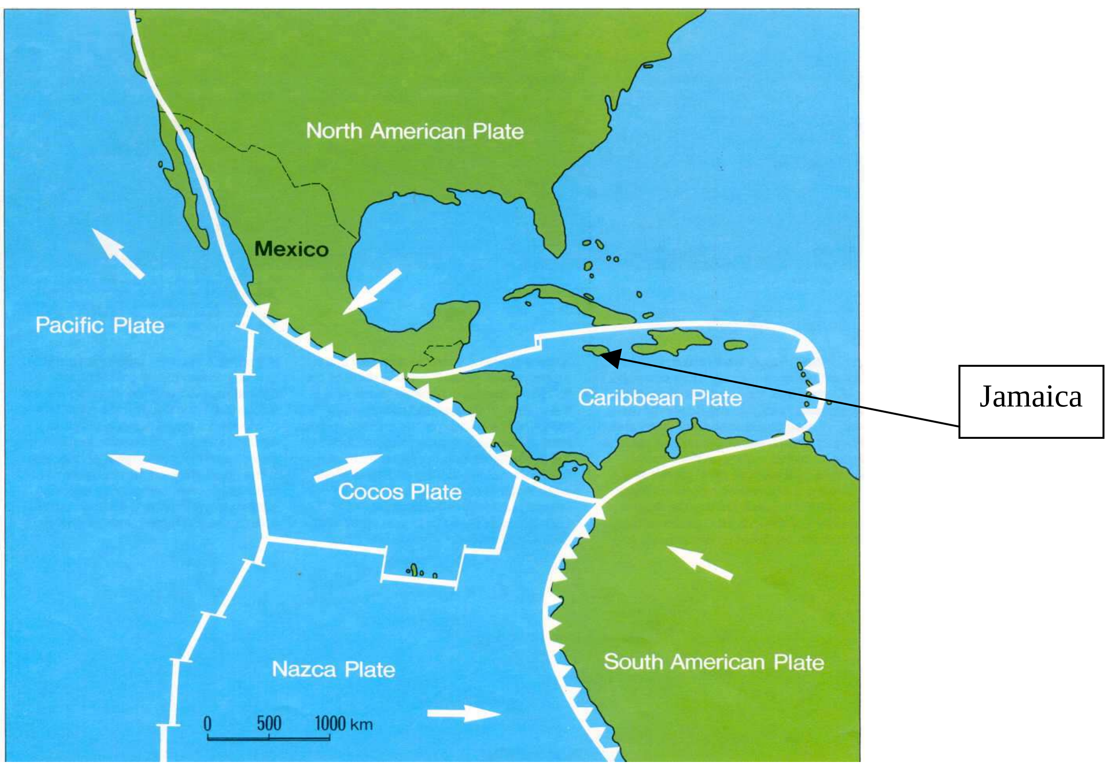

Figure 1: Earthquake map of the Caribbean showing Jamaica's location

1.2 Physical Description

The island of Jamaica measures some 225 km long and 97 km wide. It is generally mountainous with fringing alluvial areas particularly along the south coast.

Topographically, the island may be divided into an eastern mountainous region with peaks in excess of 2, 134 metres and a central and western plateau, which has been significantly dissected but reaches heights of 914 metres in places. Tertiary Limestone showing well-developed landforms in some places caps the plateau. A discontinuous series of coastal plains have been built up over the period along the south coast of the island by drainage from the hilly interior. The coastal plains are vulnerable to flood hazard.

1.3 Population Distribution

In 2001, the island's population was recorded at 2.6 million based on population census conducted in 2003 (STATIN). A large percentage of this population (>60%) is located on the coastal towns and cities, particularly along the coast. Over the past 30 years there has been a declining rate in population growth; however there is an increasing trend towards urbanization resulting in 52 percent and 48 percent of the population being urban and rural respectively.

The largest population center is found in the parish of Kingston and St. Andrew (25 percent of total population), which comprises the capital city of Kingston located on the south coast (Figure 2).

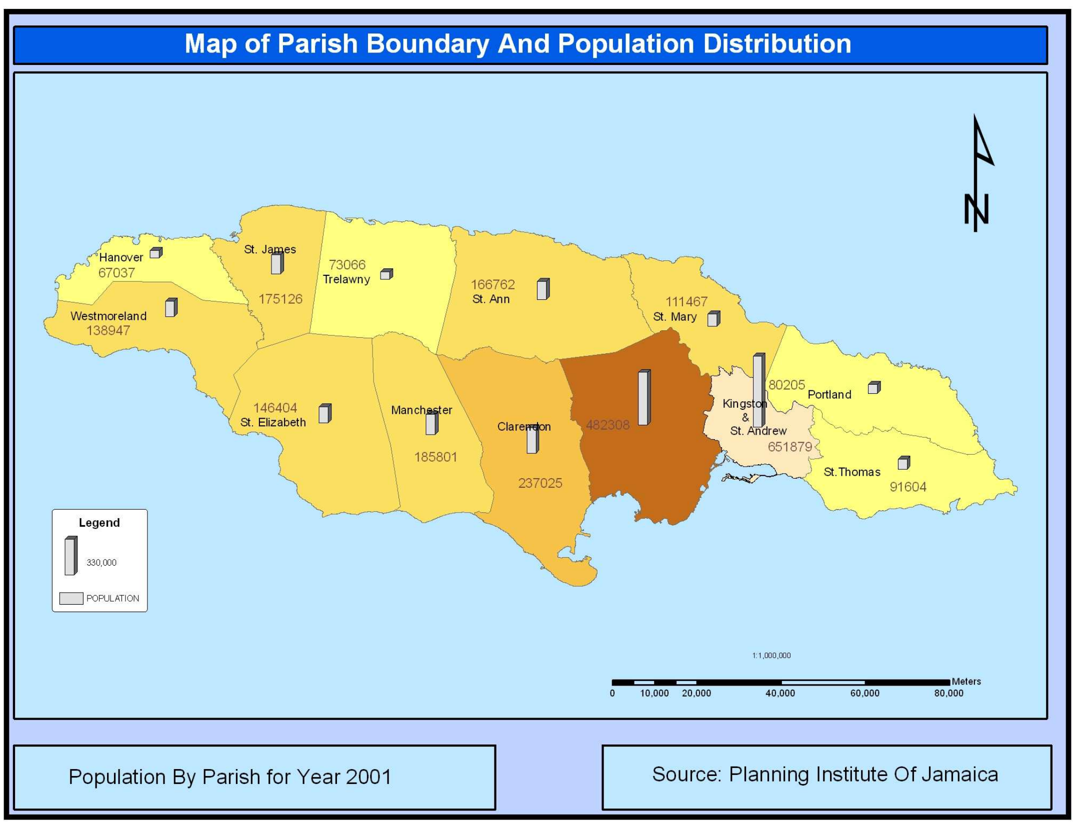

Figure 2: Map of Jamaica showing population distribution

2.0 HISTORY OF NATURAL HAZARDS IN JAMAICA

2.1 Historical Data

Jamaica has been severely affected by a number of hydrological, meteorological and geological hazards over the years.

Historical data on past hurricanes affecting Jamaica between the periods 1903-2004 is shown in table 1.

TABLE 1

DATE	NAME OF HURRICANE	LOSSESS INCURRED	DAMAGE
August 1903 November 1912 August 1915 September 1915 August 1916 September 1917	Hurricane Hurricane Hurricane Hurricane Hurricane (S. Coast Hurricane	Heavy damage 142 dead Cracked brick walls, 11 deaths, 80 % banana loss Banana and cocoa loss	 57,692 pounds
October 1933	Hurricane (West Coast	10 dead	680,336 pounds
August 1944	Hurricane	26 dead	
August 1951	Charlie	154 dead, 2,000 injured	US$20-50M
October 1963	Flora	11 killed	US$12M
October 1973	Tropical Storm Gilda	Utilities, homes affected	
August 1980 November 1985 September 1988	Allen Kate Gilbert	Widespread damage, 7 dead (49 killed, 810,000 affected)	US$18.2M? US$13.6M?
October 1998	Mitch		US$4.4.M?
November 2001	Lily & Isadore		
August, 2004	Charlie	Agriculture Damage	US$1.4M
September 2004	Ivan	Widespread damage	US$580M
July 2005	Dennis and Emily	Widespread damage	US$90.6M
September 2005	Wilma	Infrastructure and agriculture	US$93.5M

Source: ODPEM and PIOJ

The highest number of deaths (154) recorded occurred in August 1951 during Hurricane Charlie however, the greatest losses incurred occurred during Hurricane Ivan in September 2004, amounting to US$580M or 8 percent of Gross Domestic Product.

Many of the hurricanes in the past produced storm surges, which have impacted severely on the Jamaican coastline. Some of the storm surge events associated with hurricanes over the past 300 years are show in table 2.

TABLE 2

DATE	HEIGHT OF WAVES	AREAS AFFECTED	EFFECTS
1722	16 ft.	Port Royal, Queenstown & Kingston	
Nov. 2, 1726		Kingston, Spanish Town, Port Royal	Many lives lost
Oct. 3, 1780		St. James, Hanover, Westmoreland	1,000 dead
Oct. 18, 1815		Port Royal	Several vessel destroyed
Aug. 31, 1831	100 ft.	East and Northeast coast	Houses damaged
Oct. 31, 1874		Palisadoes	
1912	Surge recorded ½ mile from shore	Western parishes – Savanna-La-Mar worst hit	Lives lost
Nov. 4, 1932	Mountainous sea waves	Westmoreland, Hanover most affected.	Many lives lost
Aug. 5, 1980	40 ft. recorded at Galena Point	Entire island, north coast most affected	Roads and other coastal infrastructure destroyed
Oct. 24, 1998	50 ft. (16m) at West End - Negril	South Coast	Coastal infrastructure destroyed

Source: ODPEM and Disaster Information Kit for the Media (ver 05/95CDMP/OAS)

2.2 Jamaica's Vulnerability to Natural Hazards

Jamaica is located in a region for the passage of North Atlantic Tropical Storms and hurricanes. The most dominant period for hurricane activity is during August – November where there is generally an increase in activity over the Caribbean region.

The island is also located in a seismically active region and therefore vulnerable to earthquakes and associated tsunami activity. There is still some debate related to the level of vulnerability of the island to tsunami events, since the major faults in the region capable of generating large earthquakes are strike-slip faults, which do not normally produce significant tsunami activity.

Over 50 percent of Jamaica's population is located on, or in close proximity to the coast, therefore hurricanes and associated storm surge and tsunami activity can have a devastating effect on the social and productive sectors such as housing, tourism and fishing (Plate 1).

Plate 1: Severe damage to houses on the southern coast caused by storm surge associated with Hurricane Ivan in September 2004.

Many of Jamaica's human settlements are either located on coastal areas or interior valleys, flood plains and hillsides. The most vulnerable are the poor living in informal settlements, which occupy poorly drained coastlines, flood fringe and unstable hillside terrain (Plate 2). Heavy rains associated with hurricanes over the years have caused severe flooding and landslides that have resulted in these communities being hardest hit

Plate 2: Example of a vulnerable community living on the edge of unstable slopes of Hope River in Kingston

Plate 3a: Debris from flooded river partially destroyed a low-income dwelling

Plate 3b: Flooding of houses in a flood prone area in western Jamaica

There have been seven (7) flood events over the past four (4) years (2001-2005) associated with hurricanes and tropical depressions, which caused severe damage to the countries infrastructure as well as the productive sector (Plate4). The trend in recent years therefore shows a significant increase in the incidence of severe storm events.

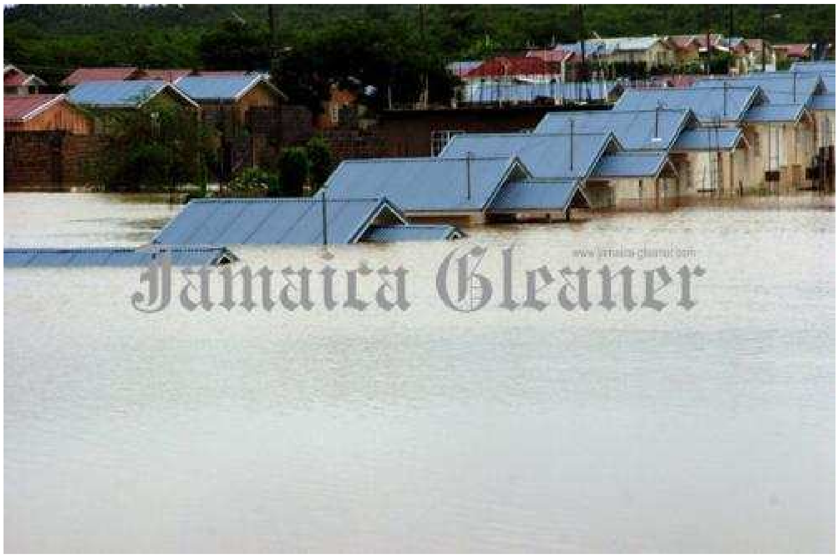

Plate 4: Example of recent flooding of a housing development in central Jamaica

3.0 CURRENT STATUS OF FORECASTING FOR REAL-TIME HAZARDS

3.1 Nowcasting Systems for Real-time Hazards

Nowcasting systems are tools used to generate specialized information that allows for lead-time of no more than several hours for use in the operation of real-time or critical warnings against severe weather. Based on information from the World Meteorological Organisation (WMO), the use of nowcasting technology is not being effectively utilized in the area of Public Weather Service. The WMO is now attempting to seriously assess the application of nowcast technology for time – critical warnings, particularly for public use.

3.2 Current Practices at the National Meteorological Service of Jamaica

The National Meteorological Service (NMS) of Jamaica is charged with the responsibility of forecasting and observing weather conditions over and around the island. It operates a radar section that closely monitors and reports on rainfall occurrence within a range of 500 km and operates radar stations at the two international airports. The NMS also uses satellite imagery along with other aids to assist in weather forecasting.

One of the major tools used for short-term forecasting is the Doppler Radar which provides information on cloud cover, rainfall intensities, information on catchment area and spatial distribution of weather conditions covered by the radar (Plates 5a &5b).

Plate 5a: Photograph of the Dopplar Radar used for weather forecasting in Jamaica

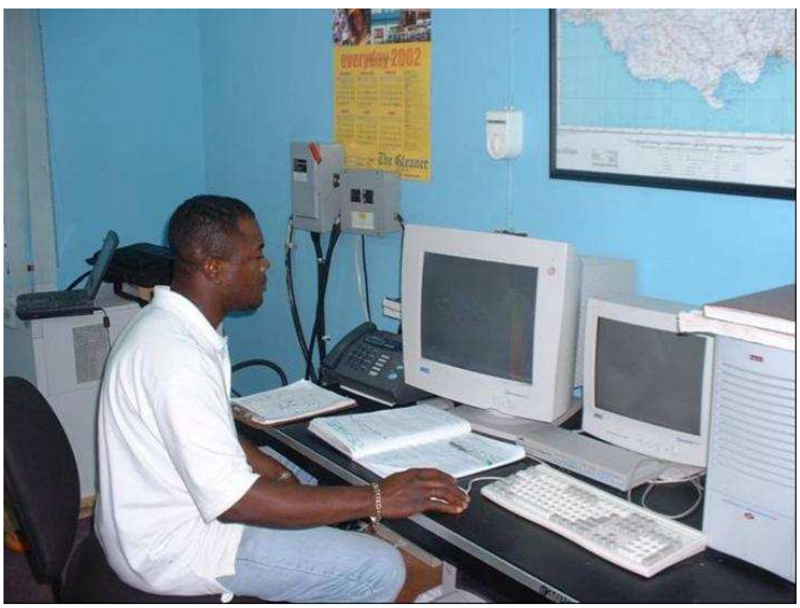

Plate 5b: An observer looking at images of the radar

In discussion with stakeholder organizations and members of the public, it is felt that forecasts from the NMS is sometimes too generalized and may not provide the type of warnings that can be used effectively by the public. Statements such as ‘expect flooding in low lying areas’ is sometimes ignored because of the non-specific nature of the advisory. In some instances, severe weather conditions that are localized are not picked up by the radar because its full capability is not utilized.

In discussions with the NMS, the full capability of the Dopplar Radar is not properly utilized for the following reasons:

- The lower-end software used to assist in interpreting the data.
- The inadequate training of forecasters/observers to utilize the full capability of the radar.
- The use of observers to transfer the information from the Dopplar Radar at its current location to forecasters at another location to be interpreted and processed for public consumption. The forecasters therefore process information that is given to them by the observers and this may sometimes lead to some critical elements of the weather not identified or under-reported.

The NMS also provides weather information to the ODPEM and media periodically. During the onset of a tropical storm or severe weather system, the NMS sends weather releases to ODPEM via fax or email that then packages the information which is disseminated to the media and public. There are sometimes concerns with this process where the bulletins and release to the public are not necessary consistent with the bulletins sent out by NMS.

As a result of technological issues affecting NMS, there is a challenge to provide information to the public within a short time.

3.3 Activities of the Water Resources Authority (Flood Forecasting)

The Water Resources Authority (WRA) is responsible for the collection and acquisition of surface and ground water and the management of the water resources of the country. With respect to hydrological data for flood hazard mitigation and management, the WRA has a network of stream gauges for the major rivers in Jamaica; however only one of these rivers, the Rio Cobre provides real-time stream flow data for flood early warnings. The Rio Cobre River was given priority for real-time flood early warning because of its potential impact on the municipality of Portmore in the southern section of Jamaica, which has a population of 157,000 and is the fastest growing community in the island.

Figure 3 shows a schematic of the real-time Flood early warning system in the Rio Cobre River.

Real-time data transmitted to the WRA from the Rio Cobre River for analysis is constrained by the fact that operations at the organization is not on a 24 hour basis, therefore important warnings may not be observed, particularly at nights. Although the system was initially set up to allow transmission of the real-time flood early warning data to other organizations, this has not materialized.

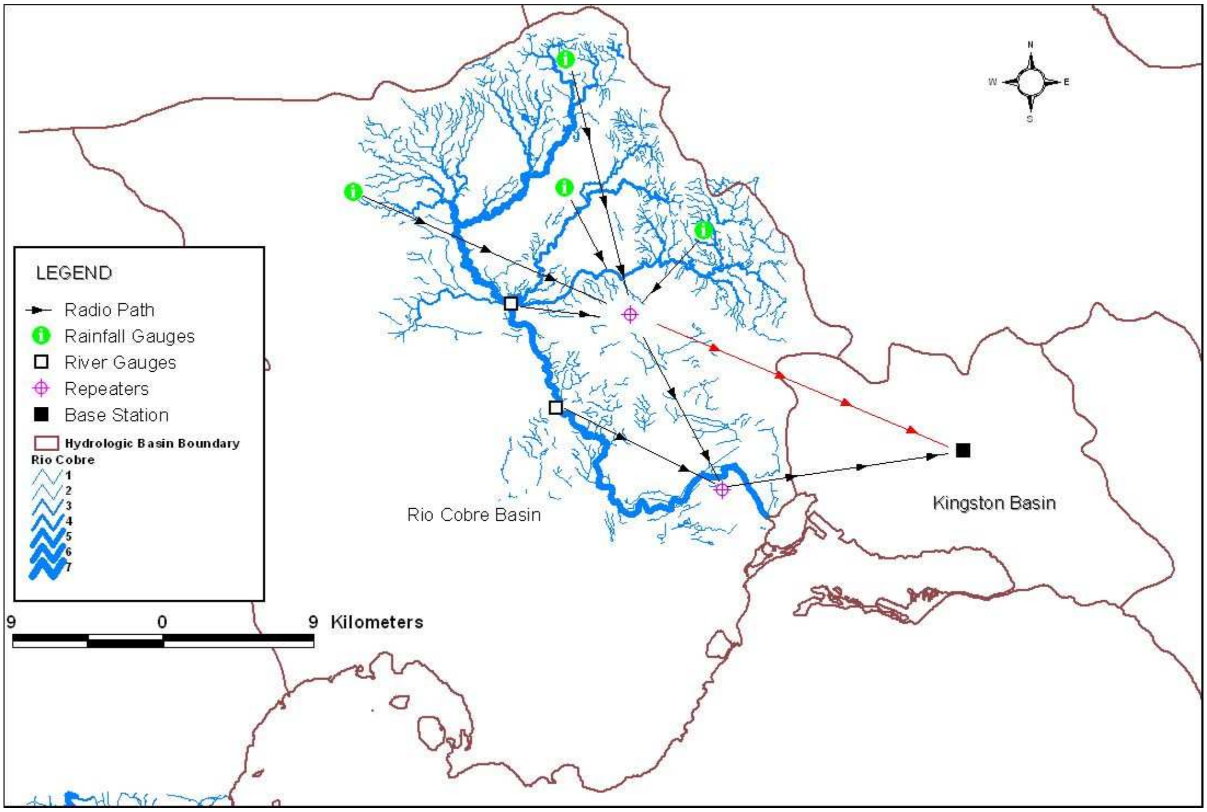

Figure 3: Schematic diagram of Rio Cobre Flood Early Warning System in Jamaica.

In rivers that are not instrumented, but have a history of flooding, the WRA has installed community flood gauges to assist in flood early warning (Plates 6a&6b). Rainfall run-off models are used to develop threshold values for flooding and this is used along with local knowledge to assist with developing community flood gauges. In conjunction with the community flood gauges are flood prediction tables, which tell the likelihood of flooding in a particular river based on the amount of rainfall over a given time. This is generally useful for gauge readers.

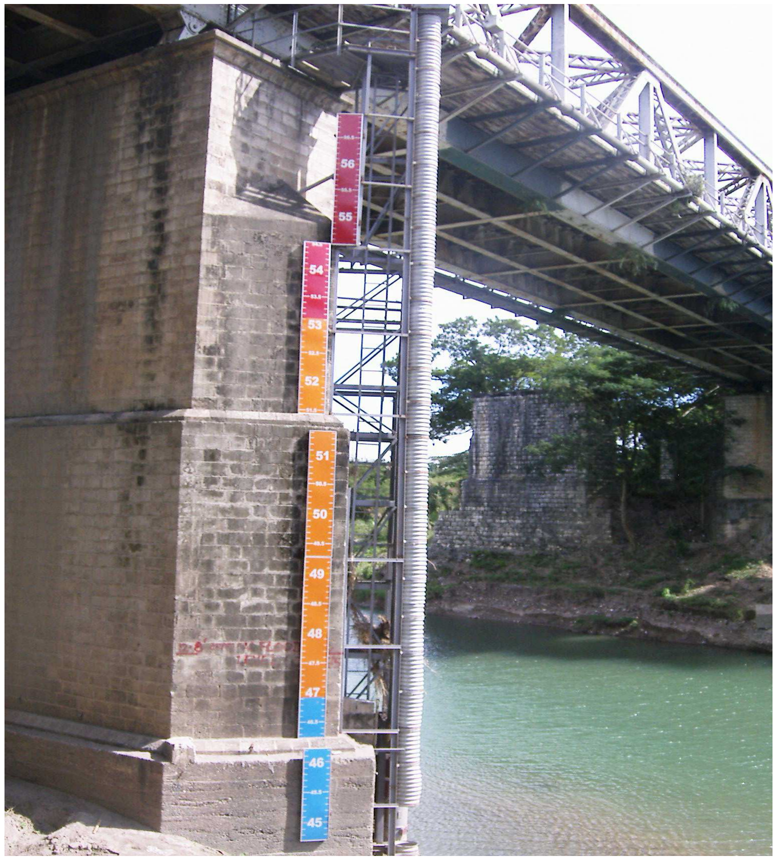

Plate 6a: Colour-Coded community flood gauges calibrated by Water Resources Authority and used by community gauge readers to assist with flood early warning on the Rio Minho River bridge in Central Jamaica

Plate 6b: Another example of colour coded community flood gauge use by the community for flood early warning

Community flood gauges are not only used in riverine flooding, but also in closed limestone areas (limestone depressions) and interior valleys where flooding have increased significantly over the past 10 years (Plate 7)

Photo7: Interior valley flooding (limestone depressions) has become more frequent over the past 10 years. An example of flooding in a limestone depression, which affected a community in central Jamaica in September 2002

Although the community flood gauges have proved useful over the years, the reporting procedures for warning or the dissemination of information from the gauge reader to the Office of Disaster Preparedness and Emergency Management (ODPEM) can be complicated due to the large number of layers in the reporting hierarchy. In addition, many of the reported floods occur at nights when it would be difficult for gauge readers to observe alert or critical levels to warn the community.

Flood early warning or nowcasting in limestone depressions is a challenge for the WRA. Although many lives are not lost in this type of flood event, the damage cost associated with flooding is high and this has a negative impact on the economy. Groundwater modeling is to be carried out in these areas to improve flood prediction.

Currently, a radar project is being implemented with funding from the United Nations Development Programme (UNDP). The purpose of the project is to provide warning to communities that are exposed to flash flood, not having adequate lead-time for flood warning. Many of the rivers in Jamaica are short and swift, therefore the lead-time for warning using more conventional methods pose a great challenge. The NMS and WRA are lead agencies in the operation of this project. A part of the project activities will involve upgrading of the radar and training of observers and forecasters.

3.4 Caribbean Tsunami Warning System.

The Earthquake Unit is given the task for the monitoring of seismic events occurring on land and offshore sites through a series of seismic network stations. The main focus on the Earthquake Unit with respect to real-time hazards is the setting up of a tsunami early warning system in the Caribbean of which Jamaica is a host. This initiative is being funded and coordinated by the United States Geological Survey (USGS) and other partners, such as the National Oceanic and Atmospheric Agency (NOAA).

Although historical data have shown incidence of tsunami in Jamaica, the island has not experienced a tsunami event in recent memory, therefore tsunami generated from earthquakes was not considered a significant hazard to affect the country. However, this has changed since the December 26, 2004, magnitude 9.0 Sumatra-Andaman island earthquake, which devastated the coasts of Aceh in Indonesia, India and other Asian countries. Since then, Jamaica is to become part of a programme to install a tsunami warning system. This is to be undertaken by the USGS which will include the installation of four Deep-Ocean Assessment and Reporting of Tsunami Buoys, as well as to install and upgrade seismic monitoring sites targeting earthquake zones in the region (IRIS Newsletter 2006, Issue 2).

3.5 Dissemination of Information (Emergency Situation)

During the onset of a severe weather system, the Office of Disaster Preparedness and Emergency Management (ODPEM) is responsible for providing timely information to the public through the media houses to prepare them for the event.

The ODPEM has set up a Public Education and Information Sub-Committee with the following terms and conditions:

- To develop a National Policy on Public Education and Information for Hazard Management.
- To clearly define the roles of all media houses and ensure smooth information flow between committee and media houses.
- To coordinate activities relating to public information and education in National Disaster Management.

The NMS issues weather bulletins or releases, which are sent to ODPEM by fax or email. Releases are issued every 5 hours while bulletins are issued by the NMS based on the intensity of meteorological event. This information is sent to the media centre at ODPEM. The NMS also disseminates information directly to the media.

Based on the information sent by NMS, the ODPEM packages and prepares news releases concerning preparedness, tailored to suit a particular hazard. This is disseminated to the media houses and copied to its web site and the NMS.

Some of the concerns relating to dissemination of information during an emergency are:

- Instances where different messages are being sent to the public by a number of organization regarding warnings, which sends conflicting information.

- The terms used for tropical weather systems are not readily understood.

The WRA also disseminates flood information to ODPEM, but in some cases this is after a flood event has occurred. Real-time flood early warning for the Rio Cobre is transmitted to the WRA, analyzed, process and the information sent to ODPEM. The direct link of real-time flood warning data to the ODPEM has been severed, but plans are ahead to reconnect the link.

During the onset of a severe weather (tropical storms and hurricanes) the public is increasingly using the internet and cable network weather station from the United States for information on warnings. This alternative provides additional information as well as more frequent updates on the event.

3.6 Landslide and Storm Surge Associated with Severe weather Systems

There are no tidal gauges or other types of instruments to measure storm surges, which may occur around the coast of Jamaica during a severe hurricane. Weather warnings for impending storm surge is largely based on the size of the hurricane and the direction of approach to the coastline. In terms of storm surge mitigation, there is a great reliance on historical records and storm surge modeling and mapping for coastal zones having large population and/or high levels of economic activity.

With respect to landslides, no landslide areas are instrumented to obtain real-time data for ground deformation or other types of slope instability. As is the case with storm surge, the country also relies on hazard maps as a tool for hazard mitigation and zoning regulations for planning purposes.

4.0 FUTURE PLANS AND PROJECTIONS FOR NOWCASTING TECHNOLOGY

4.1 Plans to Encourage Nowcasting for Public Weather Service

The NMS is acutely aware of its limitations with respect to the technological aspects of their operations for accurate and reliable nowcasting.

The following is put forward by the National Meteorological Service of Jamaica to provide nowcasting capabilities for public weather service.

- ❖ Upgrade software for the Dopplar Radar, which will provide accurate data on rainfall intensities, wind speeds and other meteorological data within a specified area for reliable prediction.
- ❖ Provide training to technical staff for improvement in the analysis and processing of the data from the Dopplar Radar using the computer upgrade.
- ❖ Increase the number of real-time rain gauges to assist with rapid and accurate prediction of the weather system in a particular area.
- ❖ Provide radar link to the international airport so that properly trained forecasters stationed at the airport are able to observe and analyse the radar images to improve forecasting.
- ❖ Improve capacity building within the organization. Structural changes will be necessary which will include the creation of an Information Technology /GIS Unit staffed with personnel who are specialized in GIS application to enhance the delivery of service to the public. These changes have been approved by the relevant organization within the Ministry.

5.2 Proposals to Improve Flood Early Warning System to Minimize Losses

In discussion with representative from the Water Resources Authority, there are plans to promote flood early warning in rivers and interior valleys for the different types of floods. The main plans are outlined below:

- ❖ Increase the number of real-time stream gauges in rivers that are prone to flooding.
- ❖ Currently, radio frequency is used to transmit real-time data. In areas of difficult topographic conditions, a large number of transmitters would be required, increasing the cost for transmitting data. There is recommendation to use radar technology in areas with topographic constraints.

- With respect to community flood gauges in rivers not instrumental, triggering devices or special sensors will be used to alert communities on a 24-hour basis.

- A new computer software will be purchased which will allow messages to be sent to the telephones of observers and technical officers at WRA and ODPEM when the instrumented rivers are at alert levels to warn of impending flood.

- Intensity-Duration Frequency Curves to be developed to determine critical threshold values for ground water, which will aid in predicting flood levels in limestone depressions and interior valleys.

5.3 Plans for Improving Information Dissemination to the Public

- At the national level, a system is to be developed to standardize the procedures for information dissemination to the public.

- To provide radar images to the Internet and television on a regular basis during the onset of severe weather conditions (storm and hurricane).

- To integrate the relevant organizations involved in real-time hazards with respect to analyzing, processing and disseminating weather warnings to the public.

- The NMS, which operates on a 24-hour basis, should be the center for the interpretation and processing of meteorological, hydrological and tsunami data to be disseminated to the public.

- A public education programme to be developed and implemented to inform the public on the procedures and types of warnings during an emergency.

6.0 CONCLUSION

- Nowcasting technology and by extension, natural hazard early warning systems are critical for the mitigation of natural hazards, particularly for small island-states whose economy can be virtually wiped out by a single event.

- Jamaica's geology, topography and location in the Caribbean region make it vulnerable to natural hazards.

- Communities of the low-economic means, live in the most vulnerable areas of the country.

- As a developing country, Jamaica is constrained by availability of resources to invest significantly in state-of-the-art technology for nowcasting applications.

- Developing partnerships with more affluent or developed countries is recommended as the path to take to increase resource allocation to less developed countries. Jamaica has benefited from such arrangements.