REPORT ON EARLY WARNING SYSTEMS IN THE CARIBBEAN SUB REGION

1. INTRODUCTION

1.1. Warning Systems

Hazard warning dissemination is a process whereby information and advice are passed between hazard monitoring and forecasting agencies and other organizations and people who may suffer loss or damage as a result of the hazardous event. Warning messages should pass from those who detect that a hazardous event may occur, to those who may be affected by it and who need alerting so that they may respond appropriately. There are particular circumstances in which members of the public might alert a forecasting agency of an event, thereby reversing the normal process of information flow.

In all but the most unexpected sudden-onset events, warnings are usually staged so that the warning level is stepped up as the event evolves, as it comes closer, as conditions worsen and as a severe event becomes more likely. A series of warnings will therefore be issued and warning dissemination becomes an interactive through-flow of information and advice ending with a message that the emergency associated with the hazard has terminated.

All this requires a number of pre-determined and pre-arranged conditions to be able to operate effectively in times of extreme stress and trauma, and previous studies have concluded that twelve such conditions determine the potential effectiveness of emergency warning systems.

- Maintenance of good interpersonal and interagency relationships between emergency personnel.
- Verification that messages are received, understood and acted upon.
- Developing redundancy in the warning system through the use of backup systems.
- Maintenance of lifelines such as stand by power.
- Message format
- Maintenance of competent staff.
- Development of backup staff teams for long onset disasters.
- Legal Framework which gives authority to the warning system by placing it at the apex of political power.
- Legal framework which links the warning system to national disaster plans.
- Public awareness of hazards and warnings.
- Close gaps between public awareness of hazard warnings and predictive capacity of scientists.
- Maintenance standards in a warning system.

These conditions usually involve and depend upon the quality of:

- Human resources, including technical and organizational expertise and communication skills.
- Institutional arrangements including laws, instruments of legitimization and inter-organizational arrangements.
- Communications technology, including telecommunications installations and networks.
- Informal (i.e. social) as well as formal communications networks.
- Mass media and media broadcast technology.
- Mobile resources of the military, Police and other agencies.

Warning systems are used for a variety of hazards which include but are not limited to:

- Hurricanes and associated storm surges.
- Earthquakes
- Volcanoes
- Floods from rivers.
- Floods from extreme rainfall.
- Forest Fires.
- Oil Spills.
- Tsunami.
- Epidemics.
- Famine.
- Pest Infestation.
- Mass migration.
- Bridge failure.
- Sea wall breaches.
- Aircraft accidents.
- Others.

Warning Systems usually employ a vast array of technology some of which are mentioned below:

Rain and river gauges with electromechanical transducers providing signaling that are automatically transmitted to a central computer where processing is done and the appropriate response is initiated. This type of telemetry is widely used in the United States to provide early warning for flooding from river overflow and rain inundation.

Satellite tracking of weather systems which is globally transmitted in real time on weather channels and which is then rebroadcast by local television and cable service providers for early consumption and evasive action by threatened populations. This early warning system has undoubtedly saved millions of lives over the past decade or so, as death tolls from weather systems were considerably higher before its development.

The Tsunami Warning System is perhaps the most safety critical of all warning networks, as it must rapidly report any occurrence of under sea activity likely to produce tsunami at any point throughout the world in to allow sufficient time for evasive action. This utilizes state of the art digital communication technology in order to fulfill its mandate.

Satellite imagery is used to detect forest fires and unusual migration of population in some countries where this is a potential hazard. These pictures also give indications of performance of crops, which provide warning of impending famine and its associated epidemic implications.

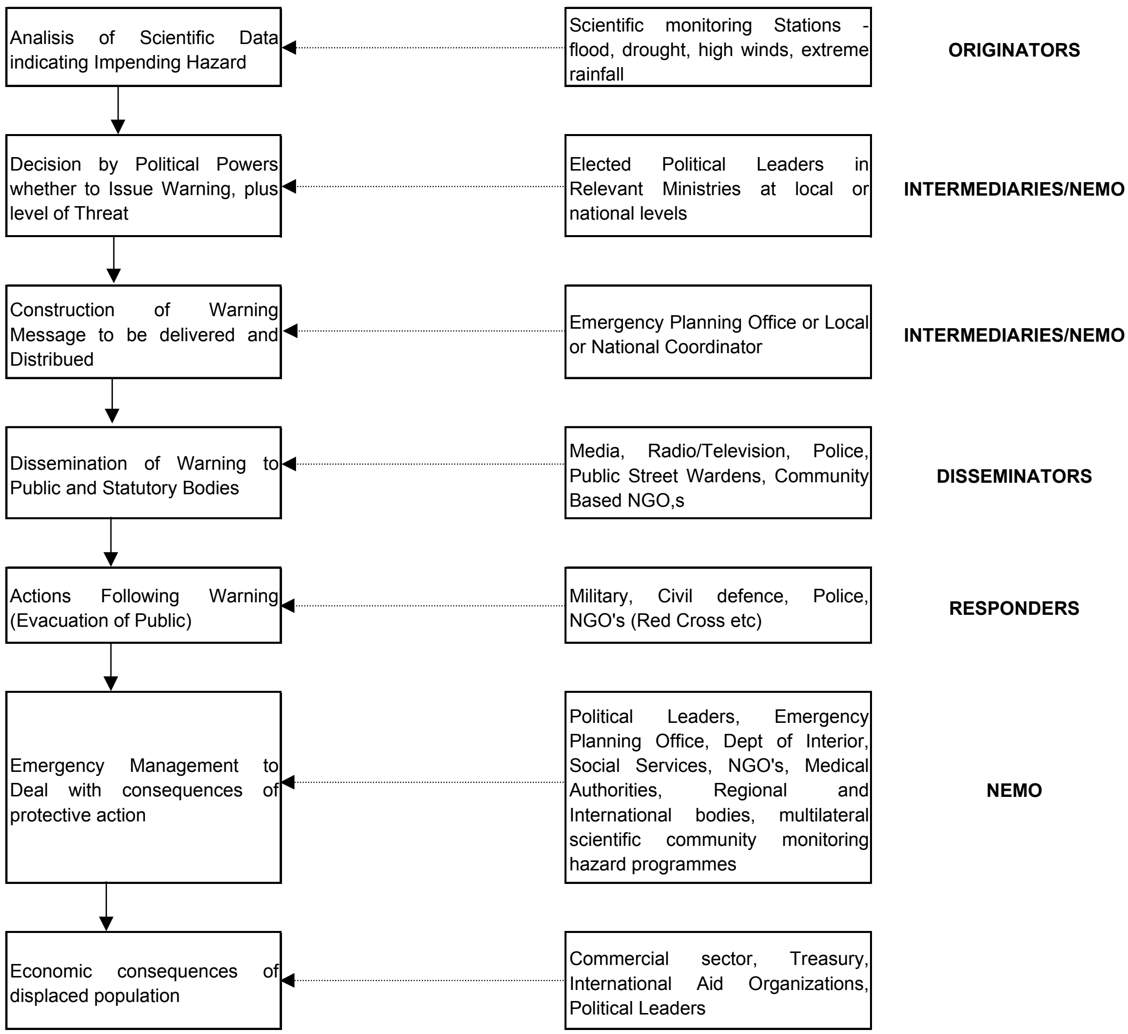
Bridge failure and Sea wall breaches are sometimes predicted or pre-empted by the use of electromechanical transducers, which use **telemetry** to signal creep. This warning system saves untold lives as buses and trucks with large numbers of people cross hundreds of times per day.

Human reporting of unusual or potentially dangerous situation is however the most widely used and effective early warning systems. This is so because it is driven by personal interest, understanding and prioritization of the potential dangers, where technological means may sometimes appear foreign to some cultures. This type of warning system is both formal and informal. Simple ad hoc reporting to the authorities by members of the community is done daily, while Health Ministries, social and humanitarian workers, scientific projects, and other government agencies have monitoring and reporting systems, which provide the most basic and reliable type of warnings. This class of warning usually utilizes the most basic communications technology.

A typical warning model is shown below:

FIGURE 1 WARNING FLOW DIAGRAM

(Based on a conceptualization developed by the Flood Hazard Research Centre)



1.2. Terminology and Abbreviations

Terminology

Hazard Warning Systems
A general phrase referring to all aspects of hazard Detection, Forecasting, Warning and Response systems.

Class Warning system
A system comprising several levels or classes of warnings intending to indicate an escalating level of threat.

Global
World level organizations and systems.

Regional
Caribbean region.

Sub-Regional
Part of the Caribbean such as the OECS.

National
Country level agencies and systems.

Local
Community level institutions and systems.

Stakeholder
Agencies and individuals who have an interest in and who are affected by the particular subject.

Alcalde
Elected Village or Community Leader.

Emergency Communications
A phrase referring to all methods of communication between Originators, Intermediaries and Disseminators of information relating to any type of emergency.

Originators
Scientific generators of warnings such as Meteorologists, Hydrologists and Volcanologists.

Intermediaries
Government decision makers and media who enact, enforce, manage or otherwise implement response measures.

Disseminators
Agencies or individuals who communicate emergency information to multiple target audiences such as emergency services, military, police, power companies, airports, port authorities, vulnerable communities and the public at large.

Receivers
Those agencies and individuals that could be potentially affected by the information disseminated.

Trunking
A method of using relatively few communications paths for a potentially large number of users

911
An emergency call and dispatch service.

Private Wire
Dedicated telephone lines connected between two or more parties for their sole use.

Open Repeater
Repeater system where all parties can hear all others.

Wireless Loop
A method of installing domestic telephone service using radio signals instead of cable.

Fibre
A communications transmission medium that uses light instead of electrical signals.

Cascade
A call out method where each person has a pre-determined list of persons he or she is to call in an emergency.

Abbreviations

AI	Artificial Intelligence
AIDS	Acquired Immune Deficiency Syndrome
AM	Amplitude Modulation
BHC	British High Commission
CARICOM	Caribbean Community
CB	Citizens Band
CCCC	Caribbean Climate Change Centre
CDB	Caribbean Development Bank
CDERA	Caribbean Disaster Emergency Response Agency
CIDA	Canadian International Development Agency
CMO	Caribbean Meteorology Organization
DFID	Department For International Development
DM	Disaster Management
DPO	Disaster Preparedness Office
EC	Emergency Communications
ECHO	European Community Humanitarian Office
EMAIL	Electronic Mail
EOC	Emergency Operations Centre
EU	European Union
EW	Early Warning
EWS	Early Warning System
FM	Frequency Modulation
GIS	Geographic Information System
HAM	Radio Amateurs
HF	High Frequency
HQ	Headquarters
i/c	In Charge
IADB	Inter American Development Bank
IMO	International Maritime Organization
ISDR	International Strategy for Disaster Reduction
ITU	International Telecommunications Union
KW	Kilo Watt
LEOS	Low Earth Orbit Satellite
Met	Meteorological
MOH	Ministry of Health
MOU	Memorandum of Understanding
MVO	Montserrat Volcano Observatory
NDC	National Disaster Coordinator
NEMA	National Emergency Management Agency
NEMO	National Emergency Management Organization
NGO	Non-Governmental Organization
NHC	National Hurricane Centre
NODS	National Office of Disaster Services
OAS	Organization of American States

OCHA	Office for the Coordination of Humanitarian Affairs
ODM	Office of Disaster Management
ODPEM	Office of Disaster Preparedness & Emergency Management
OECS	Organization of Eastern Caribbean States
PAHO	Pan American Health Organization
PLC	Power Line Carrier
POT	Plain Old Telephone
PVO	Private Voluntary Organization
RT	Radio Telephone
SARS	
SAT PHONE	Satellite Telephone
SMS	Short Messaging Service
SRU	Seismic Research Unit
TOR’s	Terms of Reference
TVRO	Television Receive Only
U/S	Unserviceable
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
US	United States
USAID	United States Assistance for International Development
UWI	University of the West Indies
VHF	Very High Frequency
VSAT	Very Small Aperture Terminal
WHO	World Health Organization
WFP	World Food Programme

2. AIM OF REPORT

This report covers the investigation of existing Early Warning Systems and arrangements in the Caribbean.

3. PRIMARY HAZARDS FACING THE REGION

Varying forms of EW systems are currently used in monitoring, forecasting, predicting and alerting for the following hazards in the Caribbean:

3.1. Hurricanes

This hazard has the singly most destructive potential and ability for reversing attempts at development in the region.

Regular aerial hurricane EW patrols began in 1945, reporting location, characteristics, and movements of any likely disturbance. Flights are made into, through, and above the storm. The easiest access to the eye of a cyclone is from the side of the stagnation point where the hyperbolic divide is located. Radar units provide warning of any storm within range. Satellites transmit photographs of any part of the Earth and its cloud systems. They give the most reliable and comprehensive coverage of cloud patterns and reveal storm systems from remote areas, where other methods of detection may not always penetrate.

3.2. Rain and River Flooding

They severely disrupt many lives and causes significant loss of production and millions of dollars in damage to roads, bridges and other infrastructure. EW systems include gauges that measure the amount of rainfall, which is used by computer models to predict flooding, and gauges that indicate river bank heights upstream, which are used to predict overflows further downstream.

3.3. Landslides

Landslides traditionally account for relatively significant damage to housing and other property in the region.

Also called “Landslip”, this is a downward mass movement of earth or rock on unstable slopes, including a number of forms that result from differences in rock structure, coherence of material involved, degree of slope, amount of included water, extent of natural or artificial undercutting at the base of the slope, relative rate of movement, and relative quantity of material involved. Many terms cover these variations; creep, earthflow, mudflow, solifluction, and debris avalanche are related forms in which mass movement is achieved by flowage. Early warning can be achieved by a combination of historical data, geological study and detection of creep.

3.4. Volcanic Eruption

This hazard could undermine the viability of some entire Caribbean states, as has already been the case in Montserrat.

These are vents in the crust of the Earth or other planet or satellite, from which issue molten rock, pyroclastic debris, and steam. Volcanoes are the surface manifestation of a thermal process, which has its roots deep inside the earth and which hurls its ashes high into the atmosphere.

The term volcano can either mean the vent from which magma erupts to the surface, or it can refer to the landform created by the solidified lava and fragmental volcanic debris that accumulate near the vent.

Volcanoes (and their products) are not the realm of any single scientific discipline. Rather, they require study by many scientists from several specialties: geophysicists and geochemists to probe the deep roots of volcanoes; geologists to decipher prehistoric volcanic activity; biologists to learn how life becomes established and evolves on barren volcanic islands; and meteorologists to determine the effects of volcanic dust and gases on the atmosphere, weather, and climate.

Volcanoes are closely associated with tectonic activity. Most of them occur on either the overriding or the diverging margins of the enormous lithospheric plates that make up the Earth's surface.

Volcanoes affect humankind in many ways. Their destructiveness is awesome, but the risk involved can be reduced by assessing volcanic hazards and forecasting volcanic eruptions.

3.5. Earthquake

Earthquakes could devastate the fragile infrastructure of some Caribbean cities with modern, high-rise construction and cause disproportionately large loss of life.

The largest percentage of deaths and property damage that result from an earthquake, is attributable to the collapse of buildings, bridges, and other man-made structures during the violent shaking of the ground. No natural event is as destructive over so large an area in so short a time as an earthquake.

If major earthquakes could be predicted, it would be possible to evacuate population centres and take other measures that could minimize the loss of life and perhaps reduce damage to property as well. For this reason earthquake prediction has become a major concern of seismologists in the United States, the Soviet Union, Japan, and China.

Investigators agree that much more has to be learned about the physical properties of rocks in fault zones before they are able to make use of changes in these properties to predict earthquakes. Recent research has suggested that rocks may become strained shortly before an earthquake and affect such observable properties of the Earth's crust as seismic wave velocity and radon concentration. Leveling surveys and tilt-meter measurements have revealed that deformation in the fault zone just prior to an earthquake may cause changes in ground level and, in certain cases, variations in groundwater level. Also, some investigators have reported changes in the electric resistivity and remnant magnetization of rocks as precursory phenomena.

3.6. Oil Spill

This is leakage of petroleum onto the surface of a large body of water and on beaches, which could severely impact local economies that depend heavily on tourism.

Oceanic oil spills became a major environmental problem in the 1960s, chiefly as a result of intensified petroleum exploration on the continental shelf and the use of supertankers capable of transporting more than 450,000 metric tons (500,000 tons) of oil. Thousands of minor and several major oil spills related to well discharges and tanker operations are reported each year, with the total quantity of oil released annually into the world's oceans exceeding 1,000,000 tons (907,000 metric tons). The costs of such accidental oil spills are considerable in both economic and ecological terms. Oil on ocean surfaces is harmful to many forms of aquatic life because it prevents sufficient amounts of sunlight from penetrating and also reduces the level of dissolved oxygen. Moreover, crude oil renders feathers and gills ineffective, so that birds and fish may die from direct contact with the oil itself. Accidents to supertankers and to underwater wells and pipelines may be the cause of major oil spills, but the unintentional or negligent release of used gasoline solvents and crankcase lubricants by industries and individuals, greatly aggravates the overall environmental problem. Combined with natural seepage from the ocean floor, these sources add oil to the world's waterways at the rate of from 3,900,000 to 6,600,000 tons (3,500,000 to 6,000,000 metric tons) a year.

3.7. Tsunamis

Tsunamis could undermine the economies of at least two Caribbean states whose capitals lie below sea level.

Also called Seismic Sea Wave or Tidal Wave, it is a catastrophic ocean wave, usually caused by a submarine earthquake occurring less than 50 km (30 miles) beneath the seafloor, with a magnitude greater than 6.5 on the Richter scale. Underwater or coastal landslides or volcanic eruptions also may cause a tsunami. The term tidal wave is more frequently used for such a wave, but it is a misnomer, for the wave has no connection with the tides.

The surface orbital motion of any progressive oscillatory wave is transmitted diminishingly downward through the water, becoming insignificant at a depth below the surface equal to approximately half the wavelength. Tsunamis, however, being enormously longer than even the greatest ocean depths, experience significant retardation of orbital motion near the seafloor and behave as shallow-water waves regardless of the depth of the ocean the waves are propagated across. Assuming an average velocity for seismic sea waves of about 200 m per second (450 miles per hour), an average oceanic depth of about 4,000 m is obtained; this figure compares very well with the modern estimate of 3,808 m. **The relationship has enormous practical value, enabling seismologists to issue warnings to endangered coasts immediately after an earthquake and several hours before the arrival of the tsunamis**.

Perhaps the most destructive tsunami was the one that occurred in 1703 at Awa, Japan, killing more than 100,000 people. The spectacular underwater volcanic explosions that obliterated Krakatau Krakatoa Island on Aug. 26 and 27, 1883, created waves as high as 35 m in many East Indies localities, killing more than 36,000 people.

3.8. Fires, including Forest Fires

If spread quickly out of control, forest fires could burn entire towns, including at least one Caribbean capital city, which is built almost entirely with lumber.

A forest fire does a number of specific things. First, and perhaps most obviously, it consumes woody material. Second, the heat it creates may kill vegetation and animal life. In most fires, much more is killed, injured, or changed through heat than is consumed by fire. Third, it produces residual mineral products that may cause chemical effects, mostly in relation to the soil.

Detection is the first step in fire suppression. New developments in remote-control television, high-resolution photography, heat-sensing devices, film, and radar make fire detection by aircraft and satellite more efficient and location more accurate. Satellites provide a rapid means of collecting and communicating highly precise information in fire detection, location, and appraisal.

3.9. Epidemics

The most recent threats coming from ‘AIDS’ and ‘SARS’, could deliver a serious blow to the regions’ already reeling tourists revenues resulting from “9-11”. Extremely vigilant national health systems, coupled with close and effective support from international organizations like PAHO, have produced very high health standards in the region.

3.10. Pest Infestation and Droughts

These hazards could destabilize those agrarian based economies in the region and are similarly controlled by EW monitoring systems at national level supported by international agencies like WFP and others.

3.11. El Nino

This phenomenon affects the Caribbean indirectly through climate changes in temperature, rainfall, hurricanes and other environmental patterns. The CCCC has been set up which provides EW through monitoring these effects.

4. TECHNICAL ASPECTS

Some hazards have more than one EW systems associated with them, which vary from state to state and include a wide range of applications, from simple, manually operated alerting systems with no component for monitoring, forecasting or predicting, requiring little or no technological assistance (such as in landslides in some areas), to very sophisticated, 'hi-tech' systems, where monitoring, forecasting and predicting are all conducted as global activities from some other region or country, while national or regional alerts simply respond to these systems, (such as with hurricanes and volcanic activity).

Some systems are also characterized by real-time, automatic monitoring and alerting, but with manually operated forecasting and prediction models made available over global media such as television and the internet (example are rainfall and river flooding EW systems).

4.1. Sophisticated systems

4.1.1. Hurricanes

Hurricanes were previously considered slow onset emergencies, but recent events have shown a shift in this pattern to one where category 5 hurricanes no longer travel across the Atlantic, but may even be developed within a 48 hour period within the Caribbean sea.

These are monitored globally by a number of weather satellites operated by the US. Military aircraft are flown around the storms (Hurricane Hunters) which are probed with sensors that transmit data to computers at the US National Hurricane Centre in Miami, which in turn provide forecasting and prediction of their intended paths, strengths, loads and the likely effects of their impact upon any country or region. This information is then broadcast for global consumption and is accessible via:

4.1.1.1. any computer on the internet,
4.1.1.2. satellite television on the "Weather Channel"
4.1.1.3. automatically transmitted "Weather faxes" to Regional (CMO and Puerto Rico) and national weather services and EOC's,

Regional and national organizations that have mandates either as government (regional and national) agencies, or as NGO's, PVO's, national met offices, public media or commercial entities, then distribute warnings to the region, sub-region, countries, communities and individuals in various formats such as:

4.1.1.4. public media (radio and TV) announcements;
4.1.1.5. print media (newspaper) articles where time for writing, printing and distribution allows;
4.1.1.6. Email "List Serves" of strategic and appropriate pre-designated contacts who are expected to further proliferate warnings at lower levels in the community;
4.1.1.7. addressable cellular telephone messages (Short Messaging Service - SMS);
4.1.1.8. Fixed Frequency radio receivers pre-issued to remote/rural communities and permanently tuned to a station on which emergency warnings would be generated;
4.1.1.9. facsimile;
4.1.1.10. satellite telephones pre-issued to specific community leaders and emergency first responders in remote areas;
4.1.1.11. land-line telephones where these exist and continue to be in service;
4.1.1.12. cell phones when these are not jammed by excessive traffic;
4.1.1.13. via 2 way radio typically through the military, police, fire ports authority and other uniformed services that regularly use vhf/uhf radios;

Local and community organizations, groups and individuals then take this information and conduct "alert procedures" by some of the following means:

4.1.1.14. "cascade" (a call out and alerting methods where designated village wardens run to the homes of key individuals to alert them);
4.1.1.15. whistle blowing by designated village wardens using pre-designated whistle codes that are understood by community members;
4.1.1.16. megaphones (also called "Bull Horns") on vehicles or foot for public warnings;
4.1.1.17. sirens using pre-designated siren codes that are understood by community members;
4.1.1.18. bell ringing using pre-designated bell codes that are understood by community members;
4.1.1.19. raising flags using pre-designated flag codes that are understood by community members;
4.1.1.20. via leaflets and loud hailers from fixed or rotary wing aircraft
4.1.1.21. via runners to carry messages;

4.1.2. Volcanic activity

Activity in the chain of volcanic islands of the Caribbean is **monitored** by the Seismic Research Unit (SRU) of the UWI. This is achieved using a number of seismic sensors that are physically located at geologically determined locations around the volcano(s), which have communications devices that transmit detected activity in real time to the SRU in Trinidad. Computer models and scientific intervention then provide analysis, which results in **forecasting** and **predictive** reports that are passed to the appropriate **government disaster management authorities for dissemination to the public as they see fit**.

The volcano in Montserrat is separately **monitored** in much the same way through the Montserrat Volcano Observatory (MVO), a team of British scientists designated to **observe, report on and provide scientific forecasts and predictions** for this hazard.

Other tiers of the warning system operate in much the same manner as for hurricanes.

4.2. Simple systems

4.2.1. Landslides

EWS for **landslides** depend on risk analysis supported by hazard mapping to determine areas prone to this activity based on historical and empirical data. Before or during heavy rainfall activity, population in landslide prone areas will be warned through a range of media options.

4.2.2. Rainfall flooding

Some **rainfall flooding** EWS employ basic rain gauges in communities with manual reading of rainfall levels at periodic intervals and reporting to national hydro-met authorities on telephone, vhf or CB radio by selected community persons.

4.2.3. River flooding

EWS in some instances also employ simple manual methods of measuring river activity using simple “height markers or river gauges” which are then reported to hydro met authorities on telephone, vhf or CB radio by selected community persons. In all cases, this information is analyzed, with forecasts and predictions publicized via a number of mass and community media options.

4.2.4. Oil Spill

EW for **Oil Spills** generally relies on national Port and Harbour Authorities maintaining close radio contact with passing ships laden with oil or other hazardous material that could pose a threat to the country. Any contamination would therefore be immediately reported to these authorities, whose mandates are to alert response agencies and implement containment and/or clean up activities.

4.2.5. Forest fires

EWS in most cases employ simple manual reporting of “bush” fires to local fire services who respond as soon as possible. Typically, this hazard is limited by the availability of serviceable fire engines sufficiently close to the impacted area to provide adequately short response times. Reporting is greatly assisted by the proliferation of cell phones throughout the region

4.3. Basic systems

4.3.1. Epidemics

Monitoring and forecasting are handled regionally by organizations such as the WHO, PAHO and the Red Cross, working closely with all countries. Nationally this is typically done by government epidemiological monitoring systems, which operate through standard manual reports from rural and urban clinics on a daily basis. Changes in health statistics at regional, national or community level would therefore be identified within at most 24 hours.

4.3.2. Pest Infestation

This follows a similar pattern to epidemics, as most countries have strong agricultural research & monitoring mechanisms that would detect unusual occurrences in a similarly short time frame.

In these cases too, information would be passed to the appropriate government and emergency authorities, from where the public alert system, would be activated.

Such information would spread rapidly, as the majority of the population have substantial connections to farming communities, where unscientifically verified information could create a panic.

As for epidemics, regional collaboration and monitoring is effectively performed by international agencies like WFP, PAHO and WHO.

4.3.3. Droughts

Droughts are slow onset emergencies and as such provide plenty of time for EW. Rainfall monitoring is the main source of information for this hazard and is typically conducted through the

National Met offices and underground water resources as well as national water provision authorities are responsible for provision of warning and response activities. In some cases where there is no national facility this is done on a sub-regional basis.

4.4. Automatic (Real time) EW Systems

4.4.1. Rainfall Flooding

EWS for rain inundation in a few cases employ “tip bucket” rain gauges that send a signal every time the bucket is filled to a certain point and tips over. It then uses vhf links to relay these signals in real time to a number of permanently manned base stations simultaneously. This information is fed into a computer model, which predicts the areas, extent and time of flooding, which is passed to the appropriate authorities for broadcast warnings by mass media and other methods to the public.

4.4.2. River flooding

EWS similarly employ river-bank sensors that use vhf links to relay signals in real time to a number of permanently manned base stations simultaneously. This information is then fed to computer models, which determine the location, extent and timing of expected flooding.

4.4.3. Hurricanes and Volcanoes

EWS for Hurricanes and Volcanoes, with the exception of some nationally installed weather radars, are virtually automatic to regional engineers, scientists and disaster managers, who monitor these global warning systems via the internet (Hurricane tracking systems, Volcano alert systems), automatically transmitted weather faxes, weather channels, seismometers set up by the SRU, MVO and other scientific institutions, as well as with other tools and procedurally warn appropriate zone authorities and communities using telephone, E-mail, list serves, cellular text messaging and a range of other media options.

4.5. Telemeterics

Tele-metering and other equipment for hazard monitoring, forecasting, predicting, warning and alerting operations include:

4.5.1. General

- Computers
- Sirens
- Bull horns
- Fax machines
- VHF/UHF radios to relay sensor signals and send warning messages
- Internet ready computers
- Land line telephones
- AM/FM radio receivers
- Satellite telephones
- Cellular telephone system
- SMS ready cellular telephones
- Computers
- Telephone lines
- Electronic (Radio and TV) Media houses
- AM 1KW transmitters

- Fixed frequency radio receivers

4.5.2. Hurricanes

- Computers
- Radios
- Cell phones
- Satellite phones
- Sirens
- Bull horns
- Weather radar

4.5.3. Rain inundation flooding

- Weather radars
- Rain Gauges
- Vhf transceivers including yagi antennae, power supplies, cables, and ancillaries
- Computers

4.5.4. River flooding

- River gauges
- Vhf transceivers including yagi antennae, power supplies, cables, and ancillaries
- Computers

4.5.5. Volcanoes

- Earth tremor sensors
- Volcanic Radon emission sensors
- VSAT terminals
- Low Earth Orbit Satellites (LEOS) (Commercial ownership/Time charges)
- Computers
- Radios
- Satellite phones
- Cell phones
- Sirens

4.5.6. Landslides

- Radios
- Hazard maps
- Bull horns
- Geographic Information System (GIS)
- Satellite phones

- Cell phones
- Sirens

4.5.7. Oil Spills

- Radios

4.5.8. Forest fires

- Sirens
- Bull horns
- Radios
- Computers

4.5.9. Epidemics

- Public media
- AM/FM radio receivers
- 1KW AM transmitter
- Fixed frequency radio receivers

4.5.10. Drought

- Public media
- AM/FM radio receivers
- 1KW AM transmitter
- Fixed frequency radio receivers

4.5.11. Tsunami

- Computers
- Radios
- Sirens
- Bull horns

4.5.12. Earthquakes

- Earth tremor sensors
- Low Earth Orbit Satellites (LEOS) (Commercial ownership/Time charges)
- Computers
- Radios
- Satellite phones
- Cell phones
- Video phones

4.6. Manual operations carried out

Throughout the range of EW systems employed, the following are some of the manual operations, which have already been articulated and are usually evident, particularly at the community level:

- Reading of rain and river gauges
- Monitoring appropriate internet web sites
- Operating fax machines
- Operating satellite TVRO systems
- Operating VSAT terminals
- Operating satellite telephones
- Uplinking data to LEOS
- Operating vhf/uhf/hf radios
- Operating computers
- Operating cell phones
- Temperature measurement of streams inside volcanoes by scientists
- Public media (radio and TV) warning announcements
- Print media warning articles
- Blowing Whistles
- Warnings with Megaphones
- Sounding Sirens (manual and automatic)
- Announcements over bull horns
- Radio announcements
- Ringing Bells
- Raising Flags
- Runners to carry messages
- Manual Cascade alerting and call out methods
- Weather radar operations
- Warning information content provision and data capture for transmission via SMS
- Maintenance of electronic equipment (Computers, radios, cell phones, communications links, rain and river gauges, fax machines, etc.)

4.7. Technical requirements

In order to carry out these operations, the following technical requirements are needed in both human and material resources at national and regional levels:

- Scientists, meteorologists and hydrologists to model and interpret hazards, based on historical and scientific data;
- Computer operators, analysts and programmers to capture and provide appropriate data for modeling, and to provide results in user friendly output formats;
- Computer operators for SMS systems to capture source warning data and transmit to appropriate population;

- Computer network and maintenance engineers and technicians to design and implement various networks and to keep tem operating efficiently
- Radio operators who understand the technical nuances of vhf/uhf/hf radio systems, satellite telephony and VSAT operations;
- Telecommunications Engineers and technicians to design and implement transducers and telecommunications systems to sense and capture geophysical activity and to transport the resultant data from its source to laboratories, operational areas and other destinations as necessary.
- Electronics technicians to maintain radio and other electronics equipment;
- Civil Engineers and contractors to provide and maintain permanent and improvised hard covering and shelter for personnel and equipment in sometimes remote, dangerous and inaccessible areas;
- Cellular telephone networks with SMS capability that are able to selectively address subscribers within threatened zones for warning messages;
- Telephone engineers and technicians to design, set up and maintain these networks;
- Radio and TV networks for media reach for public information;
- Media professionals to operate these networks in a professional and effective manner;

4.8. Costs

- **Consultants for study and implementation**
- **Equipment procurement**
- **Staffing**
- **Accommodation costs**
- **Transportation costs**
- **Telecommunications charges**
- **Spares holdings**
- **Maintenance costs**
- **Public announcements, advertising and media costs**
- **Other costs**

4.9. Technical Lessons Learned

4.9.1. Early Waning Systems are not simply about technical monitoring systems, or about sophisticated predictive and forecast computer models, or about transmitting information to the affected population and response agencies in accurate and timely fashion, but rather about well coordinated and balanced combinations of all these aspects. They therefore essentially include technical, organizational, institutional, social, legal and other considerations to produce holistic "SYSTEMS".

4.9.2. Redundancy and diversity in EW (especially alerting) technology has proven essential in "getting the message through". This is understandably so as environmental conditions, social amenities (eg electricity), cultural nuances, educational standards and a host of other factors affect the type of

application that will prove feasible for each community. A range of technologies from "high-tech" to "no-tech" is therefore needed to find a 'match' for every case. Where personal interest and stakes are high, community members are very resourceful in passing warning messages, be it by provision of electricity for radio equipment from "illegal" diversion of mains sources, 12 volt lead-acid (car) batteries and dry cell batteries, or by the use of coded signals from conch shells, drums or other methods.

4.9.3. Sufficient sensing and other equipment such as river gauges and communications gear, as well as their maintenance, are absolutely necessary for accurate and timely forecasting and predictions. In some cases tokenism is unrealistically expected to provide effective EW systems.

4.9.4. Most EW systems in the Caribbean are virtually dependent on HAM radio operators, who find their ideal "challenges" in the disaster communications arena. They have the technical competence across the diverse spectrum of communications methods and are happy to volunteer their expertise at both community and national levels.

4.9.5. Traditional disbelief in technological predictions as against local folklore and political maneuvering, is slowly being overcome as experiences such as the Montserrat Volcano have served to improve the authority of the scientists and have embarrassed those officials and opinion makers who refused to listen to the scientific forecasts and predictions before the event.

4.9.6. Increased confidence in scientific predictions have in some cases however acted as a double edged sword, as some communities are so overconfident that they believe they do not have to relocate to safer areas, since they believe the EWS will give them sufficient time to evacuate from the immediate hazard then return as soon as possible afterwards.

4.9.7. It must be mentioned that volcanic forecasting and prediction still remains very risky business and in some cases forecast information is not shared with the population by the scientific community for fear of being wrong and by the political directorate for fear of inappropriate and catastrophic community responses.

4.9.8. Deployment of EWS's in the Caribbean is generally limited only by financing, as funding for research and development and associated equipment, usually finds its way to the larger North American and European universities. Some research resources for volcanic activity have however penetrated the region, as is the case with the MVO, but this will hopefully soon be extended to Tsunami EW systems as well.

4.9.9. Caribbean National Emergency Management Organization's (NEMO's) with one or two exceptions, are under-resourced for anything but simple

monitoring and sometimes coordination of mitigation and response agencies before, during and after emergencies. Some simply act as national administrative offices for disaster matters. They rarely possess the technical capacity to support, operate or maintain technical EW systems. This development is however a continuous process, as seen by the vast strides made in recent years by some countries, almost always prompted by a major disaster event.

5. INSTITUTIONAL ASPECTS

Caribbean people have an uncompromising desire for freedom of expression (and consequently information), as manifested by the disproportionate per capita proliferation, range and programming of public media houses, for television, radio and print content, hence EW benefits naturally from this constant and vast stream of available information.

Institutional arrangements for EW are therefore fashioned to take advantage of this natural resource.

5.1. Design, implementation and routine operation and maintenance of the systems

These responsibilities are shared by a range of institutions and practitioners at diverse levels as follows:

5.1.1. Hurricanes

Scientists, Engineers, Meteorologists, Hydrologists, equipment manufacturers/suppliers and other practitioners at global and regional levels design, implement and operate and maintain the EW monitoring, forecasting and predicting system. Institutions that they represent include:

- US Military
- NHC
- NOAA
- UWI
- CMO
- CCCC
- Others

National level monitoring and alerts would then be issued by designated government agencies, media and NGO's, from institutions such as:

- National Disaster Offices
- Red Cross

- Defence Forces
- Police Forces
- Fire Departments
- Radio stations
- Newspapers
- Cable operators
- HAM clubs and operators
- Village Chairmen
- Others

5.1.2. Tsunami

The "Global" Tsunami Warning Centre based in Hawaii is to be used as a model for a proposed real time automatic Tsunami EW system for the Caribbean, as the active and growing sub-aqua volcano "Kick Em Jenny" provides the threat of a major Tsunami hazard for some Eastern Caribbean states.

5.1.3. Volcanoes

Scientists and Engineers at Sub-Regional level design, implement and operate and maintain the system. Institutions represented are:

- UWI – SRU
- UK Universities - MVO

Responsibility for alerts remains with national agencies as for hurricanes.

5.1.4. Real time Rain and river gauges

Engineers and scientists at national level design, implement and maintain the system on behalf of government agencies;

The system is typically operated (and sometimes maintained) at local level by members of the community, who in many cases read gauges and report to national authorities as they have been trained and equipped to do.

5.1.5. Oil Spills, Landslides, Epidemics, Pest infestation, Drought

Technical practitioners from global, regional and national agencies collaborate to design and implement and maintain the monitoring and forecasting system. Such agencies would include:

- IMO
- WHO
- PAHO
- Red Cross

- NOAA
- CCCC
- CMO
- and others

Operators would represent a range of government agencies and community persons of both elected and non-officials, as stated for hurricanes above.

5.1.6. Blowing Whistles, Warnings with Megaphones, Sounding Sirens, Ringing Bells, Raising Flags, Manual cascade call out methods, Reading of rain and river gauges, Warning information content provision and data capture and transmission for SMS.

National disaster managers along with Disaster workers at the community level, design, implement, operate and maintain warnings to the public.

Media professionals at national and local levels disseminate information as necessary;

Technicians at national and local levels operate and maintain computers and other electronic equipment;

5.2. Roles and responsibilities of the institutions with respect to EWS:

The following formal and informal roles are carried out by institutions in the Caribbean region:

5.2.1. CDERA

- Coordination of all aspects of sub-regional disaster management

5.2.2. National Governments (through their respective disaster offices and other agencies)

- Safety of population and property by delivery of timely warning and alerting procedures for impending disasters.

5.2.3. UWI (Earthquake Unit, SRU, Climate Modeling Unit, Unit for Disaster Studies)

- Analyses of hazards and design of appropriate EW systems.
- Implementation and operation of the of system,
- Monitoring and reporting on Caribbean volcanoes;
- Collaboration with all global, regional and national entities.
- Training of DM professionals to carry out their mandates

5.2.4. CMO / Caribbean Institute of Meteorology and Hydrology

- Monitoring, forecasting, predicting and disseminating warnings for weather information for Caribbean states

5.2.5. MVO

- Analyses of hazards;
- Design and implementation of EW system;
- Operation of EWS
- Monitoring and reporting on Montserrat volcano;

5.2.6. Caribbean Climate Change Centre

- Monitoring, forecasting, predicting and disseminating warnings for climate changes in Caribbean states including El Nino and its effects on flooding, landslides, hurricane frequency and strength, etc.

5.2.7. All Regional Tertiary Institutions

Tertiary institutions in the region other than the UWI, have not yet been able to offer disaster management training (including EW), but a few of them, as well as other governmental initiatives, are actively considering adding this to their agenda.

5.2.8. Media

There is typically more than adequate media density and coverage comprising newspapers, television stations, community cable companies and radio stations in the Caribbean. Their disaster management function is to disseminate EW information as requested by the appropriate government authorities, but they are also at liberty to publish any disaster information that they have and feel worthy of broadcast.

5.2.9. HAM operators

In most cases they operate a range of radio systems from HF to very sophisticated web based communications and form the informal (and sometimes formal) vanguard of EW for their countries. They operate at both local and national levels.

5.3. Legal aspects relating to alarms and false alarms

CDERA is tasked by CARICOM through a regional council, to provide warnings and to coordinate regional activity as a part of its mandate.

EW is not specifically covered by legislation, although Disaster Management is in most countries backed by an "Act of Parliament" at national levels, which, through national disaster plans includes EW warnings and alarms as a set of tasks to specific national and community agencies and appointments. There is likewise no legal sanction at regional or national levels relating to false EW alarms, however erroneous alarms would certainly affect institutional and individual credibility.

There is however a more structured set of rules, including some legislation between OECS states at sub-regional level.

5.4. Legal aspects associated with institutional assignments

Institutional EW assignments in most cases are done at national level through national disaster plans, which are backed by "Acts of Parliament". This includes a set of tasks to specific national and community agencies, institutions and appointments.

5.5. Use of the frequency spectrum

It has not generally been difficult obtaining frequencies for EW assignments in the Caribbean, as these are in most cases managed by a government Telecommunications Officer who is usually well incorporated within the disaster management structure. All countries have designated emergency channel(s) available for EW and disaster operations.

This will however become increasingly difficult, as with the rapid influx of cellular and other wireless commercial telecommunications services being offered in the region and with the consequent increasing demand for frequencies, governments are beginning to auction parts of the spectrum that may otherwise be assigned specifically to EW.

This is not necessarily bad however as EW has already begun and will continue to benefit significantly from these commercial operations, as their licenses usually contain a clause for provision of EW/DM services in time of emergency.

6. SOCIAL (COMMUNITY) ASPECTS

6.1. General results

Over the past 10 – 20 years, fewer lives have been lost from the two most prevalent hazards, hurricanes and flooding. This is generally attributed to improvements in EW resulting from the marriage between technical and social community systems, by the inclusion of community members in the EW process through disaster public relations and education programmes, training and decentralization and consequent greater availability of information.

There is still however significant property loss, as EW systems have militated against relocation and other mitigation strategies for disaster reduction, since the community perception of improved EW in some cases causes settlement with relative complacency in flood prone river basins and other high-risk areas and housing development in these areas with sub-standard building codes. This in turn

increases the demands on disaster management resources, as it puts additional pressure on response and recovery systems.

Most rural Caribbean communities now have some access to electricity or else they improvise using car battery banks with power inverters to provide alternating current for operating radios, computers and other lifeline equipment.

Many rural community members do not have computers, but in some instances get on-line information from those few persons in their own or neighbouring communities or work places that have such access.

Proliferation of mass media assists greatly in disaster EW, as talk shows and news programming dominate the airwaves. To find out what is happening in the countries of the region, one simply has to tune in to a radio station at any time of the day or night.

6.2. Social (community) acceptance

Community acceptance of EW systems varies from very high to no interest, depending on the type of hazard and level of involvement. In some countries, volcanoes for example represent a superstitious bad luck to "god fearing", traditional communities, who believe that such hazards are the "rods" of the almighty and that man should not be interfering by trying to predict its outcome. They ignore EW systems as they prefer the 'ostrich syndrome' of burying their heads, rather than face the harsh realities. They believe that when God is ready he will give them a sign and whatever is to be will be the will of God.

Other communities however grasp at introduction of EW technology and see this as a means of opportunity for the youth to progress by learning this science.

In other cases, EW information is tightly controlled and virtually hidden from communities, as the government may not have the resources to take the necessary actions to protect the community and expose itself to harsh criticism and possible political backlash.

6.3. Community involvement

Rain and river flooding EWS experience good interaction with communities. These systems are of necessity built with and by the community, so they automatically feel a sense of ownership, which account for their successes.

The following examples of simple, manual EW and alerting systems, are operated solely by community members, who take pride in their jobs as it gives them a sense of authority, importance and status.

- Blowing Whistles
- Warnings with Megaphones
- Sounding Sirens
- Ringing Bells
- Raising Flags
- Manual cascade call out methods
- Reading of rain and river gauges
- Radio operation
- Warning information content provision and data capture and transmission for SMS

6.4. Effectiveness of the system at community levels

Experiences with hurricane EW systems have proven to be very positive in recent times, as increased community awareness of the hazard and EW methods have reduced loss of life and property during events. Some systems however (eg volcanos, tsunami, earthquakes) have not really been fully tested (with the exception of Montserrat's volcanic eruption) and will not be until an actual event occurs. Much work still has to be done through education at the community level. Communities are however becoming increasingly aware of the importance of EW to their safety and well-being.

The Montserrat experience has also proven that as more attention was payed to the social aspects, more trust was developed by the community for the scientists and their warnings, an essential element that was sadly lacking at the early stages of that catastrophic event.

6.5. Additional benefits/advantages of a community approach

The following additional advantages of the community approach to EW are noted:

- It creates ownership by community members;
- It makes it easier to get acceptance and for community members to prevent equipment from being vandalized or mistreated;
- It ensures smoother EW operation and maintenance;
- It saves lives and property as EW takes on a personal meaning;
- Practical workable ideas come from community itself;
- Historical information on past catastrophic events is made available by older community members, which is used by the EW system for forecasting and predictive modeling;
- It becomes much easier to take care of groups with special needs such as:
    - the indigent and infirmed;
    - those with language barriers;
    - the mentally insane;
    - the disabled;
    - others.

7. BEST PRACTICES/METHODS

7.1. Socialization (Community involvement) in the systems

Some effective examples of EW systems with community involvement are:

7.1.1. In Jamaica, rain and river flood monitoring and reporting EW systems are designed and implemented along with community members, who then operate and maintain these systems to provide backup up and verification for real time, automatic systems. This 'ownership' allows for system security and a higher degree of accuracy in recording, reporting and warning procedures.

7.1.2. In the British Virgin Islands, school kids volunteer to form a "Youth Auxiliary Corps" which is integrated into the daily prevention, preparedness and mitigation activities of the Office of Disaster Preparedness, as well as providing staffing of the EOC in times of emergency activation. This assists in providing a seamless community EW and response mechanism, while developing a national culture of disaster preparedness by educating the youth.

7.1.3. In Belize, Alcaldes (or other village leaders) in some rural communities are issued with vhf radios for receiving emergency warnings and with sirens and bull horns for alerting the community.

7.1.4. In Belize, river gauges and rain gauges are read by designated community members, who report to local and national authorities by vhf radio.

7.1.5. In Jamaica, community members are trained by the Red Cross as 'Community Emergency Response Teams' and act as first responders for landslides and other rapid onset events that need immediate response in order to save lives.

7.1.6. All Caribbean states now have facilities at national level and in many communities, for tracking hurricanes either on the internet or on hurricane maps that are widely distributed. The information for tracking maps is regularly announced on radio stations, which are easily accessible to the vast majority of people.

7.1.7. In Belize and in the Turks and Cacos Islands, churches issue 'single frequency' radios freely to members of remote villages primarily for the purpose of promoting religious material. These radios double as an effective EW system for any disaster, but mainly for hurricanes, as these radios are listened to almost constantly throughout the day.

7.1.8. The city of Georgetown, Guyana is primarily built with lumber, creating a severe fire risk. They have however mitigated this hazard by maintaining fire breaks between blocks of houses and have an effective EW system of fire warders that use bells and sirens in the event of a city fire that could become a major national catastrophe.

7.2. Issues of decentralization

As mentioned before, the strong demand for freedom in the Caribbean allows for excessive decentralization of information, which has worked well for EW systems. Fewer people now die from hurricanes and flooding due partially to decentralized EW systems.

Whereas decentralized hazard monitoring is encouraged wherever practical, centralized and tightly controlled forecasting, prediction and alerting are still understandably practiced in almost every case in order to prevent inappropriate responses.

Decentralization works well for multi-island states with relatively large populations and on larger islands with large diverse pockets of people as they reduce the risk of not passing warnings in time due to communications or other failures.

Multi-island states with small populations on many of those islands use good communications equipment and centralization of resources for best effect.

Small, under-resourced, single island states choose total centralization strategies, as it is relatively quick and easy to get information to all communities and this makes best use of scarce resources.

Decentralization has been shown to work best with effective community education. This is the only way to prevent uncoordinated and inappropriate responses.

Cases where centralized systems have not provided remote populations with proper education and adequate communications have led to unofficial decentralization as people start to fend for themselves.

Such systems can however exhibit both positive as well as negative attributes. Some positive attributes are:

- They put additional pressure on **government and** DM agencies to perform creditably, since communities and individuals can get information before designated authorities and which could prove at least embarrassing;
- They provide faster, **simultaneous** information dissemination to the public;
- They provides information from a number of sources that can be cross-verified against each other;
- They allow government agencies to focus more on education and response procedures, rather than channeling too much energy into information management;

- **They help to remove EW dependency on personalities, which is a strong tendency among small under-resourced states.**

Some negative attributes are:

- Erroneous information can be passed to the public without verification, leading to inappropriate and uncoordinated responses, and to excessive loss of life and property for which the government may be blamed unnecessarily.
- Government loses some control of how they want the public to react to specific types of emergencies.
- **They can absolve government and DM authorities from accountability for errors, as they may not accept responsibility for inappropriate responses**

8. CRITICAL POINTS

8.1. Technical sustainability

Sustainability of EW systems is generally high, except in cases that are related to funding (unaffordable equipment, replacement parts or software procurement). This is usually more acute when systems are maintained by government agencies as opposed to NGO or private/commercial efforts, as the former is often tied up by beaurocracy or the money is simply not available.
There is usually very good technical competence available in the larger countries of the region that smaller countries access easily when necessary from neighbouring states or from the UWI or other regional institutions.

8.2. Analysis of cases of systems implemented by NGO's

More sophisticated, non-government EW systems that are not "community oriented" (such as volcano monitoring by the MVO in Montserrat and SRU in Dominica, as well as others), tend to work well up to the point were information is passed to the government. Thereafter, this information becomes an item of great political significance and sometimes does not reach the community, but is either hidden or 'sanitized' by the government. The usual reason given is that the population may panic unnecessarily, leading to further problems, but whereas this is often true, it is not in some cases the entire reason.

In some cases, public servants who are privy to adverse forecasting information that is being withheld, fear that leaking such information could either jeopardize their jobs or compromise them in some other way.

9. INSTITUTIONS

9.1. Typical mechanisms of technical assistance

Technical assistance is typically accessed through a number of channels:

- Direct employment of consultants by government with Terms of Reference developed by prior study/studies;
- Direct government employment of consultants using commercial or development bank loans or grants (typically IADB, World Bank, CDB, etc), with Terms of Reference developed by prior study/studies;
- Multilateral funding assistance based on project proposals (through UNDP, ITU, OCHA, ECHO, EU, OAS, OECS, ISDR etc). In most of these cases, funding agencies will assign implementing agencies such as CDERA, an appropriate government ministry or department, a relevant NGO, or other suitable and trusted organizations to manage and report on projects, including the selection of consultants.
- Bilateral funding assistance based on project proposals (typically through rich, industrialized countries (DFID, USAID, CIDA, NHC, etc). These cases are characterized by consultants and equipment from donor countries, or a mixture or donor and regional consultants;
- Consultancy and/or research based assistance from the UWI/SRU, MVO and other international and regional tertiary institutions;
- Internet based assistance from the Caribbean Meteorological Organization, National Hurricane Centre, Global Fire Monitoring System, Tsunami Warning Centre and others;
- Intra regional secondment of disaster managers, where more developed regional disaster offices provide assistance to lesser developed ones by temporary loans of their experienced personnel;
- General assistance through liaison with ongoing funded projects (such as the Caribbean Climate Change Centre, MVO and others)

9.2. Experiences

Experiences with technical assistance have generally been good, as regional consultants have typically been used by funding and implementing agencies who:

- Understand the great importance of the social considerations in the region
- Understand the cultural and social nuances in the region.
- Understand the political, cultural and other feasibilities of technological applications

There has traditionally been good relations with and service from equipment suppliers in industrialized countries, which are in many cases are either project donors or otherwise integrally involved in the welfare systems of countries in the region.

There is still however a need for agreement on a methodology for accessing information and consultants from key regional and international institutions, instead of simply imposing ‘foreign’ ‘conventional solutions’ that tend to be costly and wasteful as they either alienate and undermine regional and national competence, or else they lead to recommendations that are impractical and out of sync with the realties on the ground.

On the other hand technical assistance is sometimes undermined when consultants' report to or through political figures, whose partisan or other interests may not necessarily be met by professional conclusions. This type of situation, which is sometimes achieved by discrediting reports as "impractical" or "unrealistic" and could lead to loss of interest in further assistance from consultants, suppliers, scientific and other institutions and donors, which would inevitable result in increased vulnerability of the population.

There is typically limited technical material resources in the region and even where systems are implemented and working properly, there is inadequate redundancy, which undermines the reliability when it may be needed most. Critical shortages typically exist with basic communications facilities such as radios, telephone services, fax machines and other basic items.

10. ADEQUACY OF EWS

10.1. Necessary relationships

In order to promote and develop efficient EW systems, it is necessary to establish and maintain relationships with a number of entities for various purposes. Below are some of these partnerships of necessity with:

10.1.1. **CDERA** for:
- Maintaining a regional perspective to monitor best practices and suggesting their adoption as necessary to prevent some countries from being left behind;
- Finding donors for EW development funding;
- Coordinating EW/DM development in the region;

10.1.2. **North American and European equipment and other suppliers** for:
- Procurement and training on technical equipment;
- Possible adaptation of indigenous technologies;

10.1.3. **Central and Latin American counterparts** for:
- Sharing ideas and experiences that will continue to elevate EW systems throughout the hemisphere;
- Cross cutting global and hemispheric research involving technological and social aspects of EW;

10.1.4. **International agencies** for:
- Providing sources of funding for training and EW development and maintenance;

10.1.5. **UN and other multilateral agencies** for:
- Providing funding for training and development projects;

10.1.6. **Bilateral donors** for:
- Providing assistance with training and development and maintenance of EW systems;

10.1.7. **Caribbean Development Bank** (CDB) for:

- Loans and grants for training and project development;

10.1.8. **World Bank and IADB** for:

- Loans and grants for training and project development;

10.2. Technical capability

Technical capability in science and engineering is not short at the region level, however wherever this exists at the national level, it may be satisfied from neighbouring or other regional states.

At the technician level, there is an increasing shortage of skilled workers, as the young people are either migrating to North America, or are tending away from technical and scientific endeavors towards entertainment, sports and other activities where they see much greater and more instant remuneration.

There is almost always a shortage of funds for procuring equipment of all types, from simple radios for relaying warning data and messages, to complex equipment for monitoring, forecasting and communications.

Other specific skills that are not available in the region are readily obtainable from North America, due to its close proximity and relatively easy access.

The technical shortages therefore typically fall into the equipment and training areas, since whereas there may be technical competence to implement or install systems, the longer term maintenance demands tend to suffer from shortages and rapid turnover of technical personnel, which leads to inconsistencies in equipment maintenance and procedural standards.

10.3. Binding systems with the communities goals

Whereas early warning and disaster management are very much like insurance policies, in that they think about what if, futuristic scenarios and whereas the most vulnerable communities are poor, rural villages, where people live from hand to mouth only concerned with present issues of daily survival, communities have few, if any other recognizable goals, or else they are very difficult to define, let alone to bind or match EW systems.

Such communities are usually more culturally than technologically skewed, hence tradition, religion and culture, including music and recreational activities play great roles in the lives of these communities, which are in many cases taken into consideration when developing EW systems.

The “pride” and “status” factors are also strong in the region, particularly among poorer communities. Poor Caribbean people are often very religious and extremely proud of their rich cultural heritage and their high standards regarding honesty and other moral ideals, which elevates their status in the community and it is these people in which community based EW systems may safely be entrusted.

These communities will be found to be favorable to technological and other improvements in their communities, depending on the bearers of the new systems. They usually tend to be more receptive to agencies that do not represent political or even governmental interests, (such as the Red Cross and other NGO’s), but that they perceive represent a more genuine interest in their well being.

Younger community members are increasingly exposed to urban extravagancies and behavior, and they sometimes take these bad attitudes into the community life, creating a “struggle” between the older, generally more responsible patrons. This sometimes translates into vandalism of equipment and other delinquent actions unless they are deliberately convinced that there is something in this for them.

There are also those within the community who have criminal and/or partisan political ambitions and who try to manipulate every system within the community for their own personal interests. They also should be, and are sometimes considered when designing and developing EW systems.

10.4. Criterion for the selection of EW systems

Whereas no formal criteria have been established for selection of EW systems, successful EW systems have generally been found to fit the following patterns:

- They are relevant to the level of vulnerability of the community;
- They create training opportunities in the community;
- They create employment and or status building opportunities for individuals within the community;
- They create a sense of recognition, importance and identity for the community as a whole;
- They have cultural acceptance (superstition free) by the community;

10.5. Sustainability

Sustainability has quite understandably followed a similar pattern of considerations and these are:

- The availability of technical competence within and at close call to the community;
- The financial affordability and maintainability of the systems;
- The social acceptance;
- Political accepted at national and community levels;

10.6 Unintended additional benefits of EW systems

- **Improved integration between government agencies;**
- **Exposure to technology**
- **Proliferation of technical expertise and information;**
- **Improved telecommunications and other equipment for Police, Fire and other response agencies;**
- **Increased confidence in scientific predictions and systems**
- **Youth involvement in disaster management**

11. STRATEGIES

The following strategies for the acquisition, implementation and sustainability of EWS with a focus on the social and institutional aspects were agreed by the conference based on combined experiences.

It was considered absolutely essential that global, hemispheric, and regional strategy should be founded on the strengthening of national capability.

11.1.1. Determine and cost needs;
11.1.2. Key institutions to be a clearing house for consultants;
11.1.3. Seek sponsorship for budget shortfalls;
11.1.4. Identify national and regional consultants for system design, implementation and maintenance;
11.1.5. Identify equipment manufacturers and suppliers who are able to finance proposals;
11.1.6. Seek political acceptance of systems;
11.1.7. Seek involvement from all sectors within the community;
11.1.8. Seek more cooperation and dialogue between intra-hemispheric partners;
11.1.9. Develop guiding principles for EWS in the hemisphere;
11.1.10. Support existing organizations and programmes;
11.1.11. Share experiences with other partners in the hemisphere;
11.1.12. Promote technology transfer from industrial countries;
11.1.13. Consider transnational boundary threats eg. El Nino, epidemics, and new threats without existing EWS;
11.1.14. Promote networking between inter and intra regional monitoring mechanisms (SRU, Universities, etc);
11.1.15. Identify existing mechanisms and institutions in the region that relate to Early Warning;
11.1.16. Support mechanisms for accessing and sharing information on best practices developed using different technologies and institutional arrangements;
11.1.17. Support key institutions, processes and mechanisms for data capture;
11.1.18. Support the development of appropriate indigenous technologies and their applications to EW;

11.1.19. Promote EW issues in existing stakeholder forums for sharing experiences and new developments;

11.1.20. Establish monitoring systems and networks for non traditional hazards;