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CARIBBEAN 2017 HURRICANE SEASON AN EVIDENCE-BASED ASSESSMENT OF THE EARLY WARNING SYSTEM



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Acronyms

ACE	Accumulated Cyclone Energy	DRR	Disaster risk reduction
ACS	Association of Caribbean States	DVRP	Disaster Vulnerability Reduction Project
BVI	British Virgin Islands	EOC	Emergency Operation Centre
CARICOM	Caribbean Community	EU	European Union
CAP	Common Alerting Protocols	EW	Early Warning
CBOs	Community Based Organisations	EWS	Early Warning System
CCRIF SPC	Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company	ESSC	Education Sector Sub Committee
CDM	Comprehensive Disaster Management	GBV	Gender Based Violence
CDM CHC	CDM Council on Harmonization and Coordination	GDP	Gross Domestic Product
CDEMA	Caribbean Disaster Emergency Management Agency	GFDRR	Global Facility for Disaster Reduction and Recovery
CDB	Caribbean Development Bank	GIS	Geographic information system
CERT	Community Emergency Response Teams	HAM radio	Amateur radio
CIMH	Caribbean Institute of Meteorology and Hydrology	HoHs	Head of Household
CMC	Caribbean Meteorological Council	ICAO	International Civil Aviation Organisation
CMO	Caribbean Meteorological Organization	ICT	Information and communications technology
CPA	Country Poverty Assessment	IFRC	International Federation of Red Cross and Red Crescent Societies
CPI	Country Price Index	LAC	Latin America and the Caribbean
CREWS	Climate Risk and Early Warning Systems	LGBTIQ	Lesbian, Gay, Bisexual, Transgender, Intersex and Questioning
CU	Coordinating Unit	MDS	Meteorological Department St. Maarten
DASPA	Dominica Air and Sea Ports Authority	MS	Meteorological Services
DDME	Department of Disaster Management and Emergencies	NDO	National Disaster Office
DECR	Department of Environment and Central Resources	NDMOs	National Disaster Management Organisations
DOWASCO	Dominica Water and Sewerage Corporation	NEOC	National Emergency Operations Centre
DRM	Disaster risk management	NEP	National Employment Program
		NEPO	National Emergency Planning Organisation
		NHC	National Hurricane Center

NMHS	National Meteorological and Hydrological Service	SPSS	Statistical Package for the Social Sciences
NOAA/NHC	National Oceanic and Atmospheric Administration / National Hurricane Centre	SWFDP	Severe Weather Forecasting Demonstration Project
NODS	National Office of Disaster Services	TCI	Turks and Caicos Islands
ODM	Office of Disaster Management	UK	United Kingdom
OECS	Organisation of Eastern Caribbean States	UN	United Nations
OTs	Overseas Territories	UNDP	United Nations Development Program
PDNA	Post-Disaster Needs Assessment	UNIFEM	United Nations Fund for Women (now the UN Women's entity for Gender Equality)
QLI	Quality of Life Index	UNISDR	United Nations International Strategy for Disaster Reduction
QMS	Quality Management System	US	United States
RRM	Regional Response Mechanism	USAID	United States Agency for International Development
RRR	Report of the Rapid Review	USD	United States Dollar
SIDS	Small Islands Developing States	WBG	World Bank Group
SLC	Survey of living conditions	WMO	World Meteorological Organisation
SOP	Standard Operational Procedure		

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Foreword

The 2017 hurricane season in the Caribbean was unprecedented. High-powered, high-impact hurricanes, including *Irma and Maria*, left a path of destruction, infrastructure damage and casualties in more than a dozen territories in the region. Without forecasts and warnings, the tragic loss of life would have been even higher.

Climate change is heating both the seas and the atmosphere. A warmer atmosphere holds more moisture, increasing the rainfall associated with tropical cyclones, and although climate change is not expected to lead to a greater frequency of tropical cyclones worldwide, it may increase the number of the most powerful ones. Coastal regions, made more vulnerable by development and population expansion, will bear the brunt of increasingly destructive storm surge flooding, fed by sea level rise due to global warming-related glacier melt and ocean thermal expansion.

The World Meteorological Organization (WMO) has a long track record of assisting National Meteorological and Hydrological Services (NMHSs) and regional institutions by providing technical and financial resources and works closely with other early warning stakeholders with a view to reducing the impact of all hydrometeorological hazards. Given the intensity of the 2017 hurricane season and the scale of the impacts, and in light of current climate change projections, WMO initiated a review of the existing early warning systems (EWS) to better understand the region's urgent needs.

Through the Climate Risk and Early Warning Systems (CREWS) Initiative - a partnership for enhancing climate resilience between WMO, the World Bank and the United Nations Office for Disaster Risk Reduction (UNISDR) - the EWS review has been completed.

Together with our CREWS partners, WMO collaborated with the Caribbean Institute of Meteorology and Hydrology (CIMH) as well as the Caribbean Disaster Emergency Management Agency (CDEMA). These two institutions brought together key actors from the hydro-met and disaster risk reduction communities to critically assess the performance of early warning systems. In addition, a targeted and complementary assessment of gender integration in early warnings was carried out by a regional gender expert.

Findings from the EWS review are presented in this report. These include the need for impact-based forecasting and risk-based warnings, in particular for secondary hazards such as coastal flooding and flash floods. The review also recommends increasing the capacities of and standardizing the operational procedures between NMHSs and disaster risk management institutions. It is also evident that additional efforts need to be undertaken to ensure that early warnings reach those that need them the most in a manner that leads to effective action.

I expect the findings of this report to guide upcoming investments in the region, such as the recently approved CREWS project "Caribbean: Strengthening Hydro-Meteorological and Early Warning Services".

At WMO, we remain committed to supporting climate change adaptation, disaster risk reduction and sustainable development, and together with our partners, we will continue to work towards closing the capacity gap in the provision of weather and climate services.

WMO Secretary-General **Petteri Taalas**

Executive Summary

This report presents the key findings and recommendations for strengthening multi-hazard early warning systems in the Caribbean, following the first-ever systematic review of their performance in a post-disaster environment. The review took place after the passage of Hurricanes *Harvey*, *Irma* and *Maria* which significantly impacted more than 12 island States in the region in 2017.

While it is not possible to quantify the number of lives saved in the region by the early warning systems during the 2017 hurricane season, evidence points to the fact that the number of casualties was significantly lower than it could have been. This is due, in part, to the capacity to predict hurricanes, which Members of the World Meteorological Organization (WMO) have built in the region over the past 40 years, through the Hurricane Committee. The adverse consequences, both in terms of casualties and socioeconomic losses, were further reduced thanks to the ability to disseminate information on the potential impact of the hurricanes and the capacity of the countries and their population to understand the warnings, to be prepared and to respond.

It is clear, however, that the loss of lives, livelihoods and assets is still excessive. With climate change and rapid development along the coastline, strengthening the capacity to issue multi-hazard early warning that lead to effective response by institutions and people remains a priority for countries in the region.

The report identifies a number of areas in the value chain of the early warning systems that could have functioned more effectively.

KEY FINDINGS

1. HURRICANE SEASONAL PREDICTIONS FOR 2017

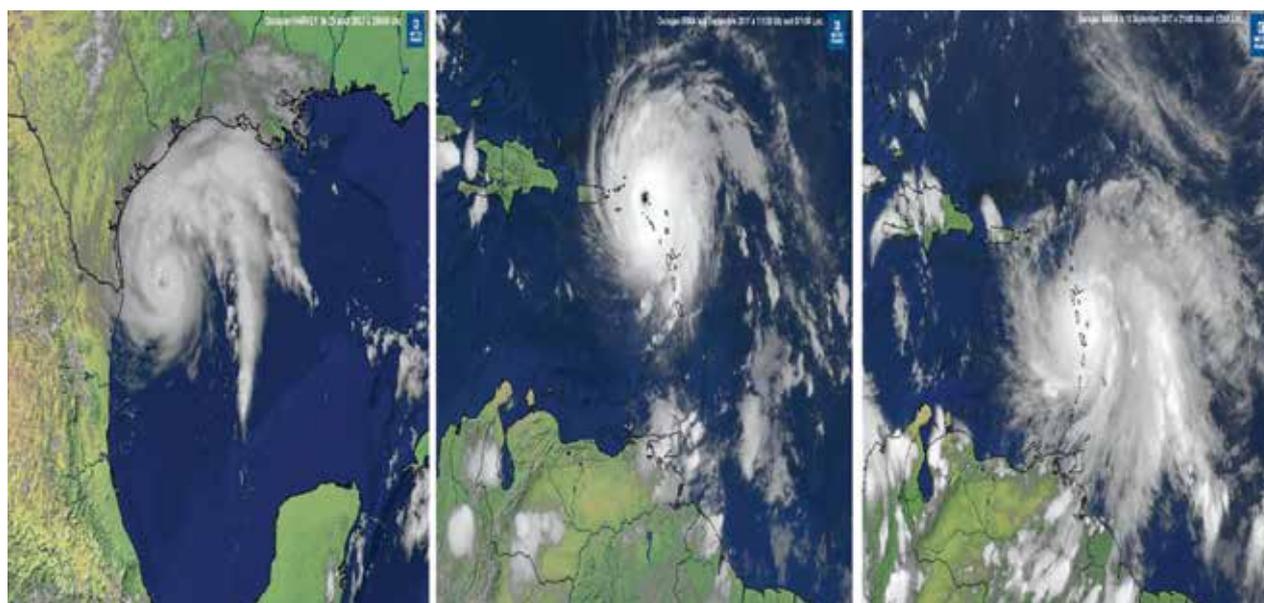
In May 2017, the National Oceanic and Atmospheric Administration (NOAA) released a prediction, citing a 70% chance of an above-average season, predicting 11–17 named storms, 5–9 hurricanes and 2–4 major hurricanes. Earlier predictions for the season had anticipated that an El Niño would develop, lowering hurricane activity. The predicted El Niño failed to develop, with cool-neutral conditions developing instead, later progressing to a La Niña – thus pointing to a more active season.

While this information is thought to be useful in raising public awareness, it is seldom used by countries for preparedness. Most countries indicate that they prepare for a worst case scenario each season.

2. FORECAST ACCURACY FOR HURRICANES THROUGHOUT THE SEASON

While challenges remain regarding the forecast of changes in the intensity of hurricanes and the communication of uncertainty, predictions of the hurricane path and intensity were overall accurate. Most countries began preparations to manage the hurricane impacts once they were included in the three to five-day cone of uncertainty, which indicated potential impacts. A number of countries initiated shut down procedures up to 24 hours before the likely impact of the hurricanes.

Figure 1: Hurricanes *Harvey*, *Irma* and *Maria*



Source: Jean-Noel Degrace, Météo-France

3. PREDICTION CAPACITIES AND EARLY WARNING SYSTEMS FOR SECONDARY HAZARDS SUCH AS STORM SURGES AND FLASH FLOODS

The availability of storm-surge forecasts providing probable storm tide (surge) height, as well as flash flood early warning systems, with related products for operational use, would contribute to reducing loss of life and assets across the region. Storm-surge forecasting pilots in the Dominican Republic and Haiti show promising results.

4. SHIFT FROM EXTREME EVENT FORECASTS TO IMPACT-BASED FORECASTS

Alerts and warnings remained principally driven by information on extreme events such as high winds, precipitation, storm surge and other types of coastal inundation. Such data combined with risk analysis to provide information on the impacts would have increased the effectiveness of the warnings and led to more appropriate actions by the population. The review found that there is an insufficient use of existing social vulnerability data combined with limited use of existing risk maps available in the region. These could be used to produce simple pre-computed impact products, which are designed to forecast hazard impact.

5. OBSERVATION INFRASTRUCTURE, COMPATIBILITY OF INSTRUMENTATION, INCLUDING WEATHER RADAR COVERAGE, AND SUPPORT TO ENSURE THEIR OPERABILITY

A number of shortcomings were identified regarding observation instruments including incompatibility of instruments due to the multiplicity of brands and the absence of maintenance plans. Efforts are required to ensure radar coverage, and to keep installed radars operational in accordance with the recommendations of WMO Integrated Global Observation System (WIGOS). There is a system in place in the region, which could benefit from further support: the Caribbean Institute for Meteorology and Hydrology (CIMH) maintains a stock of radar spares and dispenses them to Caribbean countries as required.

6. DISASTER-RESILIENT INFRASTRUCTURE OF NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES

The issue of the resilience of National Meteorological and Hydrological Services' (NMHSs) infrastructure was raised, both for the buildings housing the national weather services and for the observation equipment, as a number of weather services across the islands suffered significant damage. This affected their ability to communicate effectively with their partners. Stakeholders stated that the resilience of the physical structures should be prioritized as this plays a major role in the continuity of their operations during extreme conditions.

7. LACK OF REDUNDANCY IN EMERGENCY COMMUNICATION SYSTEMS

The fragility of the existing emergency communications architecture was evident when islands were hit by several

hurricanes. The communication systems failed, and at times the National Disaster Offices (NDOs) were cut off from the NMHSs, for as long as five days in at least one instance. This hindered communication with internal and external response actors and also affected the coordination of the humanitarian actors after the events. The failure of emergency telecommunications was attributed to the lack or absence of redundancy in the current emergency telecommunications systems, as well as to the unsuitable physical facilities of the National Emergency Operations Centres (NEOC). The urgent need for emergency communications was also raised when discussing shelters as a priority sector in the post-disaster environment. Shelters provide a key interface among risk knowledge, hazard monitoring and warning, and readiness actions. Many stakeholders indicated that this area required urgent attention as they were often without updates on the status of weather systems. Given the severity of the events, there was a great demand for shelters. Stakeholders agreed that the facilities were inadequate and that risk knowledge should have been applied to the selection process of shelters.

8. PUBLIC CONFIDENCE IN WARNINGS

Caribbean citizens were insufficiently aware of the bulletins, watches and warnings for their islands provided by the issuing Weather Forecast and Warning Offices, which were late in disseminating the relevant information to the primary recipients. In order to ensure the availability and reliability of warnings and alerts, hydrometeorological personnel expressed the need to scale up capacities as part of the subregional arrangement for the NMHSs, established under the Caribbean Meteorological Organization (CMO). Under this arrangement, countries such as Antigua and Barbuda have forecasting responsibilities for four additional islands in addition to their national mandate. The review also identified problems with the dissemination of information to indigenous populations (for example, to the Kalinago people from Dominica and Barbuda).

9. GENDER-SENSITIVE WARNINGS

There is limited understanding of how to include gender in EWS. In particular, there is a need for increased integration of gender bureaus in preparedness and early warning system initiatives. The review revealed a need for a systematic analysis of how different genders access, communicate and use warnings and alerts. This should be a central component of all early warning system initiatives.

10. INSTITUTIONAL COOPERATION BETWEEN NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES AND NATIONAL DISASTER MANAGEMENT OFFICES SHOULD BE CLEARLY DEFINED AND STRENGTHENED

The respective roles of NMHSs and NDOs need to be better identified in relation to standardized operational procedures to ensure functioning early warning systems and a continuous flow of information during and after events.

INTRODUCTION

The 2017 North Atlantic hurricane season was unprecedented, unleashing several major hurricanes that affected many small island States in the Caribbean, causing over 200 deaths and losses and damage amounting to billions of dollars. The North Atlantic basin saw 17 named storms and the seventh-highest value of Accumulated Cyclone Energy (ACE) on record, including a record monthly value for September. The *WMO Statement on the State of the Global Climate in 2017* stated

that there were three exceptionally destructive hurricanes that occurred in rapid succession in this basin in late August and September: *Harvey* formed in August with *Irma* and *Maria* following in early and mid-September respectively.

Hurricanes *Irma* and *Maria*, in particular, peaked at category five intensity, with *Irma* maintaining that intensity for 60 hours, which is longer than any North Atlantic hurricane in

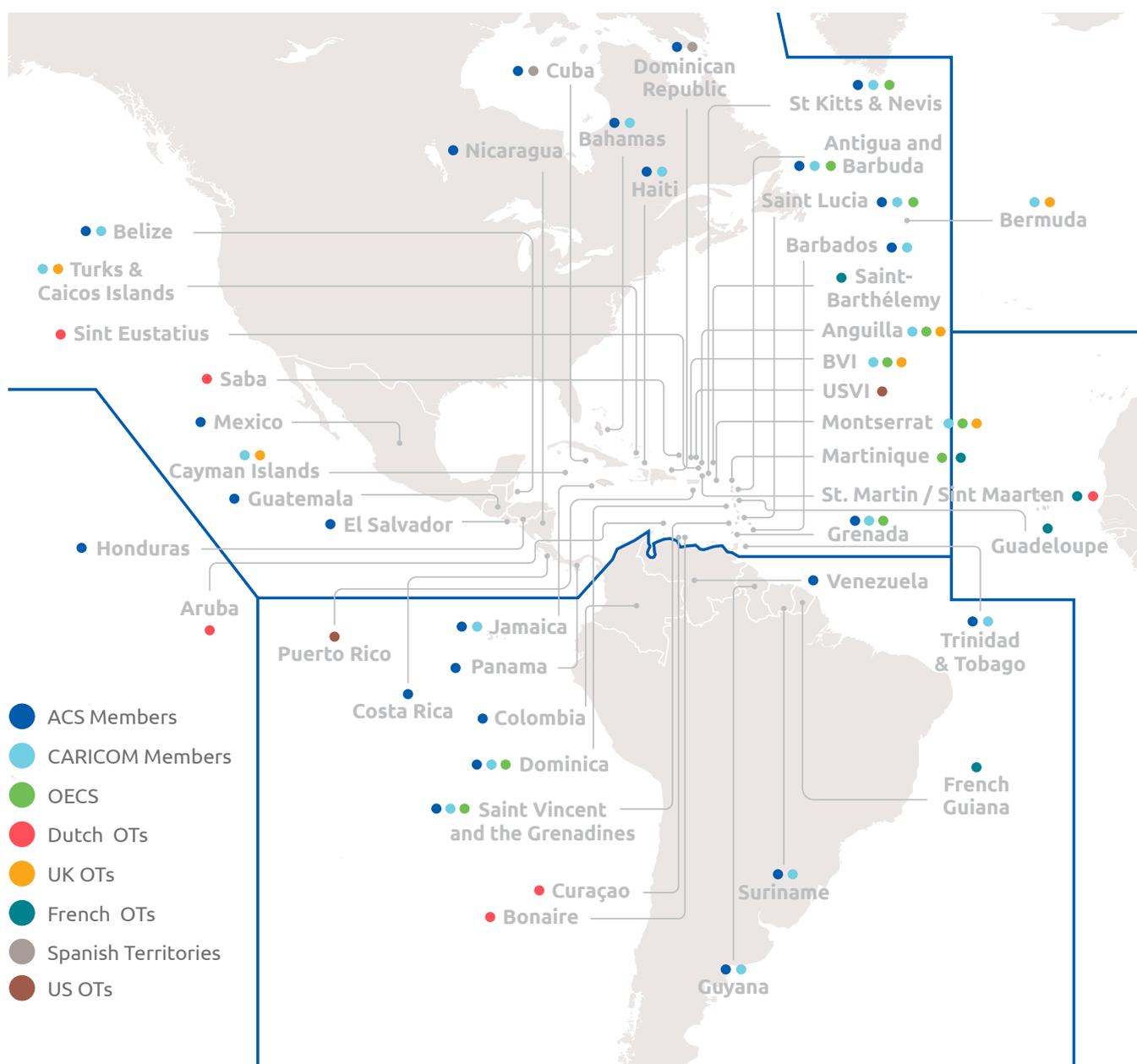


Figure 2. Different political grouping of countries in the Caribbean

the satellite era. *Irma's* initial landfall, at near-peak intensity, led to extreme damage across numerous Caribbean islands, most significantly on Barbuda, which experienced near-total destruction, with only a few inhabitants having returned as of early 2018. Other islands to experience major damage included Anguilla, Saint Martin/Sint Maarten, Saint Kitts and Nevis, the Turks and Caicos Islands, the Virgin Islands and the southern Bahamas. *Irma* went on to track along the northern coast of Cuba, leading to extensive damage there, before making landfall in south-west Florida at category 4 intensity.

Hurricane *Maria* made initial landfall on Dominica at near-peak intensity, making it the first category 5 hurricane to strike the island, leading to major destruction there. The World Bank estimates Dominica's total damages and losses from the hurricane at US\$ 1.3 billion or 224% of its Gross Domestic Product (GDP). This island also experienced a significant loss of life with 31 confirmed deaths and an almost equal number of persons missing, out of a population of less than 80 000. The storm weakened slightly but was still a category 4 hurricane when it reached Puerto Rico. *Maria* triggered widespread and severe damage on Puerto Rico from wind, flooding and landslides.

Against the backdrop of the extensive devastation caused by these weather-related events in the Caribbean, and the commitment by WMO, the World Bank and the international community to work closely with small island developing States to building resilience, the review of Early Warning Systems was necessary and timely to influence continued investment in MHEWS as a climate adaptation measure.

The Caribbean must also be understood as a region with many political complexities. This was also taken into consideration throughout the review process (see Figure 2). Therefore, the study considered at least three territories: one sovereign (Dominica), one dependent (Sint Maarten) and one multi-island territory (Antigua and Barbuda). These characteristics do play a role when identifying the critical entry points for building on existing arrangements that will lead to enhanced MHEWS in such regions.

Early warning systems are a critical tool for local, national and regional institutions in disaster risk management, as they substantially reduce loss of life, the possibility of personal injury and damage to property, infrastructure and the environment resulting from extreme events. By reducing loss and damage, early warning systems contribute to sustainable development, climate change adaptation and national security.

Given the significance of early warning systems to social and economic well-being in the Caribbean, and the considerable resources needed to operate them, it is clearly desirable to continually monitor and improve their efficiency and effectiveness.

The present review builds on a set of indicators used to measure the effectiveness of, and access to, early warning systems

developed in the context of the Climate Risk and Early Warning Systems (CREWS) initiative. National, regional and local authorities, and international institutions need to systematically assess their early warning systems to better understand the benefits, limitations and performance of the systems in terms of the needs of the user community. The review identifies opportunities for improvement in regional, national and local systems and helps define priorities for planning, institutional capacity development and related resource allocation. The review also identifies opportunities for integrating gender in early warning systems with a specific chapter dedicated to sharing the gender experience in the Caribbean.

Countries in the region can also use such reviews to increase the effectiveness of international aid, including post-event reconstruction programmes to strengthen early warning systems. Evaluation of the effectiveness of such programmes and projects, from inception to completion, will enhance the overall outcome of these development investments.

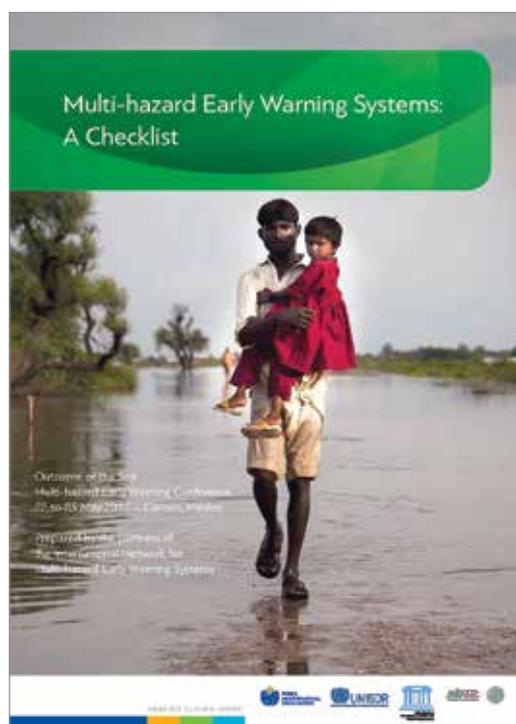
A fundamental premise of this review is that effective early warning systems should be people-centred and impact-based, in addition to providing accurate, technically sound predictions. They must, therefore, comprise or address the following elements:

- Disaster risk knowledge;
- Detection, monitoring, analysis and forecasting of the hazards and their possible consequences;
- Warning dissemination and communication;
- Preparedness and response capabilities.

From a development perspective, it is important that early warning systems be assessed in terms of their capacity to support:

- Targets for reducing loss of life, injury, and loss of livelihoods;
- Objectives for sustainable development, reduced vulnerability and greater resilience;
- Uptake of accurate and timely warnings;
- Public confidence in designated warning authorities and in their ability to use warnings, respond appropriately to hazardous events and provide feedback.

Measures of early warning system effectiveness are therefore expected to assist national, local and regional institutions in meeting their global commitments to supporting early warning capabilities, such as the Sustainable Development Goals (SDGs), the Paris Agreements, and the Sendai Framework for Disaster Risk Reduction, in particular its global target (g), which calls on countries to “substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030” (Sendai Framework for Disaster Risk Reduction 2015–2030, paragraph 18).



Finally, a key finding emerging from the study is the significant number of early warning initiatives that has been undertaken or is being implemented in the Caribbean region. This has led to stakeholders requesting that donors seek to harmonize their efforts and the value added by the investments. Therefore, CREWS, as part of its overall aim to promote coherence in investments, engaged throughout the review process the implementers of the early warning system project funded by the Disaster Preparedness Programme of the European Commission Department of Humanitarian Aid and Civil Protection (DIPECHO). This facilitated the sharing of knowledge and experience, and development of common messages among stakeholders regarding understanding of MHEWS and the priority actions required. One early result of this engagement was the adaptation and use of the revised MHEWS checklist by the implementers of the DIPECHO project across five islands to obtain baseline information on existing systems. These countries are Antigua and Barbuda, Dominica, the Dominican Republic, Saint Lucia, and Saint Vincent and the Grenadines. Baseline data and information were compiled for all islands and used to identify priority areas for action up to the time of this report.



Chapter I

Early Warning Systems: Performance of National Meteorological and Hydrological Services during the 2017 Atlantic Hurricane Season

WILLIS MILLS and DAVID FARRELL

Willis Mills

Willis Mills is the former director of the Trinidad and Tobago Meteorological Service. He is also a climate specialist who continues to serve the hydro-met environment in its quest to developing climate resilience.

David Farrell

David Farrell is the Principal of CIMH. He has many years of experience working in various areas of Hydrogeology and in Applied Geophysics. In addition to his administrative responsibilities, David is involved in various Caribbean and international scientific projects related to Hydrogeology, hydrology and geophysics. David sits on a number of Technical Advisory Committees for regional disaster management and climate change projects. David is the WMO Hydrological Advisor to the British Caribbean Territories.

CMO

The **Caribbean Meteorological Organization** (CMO) is a specialized agency of the Caribbean Community that coordinates the joint scientific and technical activities in weather, climate and water – related sciences in sixteen (16) English-speaking Caribbean countries. It originated from the British Caribbean Meteorological Service, which was founded in 1951. Federalization of the Anglo-Caribbean Countries produced the West Indies Meteorological Service, which was founded in 1958.

<http://www.cmo.org.tt/>

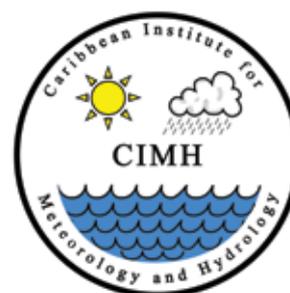


CIMH

The **Caribbean Institute for Meteorology and Hydrology** (CIMH) is a training and research organisation formed by the amalgamation of the Caribbean Meteorological Institute (CMI) and Caribbean Operational Hydrological Institute (COHI).

The Caribbean Meteorological Institute was established in 1967 by the member states of the Caribbean Meteorological Organisation (CMO) while the Caribbean Operational Hydrological Institute (COHI) was established in 1982. Even though the two Institutes were amalgamated since the mid 1980's, the organisation continued to be known as the Caribbean Meteorological Institute up until September 1999 when the name was officially changed to reflect the dual role of the Institute. Responsibility for the operation of the Institute rests with the sixteen Commonwealth Governments which comprise the CMO.

<http://www.cimh.edu.bb>



INTRODUCTION

The 2017 North Atlantic hurricane season registered the seventh highest value of Accumulated Cyclone Energy (ACE) on record, and for the month of September the value was record high. Three exceptionally destructive hurricanes occurred in rapid succession in this basin in late August and September. *Harvey* made landfall in south Texas as a category 4 system causing widespread damage and losses in the United States. *Harvey* was followed by Hurricane *Irma*, in early September, and by *Maria*, in mid-September. Both hurricanes peaked at category 5 intensity, with *Irma* maintaining that intensity for 60 hours, which is longer than any North Atlantic hurricane in the satellite era. *Irma's* initial landfall, at near-peak intensity, led to extreme damage across numerous Caribbean islands, most significantly on Barbuda, which experienced near-total destruction. Other islands to experience major damage included Saint Martin/Sint Maarten, Anguilla, St Kitts and Nevis, the Turks and Caicos Islands, the Virgin Islands and the southern Bahamas (*WMO Statement on the State of the Global Climate in 2017* (WMO-No. 1212) pp. 17–18).

Hurricane *Maria* made initial landfall on Dominica at near-peak intensity, making it the first category 5 hurricane to strike the island, and leading to major destruction. The World Bank estimates Dominica's total damages and losses from the hurricane at US\$ 1.3 billion or 224% of its Gross Domestic Product (GDP). The storm weakened slightly but was still a category 4 hurricane when it reached Puerto Rico. *Maria* triggered widespread and severe damage in Puerto Rico caused by intense winds, floods and landslides (*WMO Statement on the State of the Global Climate in 2017* (WMO-No. 1212), p. 18)

These unprecedented hydrometeorological events in the Caribbean triggered significant interest globally and regionally in examining the performance of early warning systems for small island developing States (SIDS) using the post 2017 hurricane experience. The Climate Risk and Early Warning Systems (CREWS) Steering Committee called for a lesson learnt initiative during its fifth meeting, in Bonn, Germany, in November 2017. It was recognized that such an evaluation would provide critical lessons and insightful indicators to rationalize current and future investments in early warning systems. While the primary focus was on the 2017 Atlantic hurricane season, important lessons learnt from events in previous years that map into the core areas identified for this research have also been included.

PURPOSE OF THE EXPERT REVIEW

The expert review assessed the national and regional early warning systems with specific focus on (a) forecast reliability, (b) the resilience of hydrometeorological warning networks, (c) the resilience of National Meteorological and Hydrological Services (NMHSs) and (d) the performance of the Caribbean Meteorological Organization's (CMO) service delivery mechanism. It concentrated on Early Warning Systems (EWS) priority areas covered by CMO members during and in the aftermath of *Irma* and *Maria*, which are closely linked to the four components outlined in the recently revised *Multi-hazard Early Warning Systems: A Checklist* (available at <https://library.wmo.int>). This publication was prepared by the partners of the International Network for Multi-hazard Early Warning Systems and was launched by the World Meteorological Organization on World Meteorological Day, on 23 March 2018. The key components of the multi-hazard early warning systems include disaster risk knowledge; detection, monitoring, analysis and forecasting of hazards and possible consequences; warning dissemination and communication; and preparedness and response capabilities.

This review took place during the period from May to June 2018 and consisted of several consultations with senior officials from the NMHSs and key stakeholders. These consultations built on the body of work already carried out by the Caribbean Institute of Meteorology and Hydrology (CIMH), the lead implementing institution. Prior to this, the CIMH conducted several post-disaster reviews and evaluations in the affected countries.

APPROACH TO THE EXPERT REVIEW

Senior officials from the NMHSs and the National Disaster Management Offices (NDMOs), along with other key stakeholders and members of the public, were interviewed for this expert review. Officials representing countries that were not affected by hurricanes *Irma* and *Maria* were also interviewed, given CMO established arrangements for a subregional approach, where some countries are dependent on others for forecasts. This approach is further explained in section 1.4.3.

KEY FINDINGS OF THE EWS EXPERT REVIEW

The key findings from the 2017 Atlantic hurricane season are presented below.

Findings at the global and regional levels

Global and regional numerical weather predictions performed well during the season, forming the basis of credible watches and warnings that provided the public with adequate response time. The exception to this are the forecasts for *Maria* which, due to the rapid intensification of the system, were updated approximately four times in the 12 hours prior to the hurricane's landfall in Dominica.

The vulnerability of the regional observation and early warning network increased and was further exposed due to the destruction of weather radars on Sint Maarten and Puerto Rico. There was also significant loss of ground-based hydrometeorological instruments and Automatic Weather Stations (AWS). At the time of writing, some rebuilding of the network has occurred.

Positive feedback has been received on the growing success of the situational awareness and weather impact briefings held jointly by the Caribbean Disaster Emergency Management Agency (CDEMA) and CIMH prior to impact on Members. This has been recognized as a good practice to be considered at the regional level.

Findings at the national and local levels

All meteorological services in the affected countries that were assessed lacked one or more key elements. Significantly, many were underfunded and short of trained personnel at various levels of the operational value chain, which compromised their ability to fully support EWS activities at the national level.

Many of the affected islands have either no designated meteorological service or very weak services and are fully dependent on external entities for their meteorological forecast products and services. The review also revealed the absence of national legislation clearly articulating the entity responsible for delivering meteorological forecasts, including watches and warnings. In countries where this was the case, the end result was inexperienced personnel providing forecasts and warnings.

The meteorological infrastructure in the affected countries was not sufficiently resilient to withstand extreme hydrometeorological events. The absence of resilient facilities compromises the continuity of operations of the NMHSs and their role as reliable partners in delivering effective early warnings.

Several NMHSs also lack the spare parts required in managing their observation and early warning networks. This affected the quality of data collected and the reliability of observation and early warning systems.

In some jurisdictions, the public lacks confidence in the National Meteorological and Hydrological Services. This was in part owing to the lack of effective outreach and public education programmes.

CONCLUSION AND KEY RECOMMENDATIONS

The findings from this expert review further underscore the need for countries to recognize the importance of their hydrometeorological services to national security and their overall contribution to building resilient island nation States.

While confidence in global and regional numerical weather predictions is growing, there is an urgent need to build capacities within the NMHSs. This should be accompanied by the introduction of legislation that clearly articulates the roles and responsibilities of NMHSs along with the necessary financial and human resources. The Caribbean Meteorological Organization should be involved in or advocate this process, which should also address the role and responsibilities of regional weather forecast and warning offices, and the resources required to carry out their functions.

1. APPROACH AND METHODOLOGY

The approach and methodology for this expert review built on the existing body of information produced by CIMH. The expert reviewer complemented the existing evaluations and reviews of the hydro-meteorological services post *Irma* and *Maria* with several interviews, site visits, telephone interviews, questionnaires and a desk review of literature available online (Appendix 4).

1.1 LITERATURE REVIEW

The literature review incorporated key reports produced by CMO, in particular the Country Report from the fifty-seventh Session of the CMO Council and related meetings held in St. John's, Antigua, in November 2017. This was supplemented by the report of the fortieth session of the Regional Association IV (RA IV) Hurricane Committee, held in Fort-de-France, Martinique, in April 2018. A number of other documents, as outlined in Appendix 4, were included along with the weather briefings produced by CIMH for CDEMA during the hurricane season.

1.2 COMBINED INTERVIEWS AND QUESTIONNAIRES

The individuals selected to participate in this review represented both the producers and users of weather information. Among the individuals interviewed were senior officials from CMO, the NMHSs of Anguilla, Antigua and Barbuda, Dominica, and Trinidad and Tobago. These were supplemented with interviews of individuals from several government institutions and non-governmental entities, such as the Barbuda Fisherfolk Association, and several artisans from the Turks and Caicos Islands.

Questionnaires were sent to senior meteorological officers from Barbados, Belize, the Cayman Islands, Grenada, Jamaica, Montserrat, Saint Lucia, Saint Kitts and Nevis and Saint Vincent and the Grenadines. The responses were incorporated into this report.

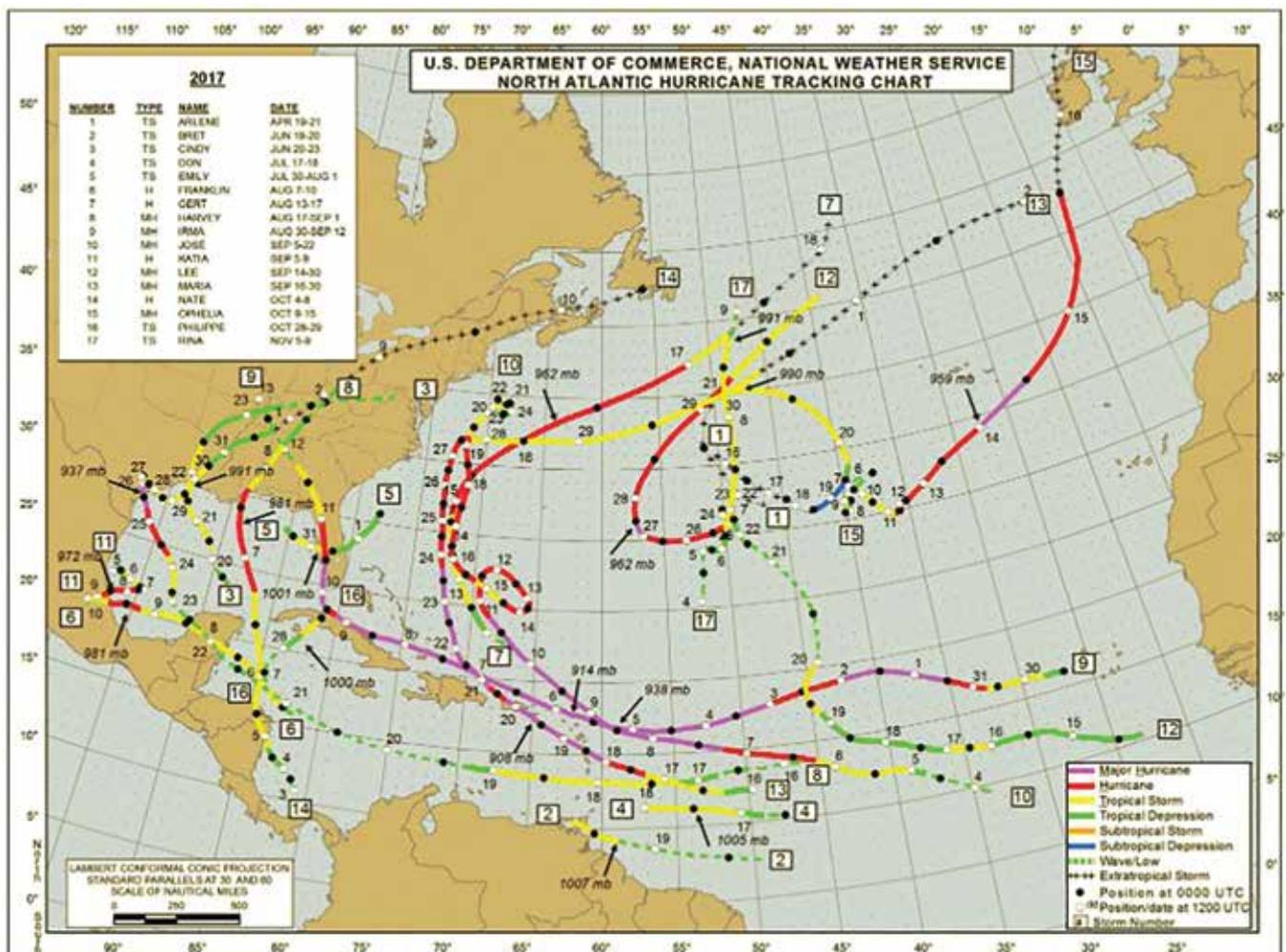
1.3 COUNTRIES SELECTED FOR THE EXPERT REVIEW

The islands selected for this expert review included Anguilla, Antigua and Barbuda, Dominica, the Virgin Islands (United Kingdom), and the Turks and Caicos Islands. These countries mirror the arrangement that currently exists within CMO. Moreover the Dutch territory of Sint Maarten was also included as a priority country.

Key findings of the EWS review

The 2017 Atlantic hurricane season was among the busiest on record. The season produced 18 tropical depressions with 17 of them intensifying into tropical storms. Ten hurricanes occurred in succession, the greatest number of consecutive hurricanes since the start of the satellite era in 1966. Six of the ten hurricanes further strengthened into major hurricanes. The tracks of these various systems are shown in Figure 3.

Figure 3: 2017 North Atlantic Hurricane Season Track Map



A total of five tropical cyclones impacted the islands of the Caribbean in 2017. Of these, *Irma* and *Maria* were particularly devastating and triggered this review of the EWS. Even though these two hurricanes will be the primary focus of the expert review, the following storms and hurricanes have also had an impact on those islands:

- Tropical Storm *Bret* in June 2017
- Tropical Storm *Harvey* in August 2017
- Hurricane *Jose* in September 2017

(full details of the level of activity for the North Atlantic hurricane season can be found via <http://www.wmo.int/pages/prog/www/tcp/HC-40.html>)

1.4 KEY ISSUES IDENTIFIED DURING THE 2017 EWS REVIEW

This section presents the key findings concerning the 2017 Atlantic hurricane season from the perspective of forecast accuracy and effectiveness. The findings are presented within the context of the recently reviewed multi-hazard EWS Checklist. Where appropriate, this section will highlight where previous interventions may require revisiting or where new interventions are necessary.

1.4.1 Disaster risk knowledge

Vulnerability information

In the EWS process, adequate vulnerability information helps in assessment of the risk to local communities. However, while such information exists for many of the impacted countries, much of the data is not readily available. In some cases, people were not trained to use vulnerability data so they were unable to assess the risk of hazards for the community. Stakeholder discussions showed that people were not fully aware of their particular vulnerabilities and risks.

Accessing and utilizing the Caribbean DEWETRA Platform

DEWETRA is an integrated system for real-time monitoring, prediction and prevention of natural disasters worldwide. In the Caribbean, the DEWETRA Platform has been spearheaded by CIMH. It is an open-source platform that can help enhance the accuracy of risk assessments and impact-based forecasts. Unfortunately, many NMHSs, especially those in the affected countries, are not taking advantage of the quality-assured vulnerability information in the Caribbean DEWETRA Platform to assess societal risks.

Spatio-temporal changes in vulnerability

One of the challenges identified during the review is that while land-use policies have been developed for most islands, these are seldom applied. As a result, unregulated development may

occur which is not represented on maps, leading to the full range of social vulnerability not being integrated into platforms that support risk assessments and impact-based forecasts. As a result, NMHSs are often unable to provide targeted forecasts to at-risk communities that are usually located on marginal lands, including steep slopes prone to landslides and river valleys and depressions prone to flooding. Many NMHSs also lack up-to-date information on population demographics, floodplains, building and infrastructure. Many are often not aware of how changing infrastructure may be influencing risk as they are not part of the team involved in infrastructure design.

After each severe hydrometeorological event, vulnerability changes at both community and national levels. It is essential to map the impacts of those events along with changes in exposure characterization, and to understand the factors that drive those changes. Unfortunately, NMHSs are often not involved in this essential exercise and have access to this critical information only when it is published. Much of the data collected is neither published nor shared for various reasons and, as a result, this information is not factored in to resources and guidance products provided by NMHSs. It is essential that NMHSs get more involved in post-impact assessments.

Limited use of geographical information systems by NMHSs

In some cases, NMHSs are still using outdated paper-based maps. Many government agencies are now using geographic information systems (GIS) to manage and distribute geospatial information in digital form. Unfortunately NMHSs, particularly those in the affected countries, are not utilizing such systems in their routine operations due in part to a lack or shortage of limited competence and organizational infrastructure.

In the past 15 years, CIMH has included the use and application of open-source and commercial GIS packages in its in-house training programmes. Special attention has been devoted to this area in the past five years with the hiring of a GIS specialist. GIS courses are also part of CIMH online continuing professional development programme. The participation of persons from the affected countries in those courses is limited and should be increased given the benefits. It should be noted that the introduction of the Caribbean DEWETRA Platform was aimed at addressing many of the issues related to enhancing access to vulnerability information to support risk forecasting.

Need for open data policies

Access to data, including vulnerability data, is difficult due to national or departmental policies in government ministries. However, such data is essential for a range of activities including scenario planning and community risk profiling. In recent years, an increasing number of governments have realized the considerable value to be derived from sharing national datasets. Some countries in the Caribbean, including Jamaica and Trinidad and Tobago, have begun sharing their

national sets. The Caribbean Community (CARICOM) and the Organisation of Eastern Caribbean States (OECS) Commission should be encouraged to explore open data and data sharing policies as one of the strategies to enhance national and regional EWS and resilience-building initiatives.

1.4.2 Detection, monitoring, analysis and forecast of hazards and their possible consequences

The United Nations Office for Disaster Risk Reduction (UNISDR) noted that sound science should be used for predicting and forecasting hazards, and that a reliable forecasting and warning system that operates 24 hours a day should be in place. This section deals with the performance of national and regional monitoring and warning systems, focusing on the effectiveness of recent developments. Special attention will be paid to the ability of the regional systems to continuously monitor hazards, and to the region's ability to translate this information into accurate and timely warnings.

It is important to recognize that hydrometeorological monitoring and forecasting in the Caribbean and the ability of NMHS to offer increasingly accurate watches and warnings are noticeably improving. The system integrates multiple levels of information at different scales and from different national, regional and global sources to produce near-seamless risk-informed forecasting through continuous monitoring.

Core elements of the hydrometeorological monitoring strategy in the Caribbean

Many tropical systems are now routinely monitored throughout their lifecycle in the Atlantic Ocean and the Caribbean Sea, using space-based and marine-based observing systems. Close to the island chain, land-based platforms consisting of a regional network of weather radars with radial coverage up to 400 km support monitoring of weather systems. On land, this monitoring network is augmented by national hydrometeorological networks consisting of AWSs, rain gauges, stream level gauges and other assorted monitoring equipment all reporting in near real-time. The spatio-temporal resolution and accuracy of data from these systems has improved significantly over the years. This monitoring arrangement is now an essential element of the regional EWS platform. During the 2017 Atlantic hurricane season, this monitoring arrangement provided essential information for reducing the risk of hazards and their likely impact on communities.

Weather radar network

A particular finding of this study relates to the fragility of the regional radar monitoring network which consists of weather radars located in Guyana, Trinidad and Tobago, Barbados, Belize, Martinique, Guadeloupe, French Guyana, Cayman Islands, Sint Maarten, southern Florida, Curacao and

Venezuela. Outputs from these radars are integrated into a mosaic to provide continuous monitoring across the islands of the Caribbean with the only significant gap being Hispaniola.

The CMO component of the radar network (Guyana, Trinidad and Tobago, Barbados and Belize) has had reliability issues caused by a weak sustainability model relying largely on countries funding the operating and training costs of the radar they host. The operating history of the network has shown that as many as two of the four radars can be out of service at any time. Depending on the islands on which such outages occur, the radar mosaic can have significant gaps. The radar in Barbados has been out of service since before the 2017 Atlantic hurricane season and remains out of service at the time of writing. The impact of this outage on the monitoring and forecasting of Hurricane Maria and other weather events in the southern Caribbean is uncertain. Should the Trinidad and Tobago radar suffer significant prolonged failure when the Barbados radar is offline, there would be a significant gap in coverage that would affect monitoring and forecasting of weather systems over the entire southern Caribbean.

The vulnerability of the radar network in the region was further exposed by the complete destruction of the weather radars in Puerto Rico and Sint Maarten by Hurricanes *Maria* and *Irma* respectively. Whereas the radar on Puerto Rico has been replaced, Sint Maarten is still in the process of procuring a new radar. In view of the 2017 experience, there is considerable concern for the long-term viability of the CMO radar network, whose radars face similar risks as those on Sint Maarten and Puerto Rico, but whose operations are significantly undercapitalized.

Community level ground-based hydrometeorological observation and early warning system

Over the last 20 years, significant investments have been made by regional and international agencies to strengthen national hydrometeorological and climate observation and early warning networks in the Caribbean. Further investments in this network are currently planned (see Section 3 of this report). After each severe weather event, a few stations in these networks are often lost to landslides and debris flow. Flooding and debris flows produced by the passage of Tropical Storm *Erika* in 2015 significantly compromised portions of the observation and early warning network on Dominica, where many of the stations lost were located near river systems. Subsequent investments resulted in partial replacement of the stations in the network.

Hurricanes *Maria* and *Irma* increased the vulnerability of the network by compromising several stations in Dominica, and totally destroying the entire 18-station network in the British Virgin Island. Anguilla and the Turks and Caicos Islands also reported significant network losses. To date, some stations in these affected islands have been replaced at significant cost by CIMH, CDEMA and partners, including instrument

manufacturers such as Sutron Corporation. It is expected that others will be replaced through international and national funding arrangements in the near future. While replacing these stations is expensive, it should be recognized that failure to replace them places communities at considerable risk. The short intervals observed between significant hurricanes during the 2017 Atlantic hurricane season underscores the need for rapid rehabilitation of observation and EWS networks immediately after impact to ensure that communities at risk receive the best warning service possible.

Accelerating station replacement immediately after impact

Following hydrometeorological events, CIMH is frequently called upon to support Rapid Needs Assessment Teams (RNATs) coordinated by CDEMA. If CIMH support to an RNAT is not required, CIMH nevertheless deploys a small self-funded team to the affected country at the earliest possible time. The deployed team frequently travels with equipment from the CIMH spares facility to repair or replace some of the affected stations. The goals of the team include: (a) making contact with the local NMHS to assess needs and assist the service in bringing its systems back on line where possible; (b) assessing the national observation and early warning network and, where possible, downloading data, salvaging equipment from damaged stations and re-establishing stations; and (c) assessing hydrometeorological impacts. In many instances, the derived information is shared with national, regional and global partners who use it to plan subsequent in-country operations. This form of intervention by CIMH is recognized as a good practice which effectively represents an increase in meteorological capacity in the country.

Through this exercise, accessible essential stations are returned to service quickly with reduced downtime, and the capabilities of the compromised EWS rebuilt at a faster rate. The ability to complete such rapid repairs to the observation system is possible because of the increased homogenization of the networks over the past 10 years, which has allowed CIMH to more effectively manage its equipment stores.

During RNAT intervention and subsequent deployments immediately after the impact of *Maria* and *Irma*, several critical stations on Dominica and Anguilla were checked, serviced and brought online, and the needs of the network and the NMHS assessed, prioritized and shared with the development community.

Assessing hydrometeorological station losses in the Caribbean

The large number of observation and EWS stations lost during the 2017 Atlantic hurricane season is a cause for concern. In recent years, informal assessments of station losses following severe events indicate two core mechanisms: (a) unavoidable losses, in which the stations suffer damage that cannot be avoided or engineered against, and (b) avoidable losses, in

which stations are lost due to poor installation and maintenance practices. While little can be done about the former, the latter raises concerns that must be addressed, and highlights the need to develop installation standards where none exist or to enforce existing standards and appropriate training where required. Unfortunately, there is often no formal review of station losses in the aftermath of severe weather events. However, given the high levels of investment in national and regional observation and early warning systems, and the importance of these systems to national and regional security, CIMH will be recommending to countries that an inventory of the failure mechanisms be compiled for training purposes and to guide future installations.

Enhancing the resilience and sustainability of hydrometeorological networks in the Caribbean

Over the years, CMO Members have learnt important lessons about managing and sustaining national and regional monitoring networks. One such lesson is that maintaining a network of heterogeneous stations is expensive and unsustainable as it requires that spare parts from multiple vendors be available at all times if the network is to have a high percentage of uptime. This is a cost many countries cannot afford.

As a result, in recent years, with the assistance and advocacy of CIMH, many countries have been moving towards implementation of homogeneous networks, with national homogeneity gradually leading to regional homogenization. This model presents several advantages: (a) CIMH is able to more efficiently service the equipment needs of countries at all times thanks to its inventory of spare parts and staff experience; (b) national equipment inventories are better streamlined; (c) equipment-related training costs are reduced; and (d) following the impacts of severe events on networks, stations can be salvaged to rebuild the national network. Actions (b) and (d) supported the rapid partial recovery of the network on Dominica following the impacts of Hurricanes *Erika* and *Maria*, and action (a) provided partial assistance to Anguilla, the British Virgin Islands and the Turks and Caicos Islands.

Many development partners are recognizing the benefits of national and regional homogenization and supporting this move either through direct national investments or through significant regional investments entrusted to CIMH. However, for this approach to be streamlined into the funding processes of development partners, NMHSs will have to develop or strengthen their procurement plans and strategies to acceptable global levels. CIMH has prepared a document that supports homogenization of networks, which it has successfully used with development partners and shared with other regional partners. Despite these gains, challenges remain with empowering communities to assist in ensuring the security of the stations in networks. In this regard, significant investment is required to communicate the importance of these systems for the safety and security of communities.

Implementing new observation and EWS technologies

The high cost of commercial off-the-shelf hydrometeorological observation make returning networks to their pre-impact state an expensive proposition, especially after the magnitude of station loss experienced in 2017. While gradual rebuilding of the network over several years is a possibility, it runs the risk of leaving communities without an EWS for possibly an unacceptable length of time. Sourcing substantial resources to completely rebuild a network is possible but such arrangements generally take time as evidenced by the slow arrival of funds to rebuild the affected networks following the 2017 Atlantic hurricane season.

In recent years, a range of low-cost stations, including the NOAA 3D-Printed Automatic Weather Station (3D-PAWS) (MC: Should we not mention the University Corporation for Atmospheric Research (UCAR) which launched the device with NOAA?), have emerged that may provide a temporary pathway to rapid rehabilitation of networks at low cost. CIMH has deployed some of these technologies in the past and will experiment with newer options to test their feasibility as a rapid deployment option.

Hydrometeorological forecasting

Over the past 12 years, CIMH has expanded its computing capacity to deliver several high-resolution (4-km) numerical weather prediction products two times per day using the WRF-ARW and WRF-NMM weather simulators. Over the past six years, the accuracy and reliability of these products have increased significantly as CIMH has developed its modelling competence. In fact, recent experience with simulation runs for Hurricane *Joaquin*, Tropical Storm *Erika* and Hurricane *Matthew* demonstrated that outputs from the CIMH models compared favourably with the outputs of global models in terms of the forecast track. For parameters such as precipitation, the CIMH model outputs are comparing favourably with observed data from satellite, radar and ground-based measurements. Because of the high resolution of the model runs, rainfall bands over watersheds are easily detected. In addition, observed flooding and landslide impacts are showing consistency with spatio-temporal patterns of rainfall predicted by the model.

In 2017, predicted trajectories for Hurricanes *Irma* and *Maria* were once again found to be consistent with other models and observed tracks. Rainfall amounts over 24-hour periods were also generally found to be consistent with satellite observations and ground station measurements. Unfortunately, the CIMH models were unable to capture the rapid intensification of Hurricane *Maria*. This failure represents an important lesson for the future as it has considerable bearing on the accuracy of impact-based forecasts for tropical storms in the region.

A common concern raised by users of the CIMH model is the late delivery of the products, which limits the application of the forecast updates being produced. This is due to the limited

computational capacity available in the Caribbean Centre for Climate and Environmental Simulations (CCCES). Recent investments in the computational platforms of CCCES should see improved delivery times.

Forecasting of significant wave heights

In addition to weather predictions, CIMH is also producing high-resolution (4-km) 5-day predictions of significant wave heights two times per day for the Caribbean Sea and adjacent regions using the WaveWatch III model. The outputs from these models are aimed at providing risk information for planning and early warning activities of (a) the marine transportation industry in the Caribbean, (b) fisherfolk in the region, (c) the recreation industry, (d) coastal zone management officials, and (e) defence and security officials. The models have been extremely useful for pre- and post-impact planning and logistics. In 2016, the model outputs for Hurricane *Matthew* showed that the southwest peninsula of Haiti would be affected by significant wave action, which would make the port at Les Cayes unusable for first response and aid shipments into the country. In contrast, the model showed that Port-au-Prince would be available for aid shipments. In 2017, the model provided good estimates for the destructive wave heights associated with Hurricanes *Maria* and *Irma*. While this product is used by CIMH during regional briefings, the uptake at the local level requires attention.

Integrated decision-making

The difficulty encountered in forecasting the rapid intensification of Hurricane *Irma* near Dominica was, and continues to be, a cause for concern. While it is not clear that such rapid intensification will be a common feature of tropical storms just prior to making landfall in the eastern Caribbean, it nevertheless suggests that (a) tropical cyclone forecasting skills in the eastern Caribbean will need to improve, (b) a more collaborative approach to tropical cyclone forecasting will have to be adopted drawing on the collective wisdom of the Caribbean and international partners, and (c) research efforts in this area are required to improve forecast accuracy and computational efficiency. With regard to (a) and (b), the recent implementation of the WMO Severe Weather Forecasting Demonstration Project for the Eastern Caribbean is a timely intervention, which should lead to greater regional collaboration around the forecasting of severe weather systems and to improved hydrometeorological forecasts and early warning across the eastern Caribbean.

Weather briefings and impact-based forecasting

Since 2008, CIMH has been providing daily briefings to CDEMA on pending severe weather events. The briefings are part of a process that provides risk information for CDEMA response scenarios. The audience for these briefings has grown

significantly over the years to include a range of development partners, disaster management offices and CARICOM officials, either in the room or online, who need to plan their post-impact response. The scenarios presented in the briefings are based on an integrated assessment of publicly available information from the National Hurricane Center (NHC) in Miami, outputs from global and regional numerical weather prediction products, regional marine products, satellite observations, radar observations, ground-based observations, vulnerability information, infrastructural information, and socioeconomic information where appropriate. The outputs from the integrative analysis, which utilizes the Caribbean DEWETRA Platform, essentially represent an impact forecast that provides risk information for an early warning process. The impact forecast is updated daily or several times a day depending on the changing status of the hazard and its proximity to landfall.

In 2017, CIMH delivered briefings to CDEMA and development partners on major systems likely to affect countries in the region. On 18 September 2017, CIMH delivered four such briefings to CDEMA and development partners, with each brief presenting changing impact scenarios as Hurricane *Maria* grew in intensity. The successful delivery of four briefs in a single day represents an important milestone for this collaborative process with CDEMA and is a regional best practice that should be replicated at the national level.

While the final brief provided a good assessment of likely impacts, it was delivered only hours before Hurricane *Maria* made landfall and therefore provided the public with little time to adequately respond to the escalating threat. It is recognized that the short notification period was due to the inability of current numerical weather prediction models to adequately predict rapid intensification. A next generation of models will therefore be required to address similar future scenarios.

1.4.3 Warning dissemination and communication

Critical to the effectiveness of NMHSs is their ability to (a) communicate with and disseminate warnings to the public, and (b) to communicate and collaborate with colleagues in other NMHSs, to ensure that the most appropriate national forecast is developed and transmitted to stakeholders. Both of these areas are discussed in this section.

When NMHSs fail to effectively communicate and disseminate accurate warnings in a timely manner, the consequences can be dire, ranging from loss of life and livelihoods to severe disruptions to commerce and governance at the national level. Warnings should be targeted and actionable, and should provide information related to the expected hazard, the area where it is going to occur, the time when the impact will be felt, the duration of the impact, and the likely societal impacts.

Meteorological forecasting arrangement in CMO Member States

Under the CMO agreement, NMHSs are responsible for hydrometeorological and related scientific matters within their national boundaries. Some NMHS have forecasting responsibilities for preparing and issuing warnings for neighbouring countries, as per the RA IV Hurricane Committee Operational Plan (more information can be accessed on the WMO website using the reference number WMO-1163/TCP-30. <https://www.wmo.int/pages/prog/www/tcp/operational-plans.html>):

- Antigua and Barbuda:** The islands and coastal waters of Antigua, Anguilla, Barbuda, British Virgin Islands, Montserrat, Nevis and Saint Kitts;
- Bahamas:** The islands and coastal waters of the Bahamas and the Turks and Caicos Islands;
- Barbados:** The islands and coastal waters of Barbados, Dominica, Saint Vincent and the Grenadines;
- Trinidad and Tobago:** The islands and coastal waters of Trinidad, Tobago, and Grenada and its dependencies.

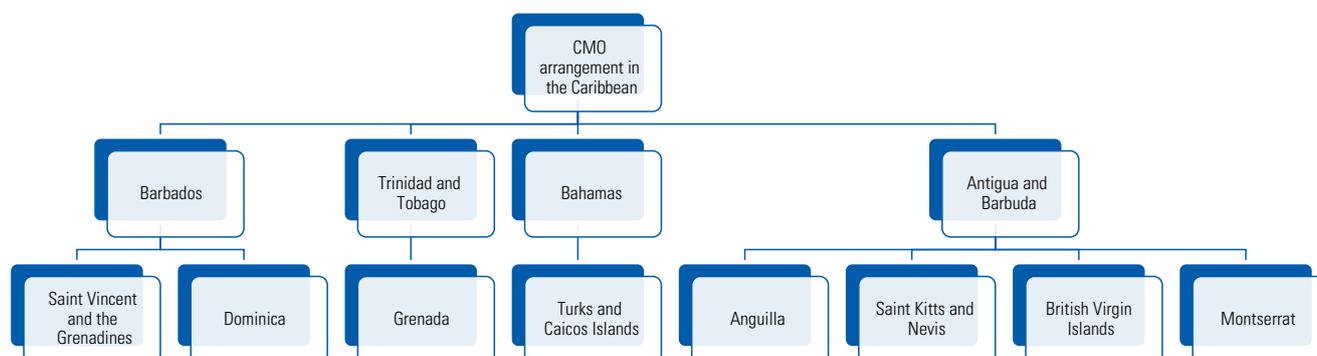


Figure 4. CMO arrangement in the Caribbean according to the RA IV Hurricane Committee

Moreover countries have established the following backups for watches, warnings and agreed-upon essential products, which should include terminal forecasts for main airports. The details of products are arranged bilaterally.

- a) Barbados will take over the responsibility of Antigua and Barbuda and/or Saint Lucia;
- b) Antigua and Barbuda will take over the responsibility of Barbados with respect to the islands and coastal waters of Dominica;
- c) Trinidad and Tobago will take over the responsibility of Barbados with respect to the islands and coastal waters of Barbados and St. Vincent and the Grenadines. Trinidad and Tobago will also serve as secondary backup to Barbados with respect to Saint Lucia;
- d) The United States will take over the responsibility of the Bahamas and Jamaica;
- e) Barbados will take over the responsibility of Trinidad and Tobago;
- f) The Cayman Islands will take over responsibility for Belize, with Jamaica serving as secondary backup to the Cayman Islands with respect to Belize;
- g) Jamaica will take over the responsibility of the Cayman Islands.

NMHSs are grouped into two technical categories reflecting their differing technical capabilities and human resources:

- a) **Weather forecast and warning offices.** These offices undertake surface and upper-air weather observations continuously, throughout the year; exchange meteorological data regionally and internationally; prepare weather forecasts and warnings of severe events for the public, aviation, marine, agriculture, water resources and industrial/commercial sectors; and undertake national and subregional studies of weather and climate. These offices are located in Antigua and Barbuda, Barbados, Belize, the Cayman Islands, Grenada, Guyana, Jamaica, Saint Lucia, and Trinidad and Tobago.
- b) **Aeronautical meteorological offices.** These offices undertake weather observations to support the public sector and the aviation industry in addition to performing climate functions. Their hours of operation are largely determined by aeronautical requirements. The aeronautical meteorological offices include the NMHSs in Anguilla, the British Virgin Islands, Dominica, Montserrat, Saint Kitts and Nevis, Saint Vincent and the Grenadines, and the Turks and Caicos Islands.

CMO Members can be grouped into two categories: those with their own forecasting office and those without a forecasting office. The latter rely on forecast products and services developed by the former. The framework has a built-in redundancy: in the event that Forecasting Office A is not operational, another nearby office, Forecast Office B, takes over the responsibility for providing forecast products and services to Forecast Office A. For this system to be effective, a strong communications infrastructure with common protocols must link forecasting and dependent offices to ensure the seamless flow of information at all times. Problems in this arrangement occur when dependent

offices are unable to communicate with the outside world, including the offices producing the forecasts.

The passage of Hurricane *Maria* over Dominica resulted in the near-total destruction of the national communication infrastructure, which was critical to the Dominica Meteorological Service. The consequent disruption, coupled with severe power failures, resulted in Dominica Meteorological Service being unable to communicate with local stakeholders and the Barbados Meteorological Service, the primary provider of meteorological forecast and warning services to the country. This situation occurred in the midst of a potential multi-strike scenario given the presence of Tropical Storm *Lee* over the Atlantic Ocean east of the northern Windward and Leeward Islands. While Tropical Storm *Lee* eventually moved north into the Atlantic Ocean, the local community was unaware of its movement and some assumed it had maintained its westward motion.

Mitigating the situation described in the previous paragraph requires that (a) redundant communication systems, independent of national infrastructure, be installed at provider and dependent services to facilitate effective communications under all national impact scenarios; (b) redundant power sources be installed at forecast provider and dependent services to ensure that failures of the national grid do not compromise the ability of those services to transmit and receive information; and (c) NMHSs be housed in more resilient infrastructure to ensure that their ability to fully function is not compromised under all plausible scenarios.

Summary of interview findings

Country level interviews indicate that many stakeholders in the affected countries believe that NMHSs in the Caribbean are functioning effectively. However, in some countries, some interviewees expressed concerns about the timeliness of weather bulletins and warnings. In such cases, they frequently opted to get information from sources other than the local authoritative voice and made their own decisions about how to respond to the information they received. In some instances, media outlets broadcast weather information from sources not recognized as national authoritative sources. Either way, it is possible that people made decisions that were inconsistent with the information being provided by the national authoritative source.

Many Caribbean citizens are under the impression that NHC issues bulletins, watches and warnings for their islands. This impression is particularly strong on those islands without weather forecast and warning offices and results largely from the NHC broadcasting these products to the issuing offices, as soon as they are made available. Unfortunately, in many cases those offices are slow to disseminate the products they have received and, as a result, their messages reach the public after those sent by NHC and others.

In-country interviews also revealed that while in some countries the local NMHS was well-known and trusted by the public, this was not the case everywhere. In such cases, it emerged that the NMHS: (a) did not engage sufficiently through traditional

media (e.g., television, radio and the print media) and (b) lacked a social media presence common in modern-day NMHSs. It is strongly recommended that in countries where this is the case, the NMHS initiates a process for building a strong stakeholders communications strategy and programme that include: (a) active engagement with all stakeholders through face-to-face meetings, traditional media and social media; (b) active solicitation of feedback from the public on a regular basis about existing products and services as well recommendations for new services; and (c) training in communications for all staff to enable more effective exchanges with the public. NMHSs may wish to consider hiring a communications specialist and engage the services of a social scientist to develop and support their communications programme.

It is important that the public is aware of and trusts the designated institution issuing watches and warnings on behalf of the government. While the responsibility for hydrometeorological events normally rests with the NMHS, in many countries there is no legislation assigning this responsibility to the NMHS. This review found that in countries where no such legislation exists, other national institutions without the required skills issue watches and warnings developed by an external entity providing such services to the government. This situation is a cause for concern. It is, therefore, recommended that those countries that lack clear legislation designating the NMHS as the national authority for issuing watches and warnings develop and implement such legislation with haste.

1.4.4 Preparedness and response capabilities

A critical aspect of enhancing the response capabilities of communities is to assist them in understanding the hazard and their likely consequences. This requires that trusted, recognized institutions engage actively with the communities. In many countries, the level of direct community engagement by the local NMHSs was lower than anticipated. As previously noted, a number of NMHSs had no active strategy or process for engaging the public. However, given the high risk of hydrometeorological hazards faced by many communities, it is essential that NMHSs establish their presence in the community prior to severe events through continued communication and knowledge sharing. NMHSs also need to understand the unique vulnerability of the communities they serve, bearing in mind that this can lead to better targeted meteorological and impact-based forecasts. Post-impact community engagement is just as important as pre-impact engagement as it (a) supports an assessment of the quality of the forecast provided as well as its effectiveness (for example, did the communities understand the forecast and take the right action to mitigate the risk?), and (b) allows the NMHSs to assess and understand the new risks that may have arisen following the event and that will have to be taken into account in future forecasts. Unfortunately, none of the services interviewed were engaged in such activities on a routine basis. However, NMHSs in the affected countries surveyed and services in non-affected countries will have to integrate these practices into their operations as they move to support national and community-based impact forecasting.

NMHSs, as part of their routine operation and as they move towards supporting the implementation and operationalization of impact-based forecasts at the national level, will have to become more engaged with the disaster risk reduction community. In particular, they will need to have a clear understanding of disaster management plans and how they operate within the framework of such plans. While the NMHSs visited are aware of local disaster management plans, it was unclear the extent to which these plans factor in to their forecasts and whether they were active participants in the preparation and updating of these plans.

2. KEY RECOMMENDATIONS

The following recommendations are based on the findings described earlier and on knowledge of the operational challenges faced by NMHSs in general. The recommendations are divided into two broad categories: regional and national recommendations.

2.1 REGIONAL RECOMMENDATIONS

2.1.1 Access to vulnerability information

Adequate information about vulnerability can be provided through existing platforms, training, increased data sharing and communication related to changing land use and post-event mapping exercises. Advocating open data policies within national and regional EWS frameworks could increase access to vulnerability information that is essential for predicting and mitigating national and community risk.

2.1.2 Personnel training

NMHSs of many CMO Members are underfunded and unable to provide the level of continuous training required to ensure the competence of their staff. In this regard, it is important that full or even partial scholarships be sought through technical cooperation programmes or some other means.

Capacity development for NMHSs should be a priority area in grant funding to support climate resilience and disaster risk reduction.



NMHSs representatives from the Caribbean

2.1.3 Advanced training

Refresher training should be scheduled for all operational staff to maintain their competence. Forecasters should demonstrate the requisite competence for forecasting tropical cyclones and other forms of severe weather and their impacts. Such training should be conducted prior to the hurricane season. If the cost of repeatedly sending technical staff overseas is prohibitive, other avenues could be explored, for example, training of trainers or participating in online programmes such as the CIMH Online Continuing Professional Development programme.

Local knowledge is essential to improve the accuracy and relevance of the product. A training programme should therefore include an introduction to the island where forecasts would be made.

Several years ago, there was an arrangement under which forecasters from the Trinidad and Tobago Meteorological Service spent a few days in Grenada, for which they had to provide forecasts. This was done on a rotation basis and the time was spent supporting observations on the island and observing the operations of its meteorological service. The aviation sector provided air transport when they were not fully booked, referring to the courtesy as a familiarization flight. The visiting forecaster's government provided the per diem. This programme should be revisited and expanded as appropriate.

2.1.4 Communication methods

Targeted messaging

One aspect of communication, which has been overlooked, is the way in which different population groups receive and react to identical messages. It has been shown that, even when communication systems transmit messages in an accurate and timely manner, different groups interpret the same message differently, depending on age, community and, in particular, gender. There should be more research into these differences to facilitate the customization of hydrometeorological information and its dissemination to the largest number of citizens.

Enhanced electronic messaging

Electronic billboards are becoming a part of everyday life in the Caribbean, along the major roads and even on some buildings. The owners/operators of these billboards could be approached to post hydrometeorological bulletins when severe weather threatens communities. Cooperation with NMHSs has minimal impact on potential revenue; it could, in fact, increase the effectiveness of billboard advertisement as communities begin paying closer attention to what is being displayed. The use of billboards also provides the opportunity to target exact geographical locations. Boards conveying severe weather and health advisories are common in Europe and North America where they have been very effective.

Weather applications for mobile devices

Several providers of weather information, most of them non-NMHSs, have produced cell phone apps that are freely available to the public. Regional NMHSs, in collaboration with their local telecommunications providers, should examine the development of weather apps designed specifically for local consumption.

2.1.5 Infrastructure

The vulnerability of the regional observation and early warning network increased and was further exposed due to the destruction of weather radars on Sint Maarten and Puerto Rico. There was also significant loss of ground-based hydrometeorological instruments and Automatic Weather Stations (AWS). At the time of writing, some rebuilding of the network has occurred. There are strong arguments for developing strategies for redundancy in communication for NMHSs at local and regional levels especially in cases where one NMHS has responsibility for generating weather products for other NMHSs.

Backup communications

Providing backup communication is challenging on a regional level as it requires a regional consultation and a collective agreement. Careful consideration must be given to existing country legislation and licensing procedures, and the strengthening of bilateral agreements. This may require the involvement of one or more of the following organizations: WMO, CMO, CARICOM, the Caribbean Telecommunication Union and the International Telecommunications Union.

Most communications systems with the sophistication required by NMHSs are dependent on electricity. Therefore, they cannot be used during a tropical cyclone if the national power supply is compromised and the standby generator, if any, fails. The solution is to identify systems, preferably two-way, that operate on rechargeable batteries. These systems must work independently of the public telephone system and internet providers, and they must function when electricity poles and cell towers are compromised. There are some basic criteria that must be met:

- The batteries, fully charged, must deliver electric power for some days before becoming fully discharged;
- The entire system must be portable enough to be easily protected during severe hydrometeorological events. Bulky fixed antennas could be severely damaged during a tropical cyclone;
- The system must maintain reasonable operability in severe weather conditions. Gusty winds, heavy precipitation and overcast skies may persist for many hours after the core of a tropical cyclone has passed;
- The system should be relatively inexpensive, although this is not a primary consideration.

There is no ideal system to provide redundancy in communications. Some organizations, outside NMHSs employ satellite phones, but it has been reported that reception drops off in overcast conditions. It is uncertain whether they can maintain enough functionality immediately after the passage of a tropical cyclone.

Two-way short-wave radios seem to be a better option in that they require a one-time purchase with no recurrent costs. All NMHSs in the region should be strongly encouraged to explore the feasibility of such systems for their operations. Where several countries are getting their meteorological information from a single NMHS, it is important that they work together to identify the best and most affordable technology for their collective use.

Fixed antennas are often damaged during tropical cyclones. If an external antenna is essential, various technologies could be explored to enable quick deployment and retraction of the antenna. The loss of communication during and immediately after the passage of a tropical cyclone is surely not unique to the Caribbean. Therefore, WMO or other credible partners could be lobbied to advocate the customization of various technologies for this purpose. A committee of experts could be established to develop a set of protocols for these systems, emphasizing that they are for use only when traditional communications fail.

2.1.6 Legislation

Governments should be encouraged to pass legislation clearly defining the status, role and responsibilities of their respective NMHS. Legislation should clearly state that the local NMHS is the legitimate authoritative organization with respect to the issuance of hydrometeorological information for that country. The absence of appropriate legislation allowed other organizations to usurp some of the responsibilities of their respective NMHSs during hydrometeorological emergencies including those of 2017. This absence posed a challenge in dealing with other organizations, especially the media.

Regional NMHSs could facilitate the process of developing appropriate legislation by requesting the CMO Headquarters Unit to research the matter and propose appropriate model legislation for consideration of the Caribbean Meteorological Council (CMC). The CMO Headquarters Unit could also lobby the CMC to require the establishment of formal NMHSs in countries that are lacking such services.

2.1.7 Quality management

Forecast verification

There is a need for forecast validation and verification. CIMH distributed the CIMH Terminal Aerodrome Forecast (TAF) Verification Tool to support forecast verification. Senior

meteorologists in CMO Member States, who were given the responsibility of applying that tool, complained that it was too onerous to use routinely. The tool has been translated into Spanish and is being used in south and central America. CIMH noted the concerns and is currently modifying the tool to improve its usability. A new version of the tool should be available within the next 12 months. It is important that prospective users be instructed in its use. It should be noted that Belize has developed its own verification tool, which other NMHSs could consider.

Verification of regional numerical weather prediction products

CIMH has been issuing high-resolution numerical weather prediction products for the Caribbean region for 10 years. While the outputs of such products compare favourably with those of global models, space-based data and data from national and regional observation platforms, robust verification of the models is not available. This should be corrected to ensure broader acceptance of this useful regional product, which will lead to increased utilization and improved forecasting.

Timely delivery of products and services

As noted in section 1.4.3 above, the occasional slow or late delivery of critical products and services is a cause of concern. Institutions delivering products and services should establish Memoranda of Understanding (MoUs) or Standard Operating Procedures (SOPs) with stakeholders defining the time of product delivery, to disaster management offices, for example. CIMH and NMHSs should determine together the delivery times for numerical weather products. Such arrangements will enhance the national and regional decision-making process related to disaster management.

2.2 NATIONAL RECOMMENDATIONS

2.2.1 Personnel

With ready and easy access to technology at work and at home, copies of technical manuals, regulations and guides should be readily available to officers who require them. These documents should include Standard Operating Procedures (SOPs) for the NMHS and the most recent update of the regional hurricane procedures, and should be provided in hard and soft copies.

Expanding NMHSs in the Caribbean

It is recommended that each country has an NMHS. All NMHSs, not necessarily all islands, should have at least one officer among their staff trained up to at least the WMO Senior Meteorological Technician level. The lack of trained weather

forecasters in NMHSs that rely on other NMHSs for their forecast products becomes more apparent during the hurricane season when severe weather events are more frequent. Certified weather forecasters are required as a credible link between the forecast providers and the local NMHSs and other stakeholders. They are not to replace the traditional forecast providers, as the existing regional arrangements should remain in force until the entire agreement is revisited. They should serve as liaisons between the forecasters with the responsibility for the final product and the service receiving the product just prior to its finalization. This will ensure a more area-specific message customized to meet the needs of the local stakeholders.

Human resources

Each NMHS must possess a cadre of meteorological equipment technicians commensurate with their needs. Consideration should be given to the size of the observation and early warning network, type of equipment in use, frequency of maintenance and calibration schedules, future expansion of the network and in-house equipment maintenance needs. Services should establish frequent training schedules for these individuals given the rapid changes occurring in the hydrometeorological instruments industry. This should contribute to the sustainability of national instrument networks.

2.2.2 Observation and early warning network

Instrument procurement strategy

Many NMHSs lack an instrument procurement strategy and, as a result, manage extremely heterogeneous observation networks that are expensive to operate. NMHSs should develop instrument procurement strategies that outline the objectives of the network, operational requirements, management/economic model and sustainability model. The procurement model and the success of the network should be shared with potential donors.

Criteria for network installation

The factors affecting the sustainability of national hydro-meteorological observation and early warning systems, such as poor network design, limited resources and few support staff, need to be addressed with great urgency. Networks suffer from avoidable failures during severe weather and other hazardous events. Network breakdowns should be researched and catalogued to identify avoidable failures, and appropriate mitigation actions should be put in place to reduce them.

Data sharing

Access to data is central to the success of EWS, impact-based forecasting systems and scenario-generating platforms. CIMH generates, collects and often freely disseminates hydrometeorological and climate data to support regional and national EWS. The effectiveness of any national EWS is based on the system being able to access and ingest vast quantities of national and regional data. Unfortunately, many sectors, individuals and governments are currently unwilling to share their vast data stores for various reasons. To enable the development and implementation of robust national EWS platforms, national governments and CARICOM should be encouraged to implement national and regional open data policies.

2.2.3 Institutional structure and capacity development:

Periodic human resources assessment

Some islands with small airports employ the same officers both as Meteorological Observers and Air Traffic Controllers. Since this system works for some, it should not be readily discarded. It should, however, be periodically reviewed to determine its continued usefulness in keeping with the development of those islands. This system does not preclude the need for officers trained at the Senior Meteorological Technician Level. It should be recognized that observers are not forecasters and should not be assigned forecaster responsibilities. Periodic human resources assessments are encouraged to ensure that the requisite human resources are in place to address the evolving needs of the service.

Communications

As noted in section 1.4.3 above, severe disruptions to the national communication infrastructure limited the effectiveness of NMHSs on the affected islands following the passage of Hurricanes Maria and Irma, and compromised the national EWS. To mitigate this problem, each NMHS should seek to acquire an amateur radio set and appropriate training to operate and maintain it, given that some are Internet capable. In addition, NMHSs should assess the need to form partnerships with the national military/paramilitary services wherever they exist. These organizations usually have sophisticated communications equipment. NMHSs and NDOs should also maintain frequently updated lists of community volunteers who can support communications; the list should document individual competencies, equipment owned and contact details.

Backup power

As discussed in section 1.4.3 above, the activities of the NMHSs in the affected countries were compromised by the failure of the national power grid. This affected not only the ability of

services to communicate but also key operational systems. The simplest solution in the event of a power failure is to have a diesel/gasoline standby generator. If the NMHS is in a facility with a reliable standby generator, it should seek to be part of that backup power system. Generators for use during tropical cyclones must be robust and properly housed in a hurricane resistant structure. A good mobile generator can also be of assistance. Standby generators must also be well maintained and frequently tested to ensure readiness. Adequate levels of fuel should also be maintained on site in robust containers.

2.2.4 Institutional collaboration and interaction

Legislation defining roles and responsibilities

As noted earlier, country discussions raised concerns regarding the respective roles and responsibilities of partner agencies involved in the EWS process. It is recommended that legislation be enacted at the national level that designates the entity responsible for delivering meteorological information to the public in order to address this concern. Until such time that legislation is enacted, it is recommended that all parties engaged in the national EWS process establish appropriate MoUs and SOPs to guide their interactions.

2.2.5 Outreach

Raising the national profile of NMHSs

Outreach programmes are critical to mainstreaming the engagement of NMHSs in EWS processes. Section 1.4.3 above points out that in some affected countries the local NMHS lacks a national media presence in the country. To address this concern, it is strongly recommended that NMHS employ a broad outreach strategy that engages all stakeholders in the EWS process, including young people, the media, professional societies, communities, religious bodies, government ministries and the private sector. In addition, it is recommended that NMHSs deliver hydrometeorological forecasts daily on local television and radio stations, where these services are lacking. NMHSs should host open days to support public engagement. NMHSs should also collect feedback during those interactions and use that information to enhance their products, services and exchanges with the public.

Strengthening NMHSs for successful outreach

Given the importance of building public confidence in the NMHSs, particularly on the islands adversely affected by the hurricanes of 2017, it is recommended that the NMHSs consider building in-house capacity to routinely support public engagement activities or consider contracting such services on a periodic basis.

Joint outreach activities

The NMHS and the NDO could co-host an annual event, inviting their main stakeholders, especially the media. This event could be used to (a) clarify certain technical terms, (b) release and clarify predictions for the upcoming hurricane season, and (c) clarify the respective roles and responsibilities of the two organizations.

2.2.6 Products and services

Facilitating the adoption of products and services

It is recommended that products and services (including underlying data, models and assumptions) issued by NMHSs be periodically reviewed to assess their quality and use by the public and key stakeholders. Each product should be in a language that is easy to understand. The language should focus on the impacts of the hazard, rather than the parameters of the event. Opportunities for introducing new products and services should be assessed as new stakeholder relationships are built.

Public education

Educating the public on how to access and use meteorological information (including bulletins, warnings and watches), within the context of national and community EWS, should be considered an important annual activity of NMHSs. The outcomes of the country visits reveal the need to mount campaigns to inform the public about the best sources and locations for official weather information and the process for issuing watches and warnings.

Product and service delivery

The public should be aware of the product and service delivery mechanisms used by the NMHS, such as websites, electronic apps, including Common Alerting Protocol (CAP), social media feeds, conventional media arrangements and telephone numbers. Special consideration should be given to communicating with, and developing products for, particular interest groups, including the deaf and the blind. Sources of information should be continuously updated and engaging to encourage viewers to return. Where applicable, surveys should be performed periodically and analytics carried out and assessed to determine the relative merits of each communication platform.

Media

NMHSs should work with regulators to ensure that media houses carry the correct and most recent available forecasts from national authoritative sources to avoid confusing the public.

3. CONCLUSIONS

This report summarizes the lessons learned following the historic 2017 Atlantic hurricane season, deemed to be the costliest on record due to the significant damage and loss incurred. From the Caribbean perspective, the 2017 Atlantic hurricane season saw significant damage and loss inflicted on Anguilla, Sint Maarten, the British Virgin Islands, Barbuda, Dominica and the Turks and Caicos Islands by two category 5 hurricanes, *Irma* and *Maria*, within a three-week period. It is recognized that these losses could have been considerably higher if Hurricane *Jose* had tracked further south and come into contact with the Leeward Islands, which had already been severely affected by Hurricane *Irma*.

This report focuses primarily on the performance of the hydrometeorological services according to *Multi-hazard Early Warning Systems: A Checklist*. In particular, the report examines key aspects of forecasts delivered during the 2017 Atlantic hurricane season and how they were delivered to the public and key stakeholders. The report also notes how lessons learned from previous severe weather events and subsequent investments fed into preparations for the 2017 Atlantic hurricane season.

The key findings of the report can be summarized as follows:

1. NMHSs and associated data collection and distribution networks are weak and unable to support large multi-strike events separated by weeks. This situation needs to be rectified as soon as possible, given the risks posed to communities, the economy and national security. A comprehensive assessment of the resilience of NMHSs in CMO Member States needs to be carried out, and the necessary mitigating measures need to be taken, through appropriately targeted investments, to ensure service delivery under all realistic scenarios. Without such action, national and regional EWS systems will remain vulnerable to severe weather events.
2. Existing partnerships and service arrangements at the national level need to be reassessed, streamlined and effectively communicated to the public to enhance confidence in the information provided by the national EWS. In particular, the lack of legislation clearly designating the NMHS as the authority for issuing watches and warnings in many of the affected islands is a cause for concern as it opens the door to various entities delivering such information. A further concern is the absence in some countries of formal meteorological services to assist with (a) the tailoring of forecasts for national use, and (b) the dissemination of national watches and warnings to national stakeholders. This situation needs to be rectified.
3. The capacity of NMHSs and regional institutions engaged in hydrometeorological EWS needs to be continuously strengthened to effectively deliver the products and services required by stakeholders to make appropriate decisions. For example, investments in regional state-of-the-art platforms capable of delivering hydrometeorological and climate projections at scales relevant to forecasting for SIDS are required. In addition, staff in NMHSs frequently need to upgrade their competencies to effectively utilize new regional and international products and services (e.g., new satellite products and services as well as new numerical products) that support national and regional EWS and related decision-making. The training capacity at CIMH will need to be expanded to address the evolving needs of NMHSs supporting the EWS process. Moreover, the range of products and services CIMH delivers to the region may need to be expanded to support new areas of marine forecasting that participate in national and regional EWS processes.
4. There is an urgent need to switch from the current forecasting paradigm to a new paradigm that stresses warnings based on likely impacts. Many deaths caused by severe weather events in the Caribbean have been attributed to people being unable to undertake actions consistent with the information they had received. In the lead-up to Hurricanes *Maria* and *Irma*, many received the forecasts but were unable to contextualize the likely impacts from the information provided. Switching to impact-based forecasting will require the development of new competencies in NMHSs and new investments in hardware and software, as well as new approaches to data management and data sharing. CIMH has already developed some skill in this area by hosting the Caribbean Dewetra Platform and utilizing its data to prepare impact scenarios for regional and national stakeholders prior to the impact of severe weather systems.





Chapter II

An Expert Review of Disaster Risk Knowledge, Warning Dissemination and Communication and Preparedness and Response Capabilities in the Context of Hurricanes *Irma* and *Maria*

JEREMY COLLYMORE and CDEMA

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CDEMA

The Caribbean Disaster Emergency Management Agency, CDEMA (formerly CDERA) is a regional inter-governmental agency for disaster management in the Caribbean Community (CARICOM). It was established in 1991 and presently comprised of 18 Participating States (PSs), Anguilla, Antigua and Barbuda, Commonwealth of the Bahamas, Barbados, Belize, Commonwealth of Dominica, Grenada, Republic of Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, Saint Lucia, St. Vincent & the Grenadines, Suriname, Republic of Trinidad & Tobago, Turks & Caicos Islands and Virgin Islands.

The Agency's primary responsibility is the coordination of emergency response and relief efforts to PS that require such assistance. This mandate was expanded in 2009 to address CDEMA's advocacy and promotion of a Comprehensive Disaster Management (CDM) approach for a safe and more resilient Caribbean region.

For more information on CDEMA, please visit www.cdema.org.



INTRODUCTION

The 2017 Atlantic hurricane season was the deadliest and costliest in the history of the Caribbean region, with the highest total Accumulated Cyclone Energy (ACE) and the highest number of major hurricanes since 2005. The three major storms, *Harvey*, *Irma* and *Maria*, impacted several islands and resulted in billions of dollars in damages and over 100 deaths.

The value of uninsured losses from *Irma* is estimated at between US\$ 7 billion and US\$ 15 billion, with the British Virgin Islands alone accounting for US\$ 3.6 billion. In Dominica, *Maria* led to damages that amounted to US\$ 931 million and losses of US\$ 382 million, a combination equal to 226% of the island's gross domestic product (GDP).

In Puerto Rico, damages from the combined impacts of *Irma* and *Maria* were in the region of US\$ 94 billion. Equally noteworthy was the rapid onset of these events, which challenged the hurricane readiness culture in the Caribbean.

In light of these unfamiliar and unprecedented events, there was acute interest at the national, regional and international levels in looking at the lessons to be learnt regarding early warning systems (EWS). To this end, in November 2017, during its 5th meeting, in Bonn, Germany, the Climate Risk and Early Warning Systems (CREWS) Steering Committee called for the initiative "Lessons Learnt on Early Warning Systems Following the Caribbean 2017 Hurricane Season" to be undertaken to identify experiences, critical gaps and major lessons to be learnt.

It is anticipated that the findings of this initiative will guide and rationalize larger EWS investment initiatives to strengthen EWS in the region. This expert review is part of three interrelated assessments to address the various elements of the EWS lessons to be learnt from Hurricanes *Irma* and *Maria*.

PURPOSE OF THE EXPERT REVIEW

The expert review sought to assess the Caribbean Disaster Emergency Management Agency (CDEMA) system EWS priority areas in the aftermath of Hurricanes *Irma* and *Maria*. An early warning (EW) is "the provision of timely and effective information, through identified institutions, that allows individuals exposed to hazard to take action to avoid or reduce their risk and prepare for effective response" (UNISDR, 2004). It is the integration of four main elements: disaster risk knowledge; detection, monitoring, analysis and forecasting of hazards and possible consequences; warning dissemination and communication; and preparedness and response capabilities.

The expert review was undertaken during the period of 28 May-4 June 2018. The assessments were conducted against the backdrop of the projected expectations for an above-normal

2017 hurricane season and the warnings disseminated on the events. The assessment focused on three tiers – the national system, the local (community) level and a priority sector, Shelter.

The intent was to ascertain whether any reviews or enhancement of operational procedures was initiated based on the seasonal forecast, how meteorological warnings and their likely projected impacts were received and shared with key constituents and what key actions were taken by institutions and communities.

It is expected that the findings of this expert review will help to guide current and future investments in building robust and comprehensive EWS and will contribute to recovery processes.

APPROACH TO THE EXPERT REVIEW

Individuals consulted for this expert review included officials from the National Disaster Offices (NDOs), meteorological professionals, shelter managers and representatives of district- or community-based entities. A mixture of data collection methods was utilized: stakeholder focus groups were contacted, interviews were conducted, literature was reviewed, specific target group questionnaires were given, both online and in hard copy, and issues were triangulated. In addition to the 28 persons listed in Appendix I, data was also generated from four regional/international organizations working in EWS in the CDEMA system and four meteorological offices, primarily through the online questionnaire. The nature of the consultations was influenced by the time constraints required for the timely delivery of the findings.

The target countries of the Review were Antigua and Barbuda, the British Virgin Islands and Dominica.

LIMITATIONS OF THE EXPERT REVIEW

The expert review was initiated for the primary purpose of determining whether Hurricanes *Irma* and *Maria* had given rise to any new issues or lessons which could contribute to an EWS project concept that was being developed for the Caribbean. The time allocated for the expert review, two weeks from initiation to presentation of the initial findings, was defined by the project schedule. This timeframe limited the issues which could be addressed and was not sufficient to allow for a comprehensive investigation of the review objectives. Consequently, a more abbreviated approach had to be taken. The approach decided upon focused on the recovery environment and the dislocation of persons and institutions impacted by the weather events.

The small numbers of individuals consulted is reflective of the generally small numbers of persons in the national disaster offices.

KEY FINDINGS OF THE EWS EXPERT REVIEW

The findings of the EWS Review are presented in the broad areas of a) monitoring and detection b) risk knowledge c) preparedness and d) dissemination and warning. The intent was to recognize the connectedness of these four EWS elements. The status and effectiveness of early warning systems is as dependent upon dissemination/communication and response capacity as it is upon the existence, coverage, quality, spatial scale and 'skill' of the warning mechanisms. Where appropriate, efforts have been made to show the interconnectedness of the actors and actions within early warning systems.

Monitoring and Detection

All the EWS actors generally agreed that the warnings were timely. However, there is a recognition for continued institutional strengthening of meteorological services and other EWS actors. Strategic planning is an emerging practice in these communities, and staff welfare management in emergency situations is weak or missing. *Irma* and *Maria* highlighted the challenges of providing multi-island monitoring and forecasting services, especially when there is more than one event and there are varying levels of threat in the various locations.

These challenges were amplified by the limited familiarity of the officials with local environmental peculiarities of communities outside the national boundaries in which they operate.

Meteorological and disaster management experts called for greater use of existing decision support technologies, such as the DEWETRA platform, in preparedness planning for hydro-met threats. The need for improved coordination of the work of key EWS was expressed strongly. Seven actions, indicated below, were recommended to help in mitigating the constraints and challenges encountered by the meteorology community. There will need to be consultation on the scope of these challenges and prioritization within a programme.

1. Explore options for enhancing staffing of meteorological offices during intense forecasting periods.
2. Examine options for access to a communication specialist or support services during the hurricane season or in periods of high demand for public information sharing and messaging.
3. Revisit communications to ensure service delivery in emergencies for local and external communities.
4. Review and enhance the use of social media options to disseminate information. This is critical to sustaining the position of the meteorological service as the primary source of meteorological information for all demographics.

5. Broaden and accelerate training in the use of decision-making support tools in meteorological and national disaster offices.
6. Strengthen strategic and resilience planning in meteorological organizations. The need for continuity of operations in the midst of a crisis is indispensable.
7. Develop a model staff welfare management system for the met services and promote its adoption.

Risk Knowledge

Risk knowledge is the awareness of the relevant risks (hazards, vulnerabilities and capacities). It helps to drive preparedness, response planning and public education and information gathering initiatives.

In the context of Hurricanes *Irma* and *Maria*, there is evidence of attempts to use risk knowledge in response planning, shelter selection and public education with respect to various hazards, by various actors and with various levels of urgency. This suggests the need for a more integrated approach within a national programme.

A key finding of the expert review is that there is a need to rethink the design and delivery of early warning systems. The approach should bring together key EWS groups – scientists and technocrats, policy makers and users.

Preparedness

Preparedness is the critical link between risk knowledge, putting in place systems to minimize the consequences of weather events and seeking to inform and guide the behaviour of potentially threatened individuals. It includes (i) receipt and dissemination non-emergency information, (ii) timeliness of information, (iii) receipt and actioning of warning information, (iv) communication failure and management.

The basic elements for generating and applying risk knowledge in order to minimize loss of life, injury and property damage exist in the Caribbean region. However, more risk mapping is required, as is the use of risk mapping within early warning systems. Particular attention must be paid to the wider and more effective use of developments in information communication technology in enhancing the means of and products for information sharing, education and community engagement.

National disaster management systems are playing catch-up with the diverse sourcing options the population is using to obtain risk and warning information.



Emergency communication architectures are fragile and will require short-term investments to improve redundancy. The reasons for communication failures suggest weaknesses across key areas of the EWS architecture in the three study countries. These weaknesses include lack of suitability of the National Emergency Operations Centre (NEOC) facilities, insufficient redundancy in the communication systems and weak continuity planning of the energy and communication utilities.

There is an urgent need to revisit the policy and practice of shelter management in the Caribbean. Shelter management is a key part of the early warning system, and it has been sorely neglected. The shelter management review has revealed that issues and constraints relating to shelter management are common. It has exposed the limitations of the components approach to EWS interventions, an approach which is still common practice in the Caribbean, in contrast to the benefits which could be gained from an integrated approach to EWS programming and practice. With the onset of the 2018 hurricane season in the already compromised Caribbean countries, addressing the issue of shelter management is a necessity. To this end, we offer three broad recommendations as initial and essential steps in changing the shelter management landscape in the Caribbean:

1. Urgently address the absence of a national shelter management policy in the Caribbean countries. While this expert review focuses on issues related to hurricanes, other hydrometeorological, geophysical and anthropogenic hazards can also generate shelter needs.
2. Revisit the assumptions which underpin shelter management policies and programmes in the Caribbean given the reality that individuals seeking protection at shelters generally arrive at the shelters late and unprepared for shelter living.
3. Evaluate the shelter management value chain, identify weak links and initiate actions to strengthen them. The issues, comments and recommendations in Table 1 can provide guidance in these areas.

Lessons identified but not learnt

The issues addressed in this expert review have been compared with those addressed in EWS Studies since 2010. The results suggest that the rate of learning is slow.

CONCLUSION AND RECOMMENDATIONS

The changing hazard and social landscape requires that the Caribbean approach to the design, operation and assessment of early warning systems be re-evaluated. The entrenched silos approach to EWS development in the Caribbean must be disrupted to accommodate an integrated EWS agenda. Hurricanes *Irma* and *Maria* have revealed the discrepancy in the speed and diversity in technology uptake between institutional actors and the communities their services target.

Additionally, while the modelling and science of risk knowledge is advancing, the pace of its application for operations and response planning is lagging. There is recognition of the need for science and its applications to work together, but this has not translated into a change in the EWS architecture or programming process. The issues raised in earlier studies have only been marginally addressed.

The changing dynamics of weather-related threats, communities and technology are altering the EWS landscape. EWS policy and practice can benefit from more investment in evidence-driven considerations. Involving higher educational institutions and the private sector in providing the evidence is no longer an option but a necessity.

Hurricanes *Irma* and *Maria* provide another opportunity to trigger a new way of thinking about and modifying EWS in the Caribbean. The recommendations below offer institutional and operational suggestions for EWS transformation.

A. Improved EWS Architecture

1. Undertake an EWS stakeholder mapping and related engagement strategy to help clarify roles, responsibilities and mandates of different institutions/bodies engaged in EWS. This is both urgent and important if duplication is to be minimized and efficiency of resources used achieved. One of the first steps in the rationalization process is to invest more effort in the integration or harmonization of EWS programmes of national and regional actors. The Comprehensive Disaster Management Council on Harmonization and Coordination (CDM CHC) is well placed to provide the platform for such an exercise.
2. Urgently establish a facility to harmonize EWS enhancement interventions around a common early warning vision for the Caribbean.
3. Revisit the funding mechanism with a view to improving predictability as a central platform for EWS enhancement.
4. Prioritize work to enhance redundancy in emergency communications, including the mix of traditional and other warning methods.
5. Broaden EWS programmes beyond disaster preparedness to exploit or build synergies with approaches to disaster risk reduction and climate change adaptation.

B. Standards, products and services

1. Invest more in developing and promoting standards for performance in all areas of EWS to include shelters, shelter management and relief services.
2. Introduce displacement and tracking tools and services to respond to emerging needs in EWS.
3. Pilot the introduction of a Sustainable Shelters concept designed around the tenets of adaptability, hardened facilities, alternate energy use, water harvesting and conservation options.

C. Researching and rethinking EWS

1. Research the use, reach and impact of social media in the Caribbean and options for enhancing these to include a review of the governance arrangements around the development and introduction of new products and tools in EWS. One focus area could be improving the capacity and capability to disseminate warning messages at the local level after hazard impacts.
2. Explore, through a more inclusive Education Sector Sub-Committee (ESSC), the establishment of an EWS evidence-based working group to draft a framework for the deeper involvement of higher educational institutions in EWS. Some areas to be considered include methods to capture and integrate data from diverse sources, the means to inform policy development and a better understanding of the social elements of EWS.
3. Rethink the conceptualization of EWS in an era of change to better embrace the principle of adaptivity.

1. APPROACH AND METHODOLOGY

An intense desk review of EWS in the Caribbean and the assessments of the Irma and Maria operations in the study countries were complemented by consultations with key stakeholders.

Scope and inception

Literature review

The literature review included a secondary data review and desk research focused on reviewing assessment reports relating to Hurricanes *Irma* and *Maria*, after action reviews and other reviews. Included among these were the Report of the Rapid Review (RRR), commissioned by the CDEMA Coordinating Unit (CU), the reports of the related meetings on its findings the implications for policy and enhancement needs of the Regional Response Mechanism (RRM) and larger issues of humanitarian reform.

The expert reviewer also undertook a desk review of other background documents related to hurricane disaster plans and associated early warning mechanisms in the target countries and their operational framework for alerts and notifications, public education and information programmes. Existing regional and other model documents or standards for EWS were also reviewed (Appendix II).

This initial data was used to develop the operational framework for undertaking the assignment and identifying the key stakeholders to be targeted.

Semi-structured interviews

The individuals selected to be interviewed were chosen using purposive and convenience sampling. This selection method was necessitated by the still-evident dislocation of persons and communities affected by Hurricanes *Irma* and *Maria* and the disruption and/or instability of road networks and communication services. Once potential key individuals were identified, they were asked to complete a hard or electronic copy of a questionnaire that directly targeted each stakeholder group.

Interviews of key individuals were conducted by CDEMA CU staff in the Preparedness and Response Division, national disaster coordinators, shelter managers and officials who oversee shelter management programmes, members of

designated organizations providing monitoring and alerting for hydrometeorological hazards at the national and regional levels; stakeholders with existing EWS programmes in the selected states and in the Eastern Caribbean including, the International Federation of Red Cross and Red Crescent Societies (IFRC), the Caribbean Institute of Meteorology and Hydrology (CIMH), CREWS and the United Nations Development Programme (UNDP).

The interviews were conducted in diverse manners, including face-to-face, via video calls and via teleconference calls. The individuals were interviewed subsequent to their completion of an online or hard copy questionnaire, which was used to facilitate consistency in the data gathering and to frame and capture the individuals' feedback (see Appendices III to VI).

Study countries

Given the limited time allocated for the data capture (two weeks), the target countries were those three which participated in the CDEMA Rapid Review: Dominica, a sovereign state extensively damaged by Hurricane *Maria*; the British Virgin Islands, an overseas territory of the United Kingdom which was also extensively damaged by *Irma* and *Maria* and Antigua and Barbuda, a sovereign multi-island state which was impacted by *Irma*. Antigua and Barbuda is also a Sub-regional Focal Point of the CDEMA system. The selected states provide a mix of the jurisdictional spaces encountered in the CDEMA system as well as a mix of levels of performance in the CDEMA country assessment reports.

Target sector

The shelter sector was targeted as the priority sector for this expert review. It plays a key national humanitarian role by providing a space for displaced individuals. Shelters are defined community meeting points and are spaces for the protection of the vulnerable, including children and the elderly. The manner in which the shelter sector interfaces with alerts and notifications and embraces hazard and risk information is critical in the national early warning system. Shelter managers in Antigua and Barbuda and the British Virgin Islands completed a questionnaire (Appendix VII) and participated in focus groups. In Dominica, this was not possible, but a national report describing the shelter managers' and officials' review of the experience relating to Hurricane *Maria*, issued in January 2018, was made available. This was complemented by an extensive interview of the officials overseeing shelter management and the National Disaster Coordinator.

Community outreach

Efforts to engage impacted communities were limited due to the time allocated for the report and logistics issues related to access. In Antigua and Barbuda and the British Virgin Islands, proxies were used. In Antigua and Barbuda, the proxies were representatives of dislocated persons from Barbuda living on the main island. In the British Virgin Islands, the proxies were the administrators in the outer islands and persons in the shelter management community who were directly affected by *Irma*.

Efforts were made to triangulate the data with the data gathered by the writers of the other chapters in this publication and with prior studies, as well as across information received from other informants.

Data analysis and interpretation

The data generated from the questionnaire for key individuals was input into Survey Monkey, from which basic descriptive information was derived using IBM SPSS software. In the case of meteorological officials and shelter managers, a content analysis was used to map common themes and issues. The data from the questionnaire, the issues from the focus groups and the desk reviews were used to frame answers and discussions relating to the three broad questions of this expert review:

- The extent of disaster risk knowledge existing in three CDEMA participating states and the level of application of this knowledge during the 2017 weather events;
- The effectiveness of warnings communicated and disseminated in three CDEMA participating states;
- The effectiveness of the preparedness measures that were put in place in the three CDEMA Participating States.

The initial findings of the review were presented to a diverse group of EWS stakeholders at a regional validation workshop. Among these stakeholders were representatives from NDOs, civil society organizations, hydrometeorological services, gender bureaus and civil aviation, regional and stakeholder organizations. This report is informed by the feedback gained from this process

Limitations of the review

This expert review was initiated for the primary purpose of determining whether Hurricanes *Irma* and *Maria* had given rise to any new issues or lessons which could contribute to an EWS project concept that was being developed for the Caribbean. The time allocated for the review was defined by the project schedule. This timeframe limited the issues which could be addressed and was not sufficient to allow for a comprehensive investigation of the review objectives. Consequently, a more abbreviated approach had to be taken. The approach decided

upon focused on the recovery environment and the dislocation of persons and institutions impacted by the weather events.

The small numbers of individuals consulted is reflective of the generally small numbers of persons in the national disaster offices.

2. KEY FINDINGS OF THE EWS REVIEW

The findings of the EWS review are presented in the broad areas of a) monitoring and detection b) risk knowledge c) preparedness and d) dissemination and warning. The intent was to recognize the connectedness of the four EWS elements. The status and effectiveness of early warning systems is as dependent upon dissemination/communication and response capacity as it is on the existence, coverage, quality, spatial scale and 'skill' of the warning mechanisms. Where appropriate, efforts have been made to show the interconnectedness of the actors and actions within early warning systems.

Monitoring and detection

The information generated here came from meteorological officials in the study countries and was correlated with responses from national authorities, shelter managers and stakeholders.

Meteorologists were generally in agreement that their forecasts for *Irma* and *Maria* were timely. This was also supported by community-level respondents, 71% of whom indicated they had at least 36 hours of warning for these two events, and 87% of whom indicated that they had more than 24 hours of warning. 95% of national authorities indicated that they had more than 48 hours of warning for Hurricanes *Irma* and *Maria*. See Figure 5.

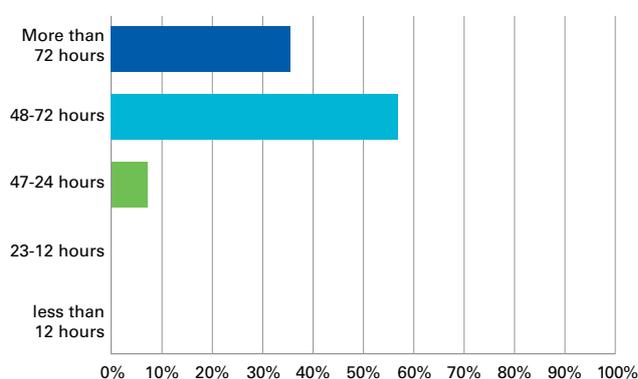


Figure 5: *Irma* and *Maria* Warning Time for National Authorities

The meteorologists did acknowledge that regular changes in trajectory and the rapid intensification of the hurricanes created warning challenges in relation to existing hurricane procedures in the national plans. It was therefore not always possible to provide the 72 hours of notification indicated in national hurricane plans.

This was compounded by intense demands for briefings, at decision-making and public information levels, associated with the rapid changes in intensity and trajectory. The result was that there were some delays in country-level briefings, especially where the warning centre had multi-country responsibility. Understandably, almost 40% of the national authorities felt that they did not have enough time to mobilize the country (see Figure 6).

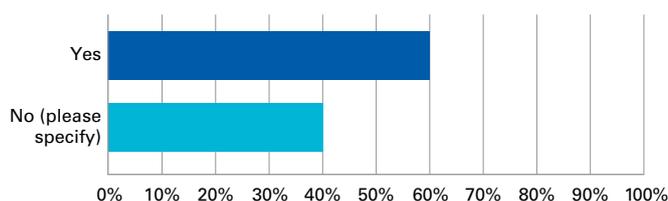


Figure 6: Satisfaction with Warning Period for Mobilization

Failures in the emergency communication systems during and after the impact of *Irma* and *Maria* led to extended periods when no warning information was provided. In some cases, these periods lasted for up to three days or more (see Figure 7).

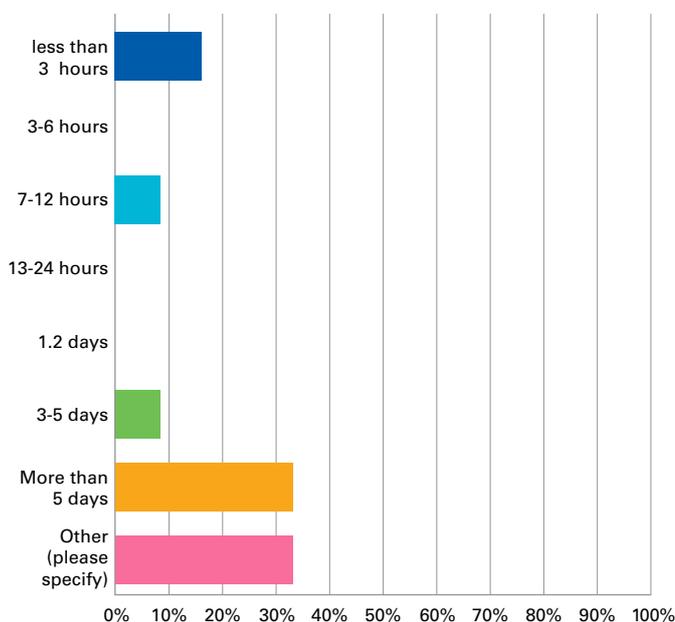


Figure 7: Period of Communication Disruption with Met Office

Meteorological officials indicated that there are no contingency arrangements for resourcing this surge in human resource demands.

Of the four meteorological individuals who were interviewed and who completed the survey instrument, only one indicated that there were systems in place to assess whether or not messages were received.

The primary means for communicating alert information are via telephone and via email. Social media is also becoming an option. It is recommended that further research be conducted regarding the timeliness of notifications and the means for receiving messages. The limited number of individuals providing information in this area makes it difficult to draw any conclusions except that information is received via a variety of means.

Interviews with key individuals indicated the need for institutional strengthening of meteorological services and other EWS actors. Strategic planning is an emerging practice in this area, and staff welfare management in emergency situations is weak or missing. *Irma* and *Maria* highlighted the challenges of providing multi-island monitoring and forecasting services, especially when there is more than one event and there are varying levels of threat in various locations. These challenges were amplified by the limited familiarity of the officials with local environmental peculiarities of communities outside the national boundaries in which they operate.

A call was made by practitioners in the meteorological and disaster management communities for greater use of existing decision support technologies, such as the DEWETRA platform, in preparedness planning for hydro-met threats. It was also noted that there is a lack of coordination with respect to many EWS initiatives involving the same practitioners.

Recommended actions for monitoring and detection

The actions proposed below can help in mitigating the constraints and challenges encountered by the meteorology community. However, there will need to be consultation on the scope of these challenges and prioritization within a programme.

1. Explore options for enhancing staffing of meteorological offices during intense forecasting periods.
2. Examine options for access to a communication specialist or support services during the hurricane season or in periods of high demand for public information sharing and messaging.
3. Revisit communications to ensure service delivery in emergencies for the local and external communities.
4. Review and enhance the use of social media options to disseminate information. This is critical to sustaining the position of the meteorological service as the source of meteorological information for all demographics.

5. Broaden and accelerate training in the use of decision-making support tools in meteorological and national disaster offices.
6. Strengthen strategic and resilience planning in meteorological organizations. The need continuity of operations in the midst of a crisis is indispensable.
7. Develop a model staff welfare management system for the met services and promote its adoption.

Risk knowledge

Risk knowledge is about the awareness of the relevant risks (hazards, vulnerabilities and capacities). It helps to drive preparedness, response planning and public education and information gathering initiatives.

Key individuals in the national authorities (the Head of the Disaster Office and officers responsible for operations and shelter management) were asked about their awareness of the extent of hazard mapping for key hazards and the extent to which related products were being utilized.

These individuals indicated that floods were the most mapped hazard at the national level (77%), and at the local levels (100%), followed by landslides and cyclones.

Sixty-five per cent the respondents who indicated that risk maps were available for their regions reported that these maps are used for disaster planning.

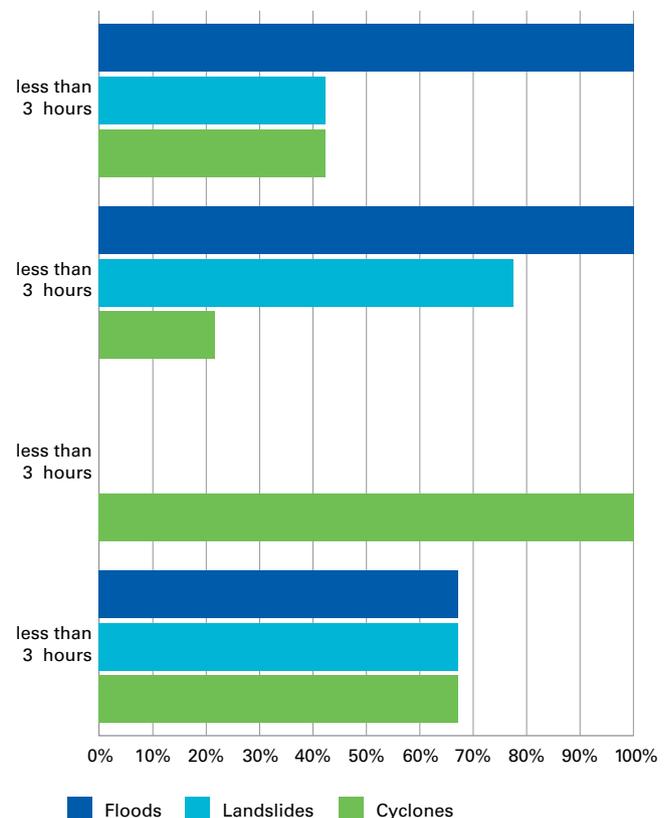
At the community level, hurricanes, floods and storms were seen to be the most frequently experienced hazards; of these, hurricanes were perceived to be most destructive hazard (65%) followed by floods (46%).

Although floods were seen as a major threat, it is notable that investment in formal flood EWS is not prioritized (CDEMA 2005, 2014; Collymore 2014).

Most of the flood hazard maps produced in the region are maps showing areas that have experienced floods rather than areas prone to flooding. Although improving, the resources and experience required to undertake flood modelling exercises may be inadequate. Other constraints include the datedness of the maps and the relatively short period of data coverage. Output maps are often poorly disseminated and the map legend used often does not effectively communicate the threat to the end users, including community members.

There is limited involvement of local agencies and local communities, which affects the accuracy of mapping and interpretation, and map scales are often too small for site specific analysis (CDEMA, 2005) (see Figure 8).

Figure 8: Existence and use of risk maps



A key finding of the expert review is that there is a need to rethink the design and delivery of early warning systems. The approach should bring together key EWS groups – scientists and technocrats, policy makers and users.

The issues of hazard experience, hazard frequency and preparedness at the individual, community and national levels need more investigation in the Caribbean context. Early research in these areas (Collymore, 1984, 1988) suggest that these are key considerations in understanding the relationship between risk knowledge, warning and response behaviour outcomes. Recent research (Smith, 2017) has reinforced the need for further investigation in these areas.

Preparedness

Preparedness is the critical link between risk knowledge, putting in place systems to minimize the consequences of weather events and seeking to inform and guide the behaviour of potentially threatened individuals.

Receipt and dissemination of non-emergency information

During non-emergency times, national disaster management authorities generally receive information fewer than three days a week from meteorological offices; up to 15% receive no information from meteorological offices at all. This suggests that the relationship may be demand driven around the response culture on which national disaster risk management (DRM) systems are anchored. The question then becomes: should communication between these entities should be routinized, and if so, what are the resource requirements to realize this?

Email is the most common medium through which meteorological services communicate with national authorities (78%) followed by telephone and social media (36% each) (see Figure 9).

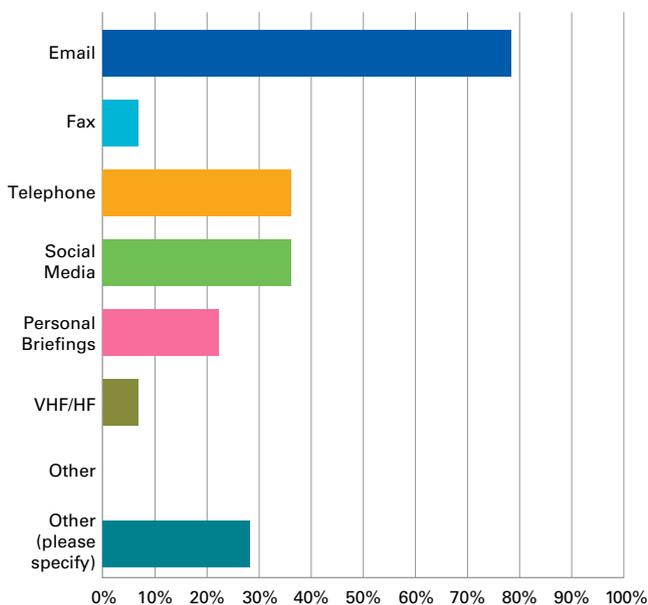


Figure 9: Communication media between the Met and national authorities

Community-level respondents had more diverse sources for getting their information on hazards and threats. Though radio is still a leading source for this information, social media is gaining prominence. WhatsApp is the major social media format, followed by Facebook and texting. Cell phones, a platform through which these media can be accessed, were also mentioned.



Caribbean early warning stakeholders: <https://www.youtube.com/watch?v=Z7ltoSF1IsQ&list=PLNaX-uTWSWrEmZBOerXkwsSgqcJQVky9&index=5>

Flexibility and mobility underpin these growing information sourcing options. To effectively communicate risk knowledge and warning information to the target populations, meteorological and national disaster authorities will need to accelerate the integration of social media options into their dissemination and communication systems.

In the British Virgin Islands, there was an indication of how WhatsApp was used to share critical readiness information before the impact of *Irma*, which may have made a difference in the number of lives lost (Collymore, 2018).

Timeliness of information

In the context of Hurricanes *Irma* and *Maria*, the representative individuals from the national authorities indicated that alerts and notification information had been received more than 48 hours before the landfall of the systems. Of these, almost 36% had more than 72 hours of notification.

All the key individuals at the community level received warnings for *Irma* and *Maria*, with 72% having more than 36 hours of warning. All the individuals surveyed stated that the messages indicated specific actions to take.

Nonetheless, only 60% of the national authorities were satisfied with the notification period for mobilizing for *Irma* and *Maria*. This may be related to the both the changing trajectory and rapid intensification observed for the systems (Taylor, 2017).

Underlying these data are two important questions: what is the system mobilization for and how is the mobilization target to be communicated to the key response actors and the general population? The discussion at the regional validation workshop found that these are critical areas of the EWS architecture that require more research.

Receipt and actioning of warning information

On receipt of an alert notification, the key actions of the national authorities included sharing this information with and consulting the political authorities (57% of cases), notifying key response agencies, partially activating the NEOC and disseminating warnings to the country as a whole (50% of cases) (see Figure 10). There was also some consultation with meteorological officials on the implications of the information shared. These steps were in keeping with existing hurricane response plans.

These responses suggest that, considering the neighbourly disposition of the respondents, incorporating a community-based EWS into a broader approach to addressing weather events, such as the Community Emergency Response Training (CERT) programme, which provides relevant tools and information, is something that should be explored.

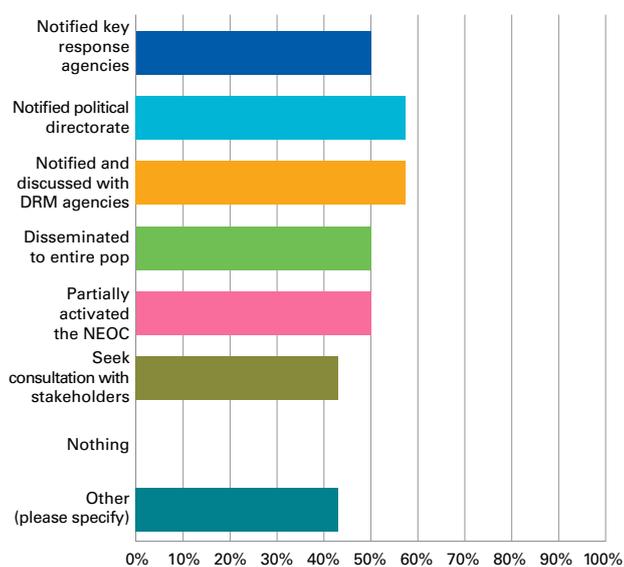


Figure 10: Actions of the national authorities on receipt of information from the Met Office

More than 83% of the community-level individuals consulted felt that the warning messages for *Irma* and *Maria* provided specific advice on the things to do. Sixty-three per cent found this information to be useful or very useful. The preparatory actions taken were primarily person-centred – securing personal property and obtaining emergency supplies (83%). These were followed by helping family members and/or neighbours to prepare (see Figure 11).

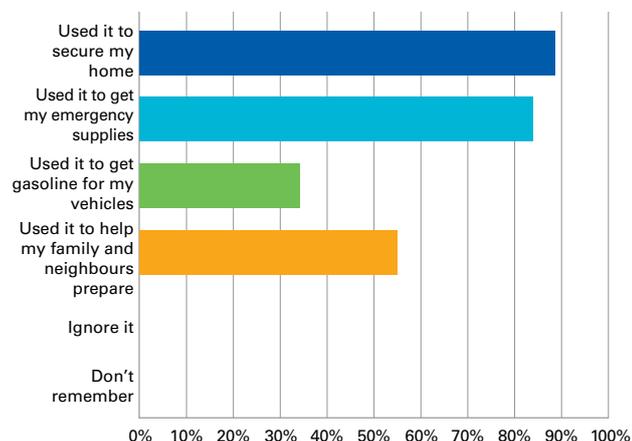


Figure 11: Community-level individuals' actions on receipt of warning information

Communication failure and management

Major concerns, with respect to EWS in the context of Hurricanes *Irma* and *Maria*, included the loss of emergency communications during and after the events (see Figure 12a) and the length of the disruptions, at least three days for about 40% of respondents (see Figure 12b). This issue was noted in several *Irma* and *Maria* assessment and review reports (Collimore, 2018; PDNA, 2017; Worrell, 2017).

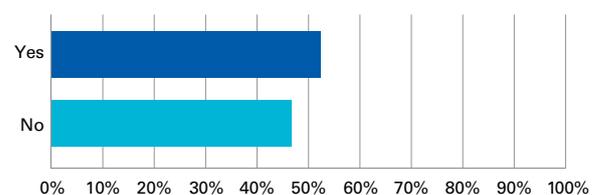


Figure 12a: Loss of communications with warning authority

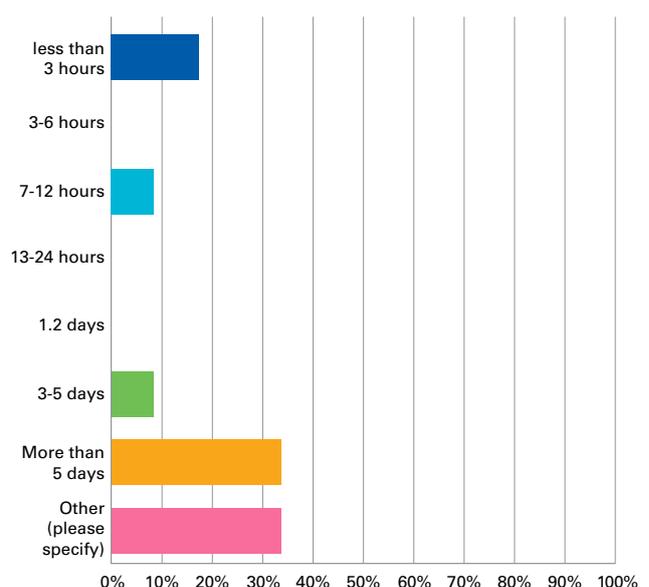


Figure 12b: Length of communication disruption

The reasons for communication failure suggest weaknesses across key areas of the EWS architecture in the three study countries. Included in these is the unsuitability of the NEOC physical facilities, insufficient redundancy in the communication systems and the lack of continuity planning for the energy and communication utilities (see Figure 13).

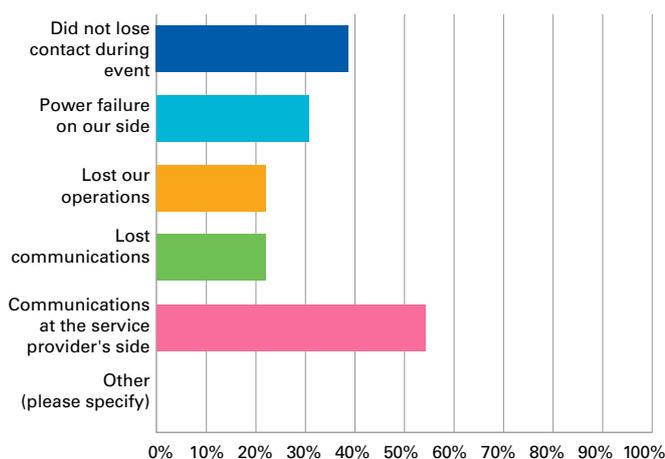


Figure 13: Reasons for communication disruption

The resulting inability to communicate with key response actors internally and externally, leading to difficulties in the coordination of humanitarian actions after Hurricanes Irma and Maria are well documented (Collymore, 2018).

Shelter management

Shelter management is a component of the preparedness system that demonstrates the important intersection of risk knowledge, hazard monitoring, and warning and readiness actions. In this expert review, the shelter management experience and outcomes in the context of Hurricanes *Irma* and *Maria* were obtained through questionnaires and focus group discussions with shelter managers in Antigua and Barbuda and the British Virgin Islands, shelter management officials in Dominica and shelterees in Barbuda and the report of a shelter managers’ meeting in Dominica. The general messages from the survey and focus groups and the discussion with officials note the following:

- i. The inadequacy of the facilities, including those designated as primary shelters;
- ii. The late arrival to the facilities of shelterees, with the associated lack of preparation, against the backdrop of the recommendations made in national procedures and advisory messages;
- iii. Growing evidence of indiscipline, including abuse of shelter managers and the resulting difficulty of finding volunteer shelter managers;
- iv. The absence of a clearly articulated shelter policy and unfamiliarity with shelter policies by the shelter managers;
- v. A limited appreciation by the shelter managers of the connection between shelter management guidelines and the national hurricane procedures of which they are a part;
- vi. The need for greater application of risk knowledge in shelter selection;
- vii. The urgent need for improved emergency communication systems which include shelters;
- viii. A call for stronger shelter management programming from NDOs and/or the designated lead and general improved coordination in the shelter system;
- ix. The need for a mobile shelter service support team approach to meeting the diverse needs of shelterees and for dealing with the limited available capacity of the shelters.

Table 1 summarises the discussions of the focus groups and country-level shelter information. It suggests that the issues and constraints are generally common and can benefit from a regional approach to action. There is an urgent need to revisit the policy and practice of shelter management in the Caribbean. With the onset of the 2018 hurricane season in the already compromised Caribbean countries, addressing the issue of shelter management is a necessity.

Table 1: Summary of issues and recommendations for shelter managers' focus groups

Shelter issues raised	Antigua and Barbuda	British Virgin Islands	Dominica	Comments	Recommendations
1. Presence and use of shelter policy	Yes	Yes	Yes	Shelter management stakeholders were not familiar with the policy where it existed. Where it existed, the need for review was recognized. This issue was raised in survey and focus groups.	<ul style="list-style-type: none"> a. Review existing shelter policy; b. Ensure that stakeholders are informed of it; c. Use it to drive programme development.
2. Training of shelter managers	Yes	Yes	Yes	This issue results from pop up shelters built in response to extensive housing damage, shelter loss and the unavailability of designated shelter managers.	<ul style="list-style-type: none"> a. Revisit the approach to shelter management training. Consider targeting existing community, and faith-based organizations. b. Build basic shelter management in community-centred DRM training programmes.
3. Familiarity with hurricane procedures	Yes	Yes	Yes	Most shelter managers had not seen the national hurricane procedures.	<ul style="list-style-type: none"> a. Provide all stakeholders in the EWS with guidelines regarding national hurricane procedures. The guidelines provide context for the shelter managers.

Shelter issues raised	Antigua and Barbuda	British Virgin Islands	Dominica	Comments	Recommendations
4. Adequacy of facilities	Yes	Yes	Yes	In Dominica and the British Virgin Islands, most of designated shelters were damaged. Many basic elements for functionality were missing in the operation facilities.	<p>a. Establish full service shelters for specific regions/zones to allow for major events and prolonged displacement. Comply with minimum agreed national or CDEMA standards.</p> <p>b. Review options to reduce post-impact demand to include incentives for alternative shelters.</p>
5. Rules enforcement	Yes	Yes	Yes	This was raised by both shelter managers and shelterees. Safety and security are growing issues.	<p>a. Provide greater dissemination of rules, including through the use of social media.</p> <p>b. Where there is no dedicated security present, examine options for providing security from security services.</p>
6. Review of shelter teams/services	Yes	Yes	Yes	Shelters provide refuge for a very diverse population, including elderly and disabled individuals. Often shelters had only a manager and an assistant.	<p>a. Establish shelter service teams. These should include social, health and counselling professionals. Resource constraints may require this to be a roving service.</p>

Shelter issues raised	Antigua and Barbuda	British Virgin Islands	Dominica	Comments	Recommendations
7. Preparedness of shelterees	Yes	Yes	Yes	Generally, shelterees arrive late to shelters. The arrival of shelterees peaked during impact and after. Latecomers were not generally prepared based on guidance given.	<p>a. Review the recommendations regarding shelter supplies for major events in light of this reality.</p> <p>b. Disseminate this information via diverse means.</p>
8. Coordination of actors	Yes	Yes	Yes	Many actors provided shelter assistance post impact. Duplication was evident.	<p>a. Establish and maintain a shelter management programme informed by policy, where available, that provides roles and deliverables for the actors.</p> <p>b. Undertake an inventory of shelter management stakeholders and their resource profiles.</p>
9. CERT value in shelter management	Yes	Yes	Yes	Shelter managers who did not have formal training but took CERT were still able to function. Broader training was very useful.	Rethink the approach to training in support of preparedness and response, taking into consideration the limited human resource pool. There should be more broad-based training to support strategic specialization.

Shelter Management is a key part of the early warning system, and it has been sorely neglected. It has exposed the limitations of the components approach to EWS interventions, an approach which is still common practice in the Caribbean, in contrast to the benefits which could be gained from an integrated approach to EWS programming and practice. We offer the following recommendations as initial and essential steps in changing the shelter management landscape in the Caribbean:

Urgently address the absence of a national shelter management policy in the Caribbean countries. While this expert review focuses on issues related to hurricanes, other hydrometeorological, geophysical and anthropogenic hazards can also generate shelter needs.

Revisit the assumptions which underpin shelter management policies and programmes in the Caribbean given the reality that individuals seeking protection at shelters generally arrive at the shelters late and unprepared for shelter living.

Evaluate the shelter management value chain, identify weak links and initiate actions to strengthen them. The issues, comments and recommendations in Table 1 can provide guidance in these areas.

Conclusions: Preparedness

The basic elements for generating and applying risk knowledge in order to minimize loss of life, injury and property damage exist in the Caribbean region. However, more risk mapping is required, as is the use of risk mapping within early warning systems. Particular attention must be paid to the wider and more effective use of developments in information communication technology in enhancing the means of and products for information sharing, education and community engagement.

National disaster management systems are playing catch-up with the diverse agile sourcing options the population is using to obtain risk and warning information.

Emergency communication architectures are fragile and will require short-term investments to improve redundancy.

3. REGIONAL STAKEHOLDERS

As part of this expert review, organizations working in the CDEMA system in the area of EWS were invited to share information on their recent and ongoing work via a short questionnaire administered by Survey Monkey and followed-up with direct interviews. The entities targeted (CDEMA, CIMH, IFRC and the UNDP) represent a diversity of DRM, scientific, civil society and multilateral actors. Much of the EWS investment is channelled through bilateral agreements and multilateral financial institutions. This not only creates engagement challenges for the beneficiary but can also result in duplication.

With the exception of the IFRC, regional stakeholders indicated that they are working directly with national disaster offices and/or international development partners. Investment beyond the DRM central agencies is limited. While many varied post *Irma* and *Maria* assessments have been undertaken, the regional stakeholders had not, at the time of this review, considered undertaking an assessment of their own EWS interventions in the aftermath of these events.

EWS interventions indicated limitations in the use of the risk knowledge and response capability interface. Though the CIMH is doing significant research in this area, the interface with the DRM community for uptake and practice validation needs to be upscaled. Information packaging and dissemination, risk knowledge sharing and disaster risk management programming have a light footprint at this time.

The review suggests that regional stakeholders are working in the same countries but on different components of the EWS in the absence of a coordinating mechanism to facilitate an integrative approach.

The national authorities raised the issue of accountability in the introduction of EWS projects and programmes by non-governmental organizations (NGOs), development partners, regional organizations and others. The tools and technologies introduced have the potential to improve EWS at the national and local levels. However, systems introduced at the community level were not linked to those at the national level or were different with little or no consideration to sustainability. One respondent mentioned that in their case, the country became a third party in accessing its own data.

If efforts are to be made to improve collaboration among regional stakeholders in EWS programme delivery, the lessons identified by Duran 2015; Collymore, 2015 and Brown, 2013 need to be considered.

4. TRIANGULATION

Given the limitations in sampling and the depth of the expert review, an effort was made to see how the issues raised and the findings of this review aligned with recent assessments of EWS interventions, projects and desk reviews. The results suggest that the lessons are being identified but not learnt.

Collymore 2015

The rapidly changing nature of hazards, society and technology calls for an overhaul of the mindset if the enhancement interventions are to impact and sustainable. There is an urgent need for a facility to harmonize EWS efforts around a common Early Warning Vision.

Duran 2015

Increase stakeholder involvement and interest, project outputs should contribute to the Work Programmes of the NDOs; adequate time considerations for input and involvement; Partnerships are important in facilitating sustainability; the relevant agencies must be involved very early in the process.

Brown 2013

Several agencies and organizations are typically involved in supporting EWS and coordination and cooperation remains a challenge, particularly where there is no guiding framework, policy or consensual vision underpinning the EWS. SHEARS EWS Scoping Study.



National Disaster Coordinators from the Caribbean

5. EFFECTIVENESS MEASUREMENT

The interest in looking at the lessons to be learnt regarding early warning systems suggests that there is a desire to assess the effectiveness of preparedness measures and warning messages. Notwithstanding the limitations the time allocated to such an assessment would pose, there is an implied assumption that there are defined EWS programmes at national and regional levels. This review did not find that such programmes exist.

At the regional stakeholder level, there is an emerging effort to define EWS outcomes and outputs. However, the design of the relevant indicators is too general to address effectiveness. In one case, the measurement spoke to the existence or absence of activity in an EWS component. The view is being posited that measurement of EWS should facilitate progress towards a set of goals, outcomes and results that reflect progress towards a desired state. More attention is needed in the articulation of indicators linked to a rating scale that provides guidance for the next steps in a critical area and/or system enhancement. Such a process can build on the UNISDR EWS basic achievement level indicators.

Additionally, there is an option to focus on the performance rating of meteorological and other forecasts based on the probability of correctly detecting weather events versus false alarms. What is being proposed is that the design of performance monitoring and assessment measures become an integral part of a Caribbean EWS programme. This will require thoughtful consideration of how to utilize higher-level educational institutions in this process.

There is a clear gap in the monitoring and evaluation of EWS and related risk assessments. More research is needed to improve our understanding of the effectiveness of these systems (what works and what doesn't) in order to inform the design of accountability mechanisms and to create protocols and opportunities for learning.



6. CONCLUSION AND RECOMMENDATIONS

The changing hazard and social landscape requires that the Caribbean approach to the design, operation and assessment of early warning systems be re-evaluated. The entrenched silos approach to EWS development in the Caribbean must be disrupted to accommodate an integrated EWS agenda. Hurricanes *Irma* and *Maria* have revealed the discrepancy in the speed and diversity in technology uptake between institutional actors and the communities their services target.

Additionally, while the modelling and science of risk knowledge is advancing, the pace of its application for operations and response planning is lagging. There is recognition of the need for science and its applications to work together, but

this has not translated into a change in the EWS architecture or programming process. The issues raised in earlier studies have only been marginally addressed.

The changing dynamics of weather-related threats, communities and technology are altering the EWS landscape. EWS policy and practice can benefit from more investment in evidence-driven considerations. Involving higher educational institutions and the private sector in providing the evidence is no longer an option but a necessity.

Hurricanes *Irma* and *Maria* provide another opportunity to trigger a new way of thinking about and modifying EWS in the Caribbean. The recommendations below can offer institutional and operational suggestions for EWS transformation.

A. Improved early warning system architecture	EWS-A1.	Undertake an EWS stakeholder mapping and related engagement strategy to help clarify roles, responsibilities and mandates of different institutions/bodies engaged in EWS. This is both urgent and important if duplication is to be minimized and efficiency of resources used achieved. One of the first steps in the rationalization process is to invest more effort in the integration or harmonization of EWS programmes of national and regional actors. The CDMHC is well placed to provide the platform for such an exercise.
	EWS-A2.	Urgently establish a facility to harmonize EWS enhancement interventions around a common early warning vision for the Caribbean.
	EWS-A3.	Revisit the funding mechanism with a view to improving predictability as a central platform for EWS enhancement.
	EWS-A4.	Prioritize work to enhance redundancy in emergency communications, including the mix of traditional and other warning methods.
	EWS-A5.	Broaden EWS programmes beyond disaster preparedness to exploit or build synergies with approaches to disaster risk reduction and climate change adaptation.
B. Standards, Products and Services	SPS1.	Invest more in developing and promoting standards for performance in all areas of EWS to include shelters, shelter management and relief services.
	SPS2.	Introduce displacement and tracking tools and services to respond to emerging needs in EWS.
	SPS3.	Pilot the introduction of a Sustainable Shelters concept designed around the tenets of adaptation, hardened facilities, alternate energy use, water harvesting and conservation options.
C. Researching and Re-thinking EWS	RES1.	Research the use, reach and impact of social media in the Caribbean and options for enhancing these to include a review of the governance arrangements around the development and introduction of new products and tools in EWS. One focus area could be improving the capacity and capability to disseminate warning messages at the local level after hazard impacts.
	RES2.	Explore, through a more inclusive ESSC, the establishment of an EWS evidence-based working group to draft a framework for the deeper involvement of higher educational institutions in EWS. Some areas to be considered include methods to capture and integrate data from diverse sources, the means to inform policy development and a better understanding of the social elements of EWS.
	RES3.	Rethink the conceptualization of EWS in an era of change to better embrace the principle of adaptivity.



Chapter III

Review of gender specific issues in EWS

ASHA KAMBON

Dr Asha Kambon

is an economist, gender equity specialist, researcher and public policy expert, with over forty years of experience working in the field of Development at the national, regional and international levels. Her work during the last twenty years has focused on Disaster Risk Management, as a post disaster needs assessment, Assessor and Trainer. Dr Kambon has conducted gender impact assessments following disasters in 2004 (Grenada), 2010 and 2016 (Haiti) and 2017 (Caribbean). Her international civil service career concluded with the Economic Commission for Latin America and the Caribbean (ECLAC), in June 2011 as Regional Adviser for Disaster Risk Reduction (DRR) and Small Island Developing States (SIDS).

Dr Kambon is also Senior PartTime Lecturer at the Sir Arthur Lewis Institute of Social and Economic Research (SALISES), University of the West Indies, St. Augustine.

Background

This review assessed the extent to which gender considerations were integrated into early warning system (EWS) processes during the 2017 hurricane season. It engaged stakeholders at different levels in the processes, including regional entities, national authorities and the women and men who experienced the 2017 hurricane season in the Caribbean region.

The 2017 hurricane season was a hyperactive, deadly and extremely destructive one. With 17 named storms and 10 hurricanes, 2017 ranked alongside 1936 as the fifth most active season since records began in 1851.

The focus of this review is on two deadly hurricanes, *Irma* and *Maria*, in three countries: Antigua and Barbuda, Dominica and Sint Maarten. In these three countries, *Irma* and *Maria* left a trail of death and destruction amounting to approximately 35 deaths (with some 34 missing), more than 1 000 injuries and 90%–95% of housing stock destroyed or damaged.

This review examined the structure of EWSs at the regional and national levels and the status of gender relations and equality in the Caribbean region. The regional institutions that support EWSs are in the main fulfilling their mandate, but they are under-resourced and have not fully taken on board the integration of gender considerations in EWSs. The Caribbean region continues to be a paradox in which the legislative framework affirms the equality of men and women, yet structural gender inequalities exist.

This review found that these structural inequalities hinder the ability of women to fully participate in the EWS processes.

Following focus group discussions with women and men organized across the three countries, certain patterns of social relations and behaviours began to emerge. It became clear that these social behaviours affected the roles of men and women within early warning system processes with respect to risk knowledge and monitoring, the technology that carries the EWS message, the EWS message itself and the capacity to respond to the EWS message once it has been heard and understood.

The reviewer identified four key variables that affect the different responses of women and men to EWSs in the Caribbean: the differences between women and men concerning the use of time, the position of women in the household and the structure of the household, the economic activity in which women were engaged and the differences between women and men concerning risk perception. These variables did not always stand alone. When they intersected, the situation of women with regard to EWSs became more problematic.

Key findings of the review included the recognition that gaps still exist in knowledge and understanding regarding how to include gender in EWSs, but there is a willingness at both the regional and national levels to address this need.

The review also found that there was insufficient use of existing social vulnerability data to address the capacity of vulnerable groups to undertake the required actions for their preparedness and safety; that is, greater use should be made of a socioeconomic evidence-based EWS programme design.

Men seemed to act out their risk perception through behaviours involving procrastination. It was suggested by male participants in focus groups that such procrastination was an expression of a certain 'machismo'. However, this acted as a stumbling block to men making preparations in a timely manner.

In the case of poor single female heads of households, the review found that limited economic and physical resources act as constraints to these women being able to take the required actions to safeguard themselves and their families, putting them at extreme risk in multi-hazard environments.

Most significantly, based on the information obtained from focus groups, the review found that both genders received the messages sent by the authorities. However, there were differences in how men and women responded to the messages. These differences related to how the different genders use time, household structure (for example, households headed by women, intergenerational families, and so forth), income level and differences regarding risk perception.

RECOMMENDATIONS

As a result of the review of the 2017 hurricane season and the assessment of gender considerations in EWSs, we are reminded of the futility of an approach to EWSs that is not holistic and does not take into account social structures and vulnerabilities in the population. The following recommendations are therefore submitted to strengthen the integration of gender in EWSs in the Caribbean region:

At the regional level

1. Regional institutions, such as the Caribbean Institute of Meteorology and Hydrology (CIMH) and the Caribbean Disaster Emergency Management Agency (CDEMA) should set an example through the establishment of a task force and/or committee to examine the gender dimensions of the EWS programmes for which they are responsible. In that way, a signal would be sent from the highest level regarding the importance of integrating gender concerns in EWSs, thus triggering positive actions at the national and local levels.
2. CDEMA may wish to make better use of its role to advocate for and to encourage evidence-based gender targeting.
3. CDEMA could consider an examination of gender considerations in its entire suite of EWS products.
4. CDEMA should seek to strengthen its capacity-building efforts with National Disaster Management Organizations (NDMOs) and National Meteorological and Hydrological Services (NMHSs) in programmes offered at its Regional Training Centre on the integration of gender considerations in alerts and warning messaging and through its standardized training material.

At the national level

5. Greater use should be made of Information and Communication Technology (ICT) for EWS messaging, but this should be coupled with improved targeting of messages to women and men.
6. There should be more and better targeting of vulnerable groups in EWS messaging, including single female heads of households, single, elderly male heads of households and chronically ill and disabled individuals when the preparation and dissemination of information on preparedness and response is being considered.
7. A greater willingness is needed to undertake applied research about the sociocultural characteristics that manifest in male and female behaviour in order to better assist women and men in understanding and managing risk.
8. An effort should be made to deepen programmatic understanding of the roles and engagement of transnational families with respect to EWSs in the Caribbean so that they may receive the maximum benefit from EWSs.
9. Gender Bureaux should be better integrated in the work of NDOs and NMHSs in order to more efficiently use existing capacity within government structures.
10. More resources must be brought to bear on social mobilization as a tool to integrate gender considerations into EWSs.

Part I

Introduction

1. OVERVIEW OF THE 2017 HURRICANE SEASON

The 2017 Atlantic hurricane season was a hyperactive and destructive season with 17 named storms and 10 hurricanes, of which six were major hurricanes,¹ seven tropical storms, one tropical depression and one potential tropical cyclone, ranking it alongside 1936 as the fifth most active season since records began in 1851.² It has been reported to be the costliest season on record, with a total of at least US\$ 282.16 billion in damages, about US\$ 100 billion higher than the total of the previous record holder, the 2005 season. Hurricanes *Harvey*, *Irma* and *Maria* were responsible for the majority of the season's damage.³

The two hurricanes of significance for this analysis are *Irma* and *Maria*, which had dire consequences for the Caribbean Small Island Developing States (SIDS) that are the focus of this review. However, it is important to note that the third hurricane, *Harvey*, was the most significant rainfall event in United States history, dumping some 60.6 inches of rainfall. It was the second costliest hurricane in United States history at US\$ 125 billion, following Hurricane *Katrina* in 2005 at US\$ 161 billion (costs estimated and adjusted for the Consumer Price Index (CPI)). At least 68 people died as a direct result of Hurricane *Harvey* in Texas, the largest number of deaths as a result of a hurricane in that state since 1919. NOAA reported that the damage caused by flooding over a large area of southeastern Texas was enormous, resulting in over 300 000 structures and 500 000 cars flooded.

In the Caribbean, Hurricane *Irma*, did not hit Puerto Rico directly; however, it dumped 7 to 15 inches of rainfall in the Puerto Rico highlands and as much as 23 inches of rainfall in parts of Cuba. Significant storm surge occurred in Barbuda, where *Irma* hit as a Category 5 hurricane on 6 September. After crossing Barbuda, *Irma* made its second landfall on Sint Maarten at 11:15 a.m. on the same day. *Irma* made its third landfall on the island of Virgin Gorda in the British Virgin Islands at 4:30 p.m., still as a Category 5 hurricane.

Irma caused 44 direct deaths as a result of its strong winds, heavy rains and high surf. Eleven direct deaths were reported in Sint Maarten and Saint Barthelemy together, nine in Cuba, two in Sint Maarten, four in the British Virgin Islands, three in the United States Virgin Islands, one in Barbuda and one each in Barbados, Haiti and Anguilla.

In the case of Barbuda, *Irma* caused destruction across the island, damaging or destroying about 95% of the structures, including the local airport. *Irma* caused most Barbudans to evacuate Barbuda, leaving the island uninhabited for the first time in 300 years. Preliminary estimates of physical damage amounted to US\$ 136 million, with losses amounting to another US\$ 51 million.

Sint Maarten also took a direct hit from Hurricane *Irma*. The Category 5 hurricane struck Sint Maarten on the morning of Wednesday, 6 September, resulting in an injury toll in excess of 200 persons and causing two deaths. Hurricane *Maria* followed on 20 September, bringing 2–5 inches of rainfall and storm force winds to an already battered territory.



A lady mourns the departure of her neighbors following the cyclone Maria in Dominica

¹ Major hurricanes defined as at level of category 3,4 or 5

² National Hurricane Centre , NOAA, <https://www.nhc.noaa.gov/data/tcr/>

³ Ibid



Maria made landfall on 19 September at 1:15 a.m. and ravaged the island of Dominica as a Category 5 hurricane. On 20 September, *Maria* hit Saint Croix and later devastated Puerto Rico as a high-end Category 4 hurricane. *Maria* caused 31 direct deaths in Dominica, with 34 missing; in Guadeloupe, two direct deaths were attributed to *Maria*, and in Puerto Rico, the official death toll was 65, with new estimates being reported of some 4,600 persons who lost their lives within the three-month period following the hurricane (Harvard, 2018). In Saint Thomas, two people lost their lives; in the Dominican Republic five people died; and in Haiti, three people died due to flood waters. In the mainland United States, four persons lost their lives.

The estimated damage to Dominica was US\$ 1.31 billion. In Guadeloupe, the damage was estimated at US\$ 120 million. The NOAA estimated the damage in the United States Virgin Islands and Puerto Rico at US\$ 90 billion.

Unfortunately, sex disaggregated data for the affected populations and the economic cost of the disasters continue to be extremely difficult to locate as the initial data regarding the effects of the 2017 hurricane season, according to official sources, were not presented by sex, age or ethnicity. Subsequent reports may provide such a breakdown. In the case of Dominica, a newspaper report listing the names of the deceased and missing allows the reader to infer, based on the names, that 14 men and 11 women died. This represents 25 out of a total of 31 confirmed dead.⁴ The official data for the three countries under review are presented in Table 2.

⁴ <http://dominicanewsonline.com/news/homepage/news/general/police-release-names-of-31-dead-34-missing-due-to-hurricane-maria/>

Table 2. Selected socioeconomic data relating to the 2017 hurricane season for Antigua and Barbuda, Dominica and Sint Maarten

Selected social statistics following 2017 Hurricane Season			
	Antigua and Barbuda	Dominica	Sint Maarten
Lives lost	1	30 (34 missing)	2
Numbers of persons in Shelters	600		400
Numbers of persons Injures			200
% housing stock destroyed/damaged	95%	90%	90%
Selected Economic Data following 2017 Hurricane Season (Barbuda only)			
Value of Damage (USD)	136.1 M	931 M	11.8 B
Value of Loss (USD)	18.9 M	380 M	52.9 M
Impact on GDP	9%	226%	
Contribution of Tourism to GDP	60%		
Contribution of Agriculture to GDP	2.30%	10.40%	

Source: Compiled from post-disaster needs assessments (PDNAs) and the damage and loss assessment (DaLA) report (for Sint Maarten)

One of the most significant ways in which one can get a sense of the impact of the events following the 2017 Hurricane season on women, is to reflect on the proportion of female heads of households in the region, which is reported to be high ranging from 22% to 47%. Dominica is a good case in which women represented 39% of the heads of households. Reports following the 2017 Hurricane season, suggested that the majority of these women did not have housing insurance. So when it is reported that 95% of the housing stock is destroyed or damaged (as in Table 2), it is possible to conclude that many female heads of households would have lost their major and most valuable asset.



Margaret Auguiste interview: https://www.youtube.com/watch?v=XK0vF_4dmOI&list=PLNaX-uTWSWrEmZBOerXkwsSgqcdJQVky9&index=9

2. STRUCTURE AND ORGANIZATION OF EWSs IN THE CARIBBEAN REGION

From Discussions with two key entities in the Caribbean region, and key informants, an architecture for Early Warning Systems in the Caribbean emerges. That architecture is illustrated in Figures 14 and 15. It suggests that the first level actors can be grouped into those who operate at the regional and international level, such as regional institutions and international development partners.

The second level actors function at the National level and include NDMO's, the National Meteorological & Hydrological Services, the National policy authorities such as the Prime Minister and their or his/her National Operations Centre. At the local level we find the local authorities (state and non-state actors) such Parish Councils, civil society organisations, communities and their Community Based Organisations (CBO's) such as the CERTS, families both locally resident and those resident abroad, and individuals.

The literature suggests that EWSs have been receiving the attention of policy makers in the region for more than three decades. The Caribbean region played an active role in the development of the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters and continued to play an active role in the development of the successor instrument, the Sendai

Framework for Disaster Risk Reduction 2015-2030. There have been some improvements in early warning systems in the region, though this has varied according to hazard and location. The region has seen some shifting towards an integrated multi-hazard warning systems culture, but such shifts have been characterized as slow (Fontaine, 2018; Collymore, 2016). It has been suggested that the resource-constrained environment (both human and financial) in which these institutions are forced to function has affected the pace at which the region transitions from the dominant techno-scientific warning system architecture to one that embraces all EWS stakeholders.

In this context, a successful EWS has to meet several requirements: it must incorporate the appropriate technology and know-how; the parties must have clearly designated responsibilities; there must be effective decision-making support mechanisms; there must be functioning communication systems and the system must support preparedness instruments, including evacuation planning and response structures. In terms of the effectiveness of the system, it is important to consider the adequacy and timing of the messages and information disseminated, as well as the public's confidence in the EWS process. In the Caribbean, while we have made significant advances in EWSs, especially for cyclonic events, there is still much work to be done to meet these essential elements of a successful early warning system.

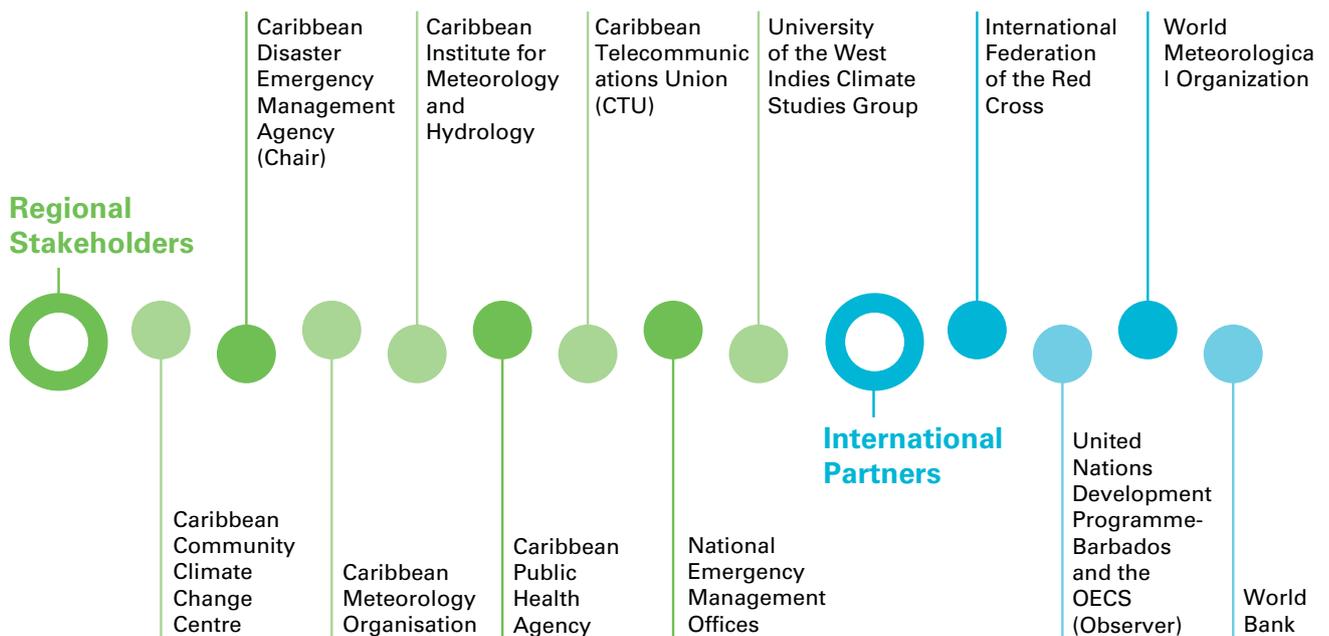


Figure 14. Regional and international stakeholders in the Caribbean EWS architecture
Source: Interviews with key informants

Above all, there is a need to have clear standards for performance and ways to measure the effectiveness of EWSs.

Recent assessments of existing early warning systems show that in most cases, communication systems and adequate response plans are missing. Even where EWS protocols have been elaborated, there are many instances of limited familiarity with the systems and/or conflicting legislative or regulatory instruments that compromise effective operationalization (Collymore, 2016; Fontaine, 2018).

CDEMA, as part of its Comprehensive Disaster Management programme, encourages the enactment of multi-hazard early warning systems. A multi-hazard early warning system is “an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events” (Open-ended Intergovernmental Working Group (OIEWG) on Indicators and Terminology Related to Disaster Risk Reduction).

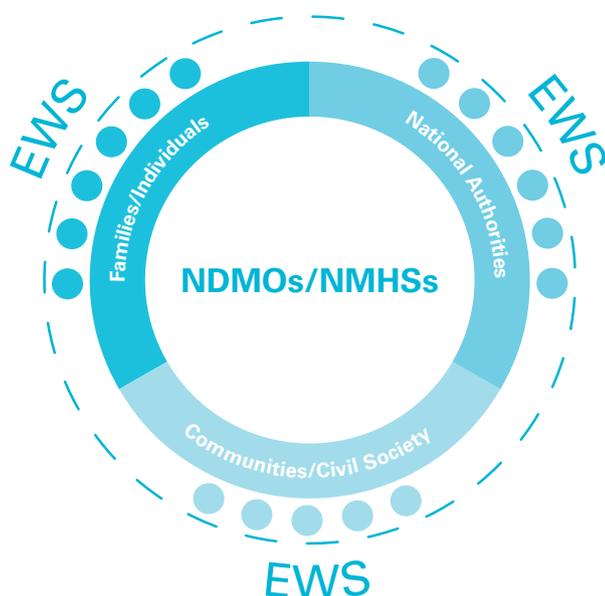


Figure 15. Early warning system stakeholders at the national and local level in the Caribbean

Source: Information collected by the researcher from interviews

3. GENDER RELATIONS AND EQUALITY IN THE CARIBBEAN

The Caribbean continues to be a paradox in which the legislative framework affirms the equality of men and women, yet structural gender inequalities persist. A recent report from the Caribbean Development Bank (CDB) (Baskh, 2016) confirmed that the Caribbean region continues to battle with gender inequalities. The report examined data from 10 Caribbean borrowing member countries (BMCs),⁵ two of which are included in this review – Antigua and Barbuda and Dominica.

Some of the inequalities highlighted in the CDB report and of particular relevance to the present review are the continued occupational segregation of men and women, with women tending to have lower-wage occupations, and less female participation than male participation in the labour force. The CDB report noted that the higher-educational achievements of girls had not translated into either higher participation in the labour market or a narrowing of the wage gap. See Figure 4, which illustrates that in those Caribbean countries for which data was available (Jamaica, Barbados and Trinidad and Tobago), for every 100 cents which a man earns, women earn 74 cents (WEF, 2017).

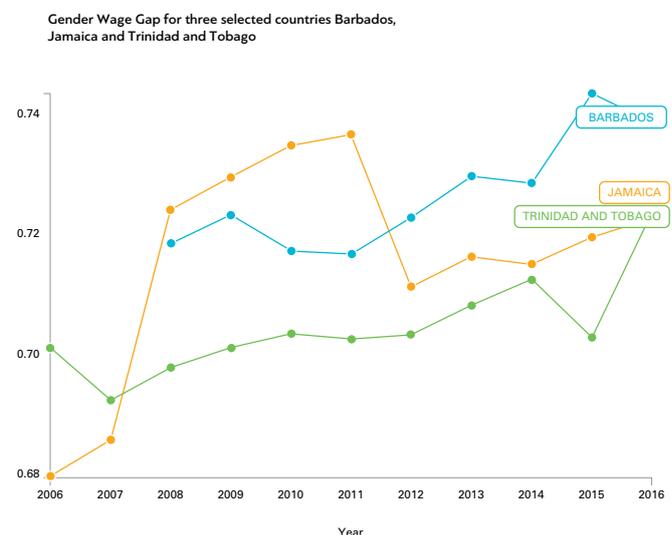


Figure 16. Gender wage gap for selected countries where data were available: Barbados, Jamaica and Trinidad and Tobago

Source: World Economic Forum (2017), Global Gender Gap Report

⁵ The 10 CDB BMCs surveyed were: Anguilla, Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines.

Table 3. Selected demographic and social data for Antigua and Barbuda, Dominica and Sint Maarten

Country	Antigua and Barbuda			Dominica			Sint Maarten		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Population	40,007 (48%)	43,271 (52%)	83,278	39,973 (51%)	33,940 (49%)	68,913	46,06 %	52,90 %	40,535 (100%)
Household Held	51.60 %	43.50%		61%	39%				
Labour Force Participation Ra	18,602 (47%)	21,341 (53%)	39,943						
(Barbuda specific)	78.60 %	75.90 %	849 (88,9%)						
Unemployment Rate A&B			14,1 %	2,164 (12.3 %)	1, 238 (9,9%)	3, 402 (11,0%)			
(Barbuda specific)			7,4 %						
Percentage of population at risk (vulnerable, poor, indigent)			28.3 %			43.40 %	23 %	34.10 %	57.10 %
AB-2017; Dom-2010;StM-2011									

Source: *Population and Census 2011; Country Poverty Assessment, Antigua and Barbuda, 2007; Dominica, 2010; Sint Maarten, 2011*

The CDB report further highlights the poverty and high dependency ratios of a high proportion of female-headed households. See Table 3 for details concerning heads of households and poverty rates in the three selected countries. Of the two countries for which data was available, Antigua and Barbuda and Dominica, 43.5% and 39% of households, respectively, had female heads. Based on the gender segmentation in the Caribbean labour market and the predominantly low position which women are situated within these markets we can assume that these households are functioning in very challenging framework. Table 3 shows gaps in the data; this continues to be one of the development challenges plaguing the region and making social and gender analysis difficult.

The CDB report noted two other significant conditions: the social isolation of elderly men, which was a phenomenon observed during the first gender impact assessment undertaken following Hurricane *Ivan* in Grenada in 2004 (Kambon, 2005), and gender-based violence, which was described in the report as endemic among the researched countries, with predominantly male perpetrators, and women and girls as the vast majority of victims. Although both of these are significant concerns, due to time constraints, these two phenomena were not examined as variables that could affect EWSs in the Caribbean; it is recommended that they be investigated in the future.

The review did not uncover any particular concerns of the LGBTIQ community and therefore these are not reflected in this document. This too may be an area for future research.

4. METHODOLOGY

4.1 Scope and objectives

The scope of the review entailed a report on three impacted countries in the Caribbean following the 2017 Hurricane Season. The Climate Risk and Early Warning Systems (CREWS) Steering Committee, during its fifth meeting, in Bonn Germany, in November 2017 called for an initiative entitled “Lessons Learnt on Early Warning Systems Following the Caribbean 2017 Hurricane Season”, to be undertaken to identify the critical gaps and experiences. The findings were expected to rationalize those areas already put forward in a larger investment initiative which sought to strengthen EWSs in the region.

The approach to this initiative, was disaggregated into three key areas that address hydrology and meteorology, disaster risk management and gender. The fundamental question which this researcher sought to answer in the present review was: How effective was the performance of “end-to-end” or “people-centred” early warning systems during the 2017 hurricane season in the Caribbean with regard to gender concerns?

This review addresses the assessment of gender considerations integrated into EWSs. The reviewer was tasked with engaging key constituents, capturing their experiences and documenting lessons learnt and recommendations for strengthening the inclusion of gender-specific issues in EWSs in the Caribbean region. The reviewer was also expected to be in close communication with the lead institutions at the regional level and to participate in and contribute to their specific thematic reviews in the areas of hydrometeorology and disaster management.

4.2 Research design

In order to best fulfil the objectives of the review, the reviewer decided on a four-stage research design:

1. Desk review of existing literature on EWSs in the Caribbean;
2. In-depth interviews with key informants;
3. Focus group discussions;
4. Validation workshop

The knowledge and understanding gained from the literature review was used to develop the questionnaires for the key informant interviews and to develop the guide for the focus group discussions. Both the questionnaires and the guide for focus group discussions are included in Annex 1 of this document. Two slightly distinct questionnaires were created, one for regional stakeholders and one for the national authorities.

The guide for the focus group discussions was designed to be altered if necessary based on the responsiveness of each focus group.

Focus group discussions were selected as a useful methodological tool for gathering information. The focus group research involved organized discussions with a select group of individuals to gain information about their lives and experiences with regard to the issues under investigation. The target groups for the focus group discussions were men and women aged 20 to 40 years and over 40 years. Participants were identified based on having experienced Hurricane *Irma* or *Maria* and their own interest in participating in a focus group discussion. Communities from which the groups were solicited were identified based on the known hardships experienced as a result of the 2017 hurricane season. The identification and forming of the groups were undertaken by NDMOs, Directorates of Gender Affairs or community development authorities, as the national situation on the ground warranted. Focus group discussions were in the main held in the late afternoon hours to accommodate women who had household duties to perform and to accommodate men who may have been involved in work away from the household.

The benefits of using focus group discussions as a methodological approach include the ability to gain insights into people’s shared understandings. The main purpose of focus group research is to draw upon respondents’ attitudes, feelings, beliefs, experiences and reactions in a way that would not be feasible using other methods such as observation, in-depth interviews or questionnaires.

Through the focus group discussions, the researcher sought to gain a deeper understanding of a number of issues. These included:

1. What women and men knew about the risks which they faced in their living or work environments;
2. How women and men engaged in monitoring any of the identifiable hazards and the possible consequences;
3. How women and men received information about the previous hurricane season;
4. How prepared women and men were to respond to the warnings received.

One limitation of using focus groups is that the results cannot, nor should be generalized to groups with different demographic or other social characteristics.

Key informants were selected using reputational selection, a technique in which interviewees are selected based on their known expertise, and purposive and snowball sampling techniques were used to identify other informants, not only due to the time constraints of the review, but also to

ensure, as far as possible, that the researcher would find and interview those individuals who possessed a particular insight into early warning systems at the country level. Also, due to the small nature of the societies in question and the fact that most of the people knew each other well, the researcher could be directed to informants with first-hand knowledge to share.

The draft report with preliminary findings was presented to a validation workshop which brought together stakeholders from the meteorology, hydrology and disaster management fields and directors of women's bureaux in the region. In this way, feedback could be received on the initial findings and taken into consideration for the final report.

In selecting countries to be included in the review, only those countries that were severely affected by the 2017 hurricane season were considered. Both independent and non-independent territories and both single-island and multi-island jurisdictions were evaluated. It was decided that the review would focus on Antigua and Barbuda, Dominica and Sint Maarten.



Gender: <https://www.youtube.com/watch?v=rnOEVm3P7kc&index=6&list=PLNaX-uTWSWrEmZBOerXkwsSgaccdJQVky9>

Part II

Why integrate gender in EWSs

1. THEORETICAL UNDERSTANDING OF EWSs

The United Nations Office for Disaster Risk Reduction (UNISDR) states that “[e]ffective ‘end-to-end’ and ‘people-centred’ early warning systems may include four interrelated key elements: (1) disaster risk knowledge based on the systematic collection of data and disaster risk assessments; (2) detection, monitoring, analysis and forecasting of the hazards and possible consequences; (3) dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact; and (4) preparedness at all levels to respond to the warnings received.” UNISDR further states that these components need to be coordinated within and across sectors and articulated at multiple levels for the system to work effectively. In order to best monitor an EWS, a feedback mechanism would be necessary, thus ensuring continuous improvement (UNISDR website).

Failure in one component or a lack of coordination across the components could lead to the failure of the whole system.

The Comprehensive Disaster Management (CDM) strategy of the Caribbean calls for multi-hazard early warning systems which address several hazards and/or impacts of similar or different types in contexts in which hazardous events may occur alone, simultaneously, in cascade or cumulatively over time, taking into account the potential interrelated effects (CDEMA, 2018).

The CDM strategy argues that a multi-hazard early warning system with the ability to warn of one or more hazards increases the efficiency and consistency of the warnings through coordinated and compatible mechanisms and capacities, involving multiple disciplines, for updated and accurate hazard identification and monitoring.

Community involvement is critical at all stages of EWSs. Communities need to be strengthened in order to protect themselves, react appropriately and help during an emergency situation.

Early warning systems are well recognized as a vital, life-saving disaster risk reduction tool. The Sendai Framework for Disaster Risk Reduction 2015-2030 refers to early warning systems as a critical element for disaster risk reduction. One of the seven global targets of the Sendai Framework is to “substantially increase the availability of and access to multi-hazard early warning systems.” The development, maintenance, sustainability and strengthening of early warning systems is also part of the 2014-2024 CDM strategy.



2. THE UNDERSTANDING OF GENDER IN EWSs

The concept of gender-sensitive early warning systems does not only relate to women and girls. It concerns the way in which differential roles, relationships, responsibilities and psychosocial perspectives are socially structured in any given society so as to affect the capacity of men and women and girls and boys to respond to EWSs. This is illustrated in Figure 5.

Gender-neutral EWSs ignore the reality of the social structures and power relations that exist within societies. They may miss influencing and empowering men and women so that they can safeguard themselves in multi-hazard situations, or they may fail to address existing power relations that have become structurally embedded in cultural practices relevant to safety and risk management.

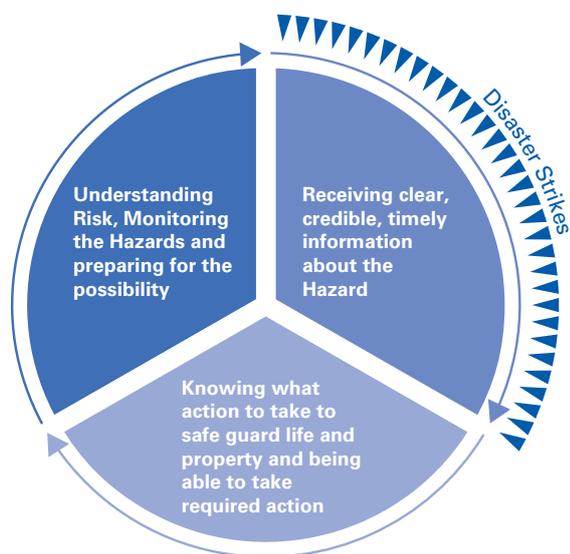
Early studies suggested that gender-blind EWSs could lead to harmful outcomes for women and girls and result in detrimental gender relations (UN Women, 2012). More importantly, by overlooking female stakeholders in EWSs, the potential contribution of women was being wasted.

Research suggests that a variety of factors ranging from socioeconomic status to cultural values can affect the ways in which EWSs operate.

Gender theory, drawing on the framework of intersectionality, suggests that we can identify key issues that intersect with gender to produce the observed results in any given scenario. Intersectionality is an analytic framework developed by Kimberlé Crenshaw in 1991 which analyses interlocking systems of power with respect to the differential roles and relationships of women and men. In the case of EWSs in the Caribbean, we can look at household structure and income as two key variables, as illustrated in Figure 6, that impact gender roles and relationships in society.

In the countries under review, two issues concerning ethnicity arose, one with the Kalinago people of Dominica, whose isolation and hardship have been acknowledged,⁶ and the other with the people of Barbuda, who have experienced a fairly isolated and culturally separate development from the populations in their sister island of Antigua, and whose historical and cultural differences had not received similar attention until the devastation caused by Hurricane *Maria*.

Figure 17. Understanding Gender in EWSs

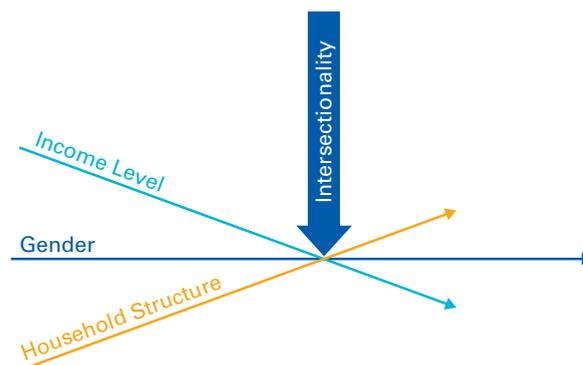


EWS Process is affected by the differential

- roles
- relationships and
- perceptions of men/women and girls/boys

Source: Illustration by the researcher

Figure 18. Key variables in the application of intersectionality in EWSs in the Caribbean region



There is no one single factor that affects women’s or men’s ability to fulfil the requirements of Early Warning Systems

Source: Adapted from Intersectionality Framework⁷

⁶ Dominica Country Poverty Assessment (December 2010)notes that the Carib population (Kalinago people) is over represented among the poor and presents descriptions of the hardships, such as poor housing, access to health care, labour market opportunities that are faced by the Community.

⁷ See discussion of the Intersectionality framework in the work of Kang M, et al (2017)

The different levels of risk perception of men and women in the Caribbean is key to appreciating and understanding the risk perception of communities, families and individuals and the factors affecting their decisions.

One example of the way in which an event may impact women and men differently became clear following examination of flooding experiences. Women may be affected disproportionately by floods and are often found among the “most vulnerable” by institutions involved in flood response (Singh Shrestha, 2016).

In 2012, the United Nations Development Fund for Women (UNIFEM) reported that during the 2010 floods in Pakistan, despite flood EWSs in place, there were women who refused to leave their houses for reasons such as “disbelief of flood warning[s]; concerns of theft or occupation of, or losing claim[s] to property; reluctance to move to camps due to cultural norms, and hesitation about taking women and girls out of protected environment[s] of homes[,] exposing them

to strangers.” Furthermore, as evidenced by various post disaster assessments, floods also increase women’s domestic burdens, as in most households, women depend on their houses for sustaining their livelihoods. Although a gender-inclusive EWS would surely improve women’s capacity to respond to floods, the gender factor is often neglected when designing related projects. For this reason, it is important to consider a gender framework in EWSs, rather than defining it as a technical process independent from the social constructs in the society, particularly those social structures that support power relations between men and women at all levels in the society. A challenge to operationalizing a gender sensitive EWS is that the power relations between women and men are somewhat invisible and are taken for granted, as they have been accepted over time.

The research undertaken for this report and presented in parts 3 and 4 reinforces the notion that without taking into consideration the gender differences, it is not possible to expect EWSs to operate efficiently.



Cecile Shillingford interview: <https://www.youtube.com/watch?v=qnwGSXCCTIE&list=PLNaX-uTWSWrEmZBOerXkwsSgqcdJQVky9&index=7>

Part III

Review of mechanisms at the regional and national levels and integration of gender in EWSs in the Caribbean



This section of the review sought to gain an understanding of gender interpretations within organizations. The researcher thought it essential to clarify any such interpretations since the actions of these organizations directly affect communities and their responses to disasters.

Information is presented at the regional level followed by the national level.

There are three key institutions at the regional level whose actions, mission and programmes address EWSs directly: CDEMA, CMO and CIMH. This review engaged with two of the three stakeholders: CDEMA and CIMH. Since CIMH is the implementing agency of CMO, it was selected for engagement by the researcher. This section begins with a brief overview of the role of all three institutions and an analysis of the gender interpretations of two of the stakeholders based on the responses to the questionnaire which was sent to both parties.

This is followed by a review of the national stakeholders, the NDOs and NMHSs.

An interesting phenomenon which the review has illuminated is the changing face of managers and senior officials in regional and national level institutions responsible for EWSs. From what has been garnered, this change from male to female has not been by design but by accident, resulting in an increase in the number of women achieving managerial and decision-making positions in national and regional organizations responsible for EWSs. This changing of the guards, so to speak, is taking place as there is an increasing number of female graduates from tertiary institutions available for the posts and as more women than men opt to meet their career goals in the national and regional civil service. This trend is not unusual throughout the Caribbean national civil service. Unfortunately, unless this change is accompanied by training in gender analysis, it will not affect the integration of gender concerns into EWSs.

1. REGIONAL INSTITUTIONAL MECHANISMS

1.1 CDEMA

At the heart of EWSs in the Caribbean is the Caribbean Disaster Emergency Management Agency (CDEMA), which oversees the EWS architecture and is the regional intergovernmental agency for disaster management in the Caribbean Community (CARICOM).

The Agency was established in 1991 as the Caribbean Disaster Emergency Response Agency (CDERA) with primary responsibility for the coordination of emergency response and relief efforts to Participating States (PS) that require such assistance. It transitioned to CDEMA in 2009 to fully embrace the principles and practice of Comprehensive Disaster Management (CDM).

CDM is an integrated and proactive approach to disaster management and seeks to reduce the risk and loss associated with natural and technological hazards and the effects of climate change to enhance regional sustainable development.

Two of the three participating countries in the study, Antigua and Barbuda and Dominica are Participating States of CDEMA.⁸

CDEMA is involved in all aspects of disaster management, policy and strategy formulation, coordination, implementation technical support and research, education and training. Through its Regional Response Mechanism (RRM),⁹ CDEMA supports the activities of its 18 PS by providing training and exercises. The beneficiaries for these activities include the NDMOs, development partners, military personnel, fire services and police services.

Of a staff of 21 individuals, 15 are women. Four of the five managers are women and one of the two executives is a woman.

The Regional CDM policy document and model documents for policy, as well as the legislation adaptation guide, specify that gender considerations must be taken into account in the creation of policies.

There is no organization-wide task force on gender to coordinate hazard identification, vulnerability and risk assessment. A gender working group was established in 2006/7, and gender was deemed to be a key cross-cutting issue in the CDM strategy; however, due to human resource and finance constraints, the gender working group petered out between 2010 and 2011.

Despite the fact that gender issues are not mainstreamed into the agreement that established CDEMA (established in the agreement as CDERA), equal opportunities exist for women to be part of EWS scientific and technical expert groups.

CDEMA notes that it has no role in monitoring and warning services, as this is the remit of technical service institutions. It does have a role in disseminating information, but it does not disseminate information to the general public. CDEMA disseminates information to NDMOs, special agencies and members of the donor community. As a regional entity, its focus is institutional arrangements, and it provides synthesis information and acts at the regional level.

1.2 CMO

A regional level institutional mechanism, the Caribbean Meteorological Organization (CMO) is a specialized agency of the Caribbean Community that coordinates scientific and technical activities in weather, climate and water-related sciences in 16 English-speaking Caribbean countries¹⁰. Two of the countries participating in this review are members of CMO: Antigua and Barbuda and Dominica.

The Caribbean Meteorological Council is the supreme body of CMO and includes ministers who are experts in meteorology. The Caribbean Meteorological Council meets once per year. The Council issues directions of a general or special character as to the policy to be pursued by the Organization and its many organs. CMO provides the framework for regional and international cooperation.

The CMO Headquarters Unit is located in Trinidad and Tobago and is headed by a Coordinating Director. The functions of the Headquarters Unit include undertaking and carrying out decisions of the Council, as well as advising and assisting Member States, in particular, those States without national meteorological services.

The Coordinating Director, as the Permanent Representative of the British Caribbean Territories with WMO, also ensures the participation of relevant regional experts in the technical work of WMO for the benefit of the entire CMO Membership.

The Caribbean Institute for Meteorology and Hydrology (CIMH) is the education, training and research arm of CMO, so this review engaged with that institution.

1.3 CIMH

CIMH, located in St. James, Barbados, is a training and research organization formed by the amalgamation of the Caribbean Meteorological Institute (CMI) and the Caribbean Operational Hydrological Institute (COHI). Responsibility for the operation of the Institute rests with the sixteen commonwealth governments which comprise CMO. The role and mission of the CIMH is to improve meteorological and hydrological services and to assist in promoting awareness of the benefits of these services for the economic well-being of CMO countries. This is achieved through training, research and investigations, and the provision of specialized services and advice (CIMH, 2018).

⁸ The Participating States of CDEMA are Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands and the British Virgin Islands.

⁹ The RRM is a multi-layered arrangement for the coordination of disaster response among the 18 Participating States and regional and international agencies.

¹⁰ The 16 English-speaking Caribbean countries are: Anguilla, Antigua and Barbuda, Barbados, Belize, the British Virgin Islands, Cayman Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands.

The primary functions of the Institute are to provide facilities for the training of various categories of meteorological and hydrological personnel, to operate as a centre for research in meteorology and hydrology and associated sciences, to operate as contractors and consultants on various meteorological and hydrological projects, to maintain a service for the upkeep, repair and calibration of meteorological instruments, to provide advice to participating governments on meteorological and hydrological matters and to collect, analyse, and publish meteorological and hydrological data.

Its geographic coverage is Caribbean-wide, and its direct beneficiaries are CIMH, National Meteorological and Hydrological Services, the disaster management community, the climate community, climate-sensitive sectors and University of the West Indies (U.W.I.). CIMH considers the entire Caribbean population to be its indirect beneficiaries.

Gender equality is not included in the mandate of CIMH; however, CIMH is an equal opportunity employer. Twenty-four of 43 staff members are women, and two of the five senior managers are women.

CIMH supports policy formulation at national and regional levels in areas related to weather, hydrology/water resource management and climate-related policy, including drought management and climate services. As an implementing agency, CIMH provides technical support in areas of its core competency, including technical support to NMHSs, disaster management support, water resource management support, agriculture and food security support and health, energy and tourism support. Technical support is provided through the delivery of daily, monthly and seasonal products and services. Technical support is also provided to the governments that comprise the CMO.

In the area of research and training, CIMH supports research in the areas of meteorology, hydrology/water resource management and climate as they pertain to understanding sub-seasonal, seasonal, annual and multi-year climate variability and the corresponding impacts on climate-sensitive sectors. CIMH provides training for meteorologists, meteorological technicians and hydrological technicians, both in-house and as part of the BSc in Meteorology programme at the University of the West Indies.

During the 2017 hurricane season, CIMH provided scenario assessments and weather system and impact forecasts to CDEMA, to members of the Eastern Caribbean Development Partner Group (ECDPG) and to other interested parties including other CARICOM Institutions.

With regard to risk knowledge, the CIMH reports that both men and women participate equally in scientific and technical expert groups related to EWSs and in reviewing and updating data each year. CIMH has not, however, engaged women's groups or institutions in the capacity-building of men and women or in developing standards and tools for risk assessment.

With regard to monitoring and warning services, CIMH neither develops nor issues warnings. CIMH does, however, manage and is responsible for a significant portion of hydro-met and climate EWSs in the eastern Caribbean. CIMH is also heavily involved in training related to hydro-met and climate EWSs.

Where information dissemination is concerned, during the 2017 hurricane season, CIMH carried out a technical role involving:

1. Running a high-resolution (4 km) hydrometeorological forecast four times daily to support regional weather forecasting. Information was made available to NMHSs to allow for necessary update of their forecasts.
2. Developing and disseminating, via the wet season Caribbean Climate Outlook Forum (CariCOF), climate outlooks for stakeholders and the public. The data used was aggregated and assessed from multiple authoritative sources.
3. Making hydro-met and climate EWS information available to stakeholders to plan and organize their activities during that period.

Gender considerations were not taken into account in any training which CIMH provided nor in any of the above areas of their work, nor is CIMH responsible for the response capability of the population.

2. NATIONAL LEVEL MECHANISMS

At the national level, the researcher met with the directors of the three NDOs and the NMHS of the respective countries. Although the Bureaux of Gender Affairs were not identified as either stakeholders or mechanisms in EWSs, the researcher engaged with those entities which were responsible for women's affairs or gender affairs in the three designated countries to get an understanding of their roles and responsibilities (if any) with regard to EWSs.

NDMOs and Meteorological Services (MS) evinced a high degree of cooperation between and among themselves, despite the fact that in the three countries reviewed, it was evident that each faced significant and differing challenges which impacted their capacity to deliver and manage end-to-end EWSs efficiently. The informality of the cooperation between NMHSs and NDOs may be both their strength and their weakness. As individuals on whom the informal relationships depend move on, the collaboration and cooperation may disintegrate as it has not been institutionalized. All entities faced the burden of inadequate risk and vulnerability analysis and emergency planning specific to the local (community) level and insufficient human capacity to fulfil mandates. The lack of capacity, both human and financial, to undertake social research was a constant articulated challenge.

Sint Maarten

In the case of Sint Maarten, disaster management fell under the purview of the fire department, which has the overall responsibility for citizen safety. This includes preventing, minimizing and combating fire and accidents and preventing and managing disasters, should they occur (Government of Sint Maarten website). Should there be a disaster that warrants their participation, the entire contingent of fire officers is at the disposal of the Chief Fire Officer who is the Coordinator of Disaster Management on the island. The Disaster Risk Management (DRM) department has three positions: the Coordinator, the Sector Head and the Sector Head's assistant, all male. Such a small number of positions (coupled with lack of diversity) clearly is insufficient, particularly in light of the fact that among its requirements is the task of engaging communities of multiple ethnicities in EWS processes.

The Coordinator of the Disaster Management Office (DMO) and the NMHS are responsible for disseminating alerts and warnings well in advance of the hurricane season. The NMHS also monitors weather events for the territories of St. Barthelemy, Saba, and Sint Eustatius.

In May, June and July of 2017, the NMHS and the DMO began informing the public of the approaching hurricane season. They reported mounting public awareness campaigns and providing lectures and interviews by forecasters. Additionally, presentations on hurricanes were given to 6th graders in schools.

The Disaster Risk Management Department reported that it completed a risk analysis for a number of communities, but gender differences were not taken into account, and community engagement was weak.

The NMHS reported that in August to September of 2017, 69% of those who viewed their Facebook page were women and 31% men, and there is growing recognition by both the NMHS and the NDO of the importance of social media as a tool to support EWSs.

Both the NMHS and the NDO noted that prior to this review, they had never paid any particular attention to gender differences in messaging, nor had they ever undertaken research to understand how the different genders were receiving the messages they disseminated. Feedback mechanisms were weak to non-existent. Even the participation of women in the NMHS is new. Before 2011, no women were employed at the NMHS. Then mid 2011, one woman was hired. Today, five women work at the NMHS.

Antigua and Barbuda

In the case of Antigua and Barbuda, disaster management is handled by the National Office of Disaster Services (NODS). NODS was established in Antigua and Barbuda in 1984 as a division in the Ministry of Health and Home Affairs following a Cabinet decision. The mission of NODS is to reduce the vulnerability of natural and technological hazards in Antigua and Barbuda through multi-sector and integrated hazard risk reduction planning practices. Women play their part in disaster management; they comprise 9 out of 17 district disaster coordinators.

In 1991, four sub-regional focal points were established by CDEMA: Antigua and Barbuda, Jamaica, Barbados and Trinidad and Tobago. The country of Antigua and Barbuda is responsible for Anguilla, the British Virgin Islands, Montserrat and Saint Kitts and Nevis. Barbados is responsible for Dominica, Saint Lucia and Saint Vincent. Trinidad and Tobago is responsible for Guyana, Grenada and Suriname. Jamaica is responsible for Belize, the Bahamas, Turks and Caicos Islands and Haiti.

The MS in Antigua and Barbuda are also responsible for warnings and forecasts for the Leeward islands and the British Virgin Islands. The MS work closely with the National Hurricane Center in Miami. They produce a hurricane plan and are actively engaged in educational programmes in schools and meetings with non-governmental organizations; together with NODS, they mount various exhibitions. Their educational activities begin on 1 June. Together with NODS, they seek to explain the scientific information both locally and on Radio Anguilla, Montserrat and Saint Kitts and Nevis. They also share information with Puerto Rico and the United States Virgin Islands.

Four types of EWS bulletins: information bulletins, alert bulletins, watch bulletins and warning bulletins are prepared and sent out by MS for their main client, NODS, and the Leewards Islands' disaster offices. Information is posted on the MS website and they often follow up with telephone calls and WhatsApp messages for a Hurricane event expected at level 3 or 4.

Once the National Emergency Operations Centre (NEOC) is activated, the meteorological service sends a meteorologist to work with them to ensure that the country can understand the messages.

The staffing insufficiency and the changing face of the MS in Sint Maarten mirror the situation in Antigua and Barbuda. In Antigua and Barbuda, 27 of 40 positions are filled. The gender balance is shifting towards women as men opt for different careers. Of a staff of eight meteorologists/forecasters, two are female, and of the 13 metrology observers, five are female. There was a time when the staff was all male.

With regard to the attention given to gender differences in messaging and receipt of information disseminated, NODS and the MS in Antigua and Barbuda, both agreed with their counterparts in Sint Maarten that they had not given this issue deep consideration before the review.

Dominica

In the case of Dominica, disaster management is coordinated by the Office of Disaster Management (ODM) under the auspices of the National Emergency Planning Organization (NEPO) and the National Advisory Committee, which is chaired by the Prime Minister. ODM is managed by a National Disaster Coordinator under the direction of the Permanent Secretary and Minister for Justice, Immigration and National Security. Together, ODM and NEPO coordinate overall disaster management programmes in accordance with the principles of prevention, mitigation, preparedness, response and recovery. They do so through district disaster committees, community disaster management committees and national emergency response teams and community emergency response teams.

ODM is the lead agency for EWSs in Dominica and has supported projects on hazard mapping and vulnerability assessments and the installation of instruments to strengthen earthquake monitoring, in addition to Common Alerting Protocols (CAP) Projects.

The hazard monitoring functions of the MS and ODM were considered in a recent gaps assessment report which suggested that among other gaps found, regular system-wide tests and exercises were minimally conducted (Fontaine, 2018). It was also found that minimal to moderate progress had been made in building credibility and trust in warnings issued.

In Barbuda, Dominica and Sint Maarten, there is a need to replace and maintain the communication systems and equipment used for EWSs due to the recent impact of multiple hazards and destruction of property.

In all three countries, professional staff were limited, and disaster management activities were project-driven, further limiting the achievement of sustainable processes, including those relevant to EWSs. Collecting information on the social vulnerability of the populations mapped to hazards and taking into consideration cultural practices and socioeconomic behaviours that may compound risks did not seem to form an institutional aspect of EWSs in the countries under review (Fontaine, 2018; Carby, 2018; Collymore, 2016).



National Gender Bureaux

The role of the Gender Bureau or Bureau of Women's Affairs or Women's Desk, as they are variously called in the countries under review, in the context of EWSs, is negligible to non-existent. These institutions are involved in humanitarian relief and the response phases of a disaster, but they have a very limited role, if any, in preparedness, and therefore EWSs. Their advice with respect to EWSs is not sought nor are they involved in any committees where it can be given.

In addition, these bodies continue to be insufficiently staffed to conduct the work they are mandated to undertake, much less new and additional duties. The exception to this is the Gender Bureau of Antigua and Barbuda, which has a staff of 20, with 6 professionals. The Sint Maarten Women's Desk has a staff of one, and in Dominica, the Gender Affairs Department has a permanent staff consisting of one director, one secretary, one driver and two temporary interns.

Despite these shortcomings, these women's desks or bureaux have the know-how and understanding to provide advice on gender concerns and analyses.

Part IV

In-country review of gender considerations integrated in EWSs

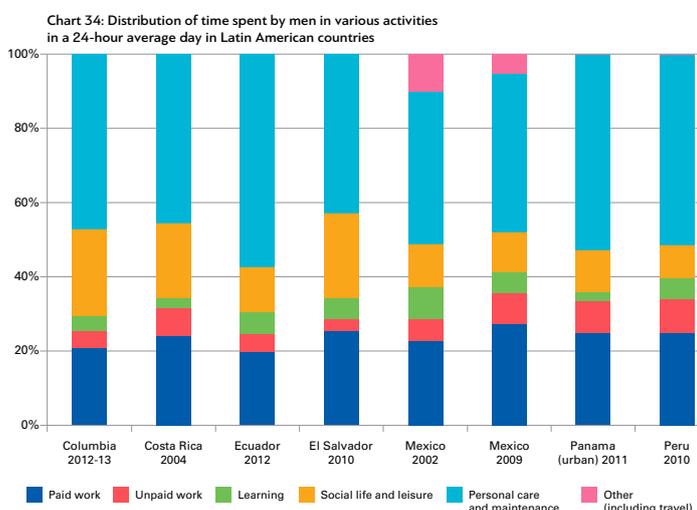
Following the focus group discussions organized across the three countries with women and men, certain patterns of social relations and behaviours began to emerge. It became clear that these social behaviours affected the roles of men and women within the early warning system processes with respect to risk knowledge and monitoring, the technology that carries the EWS message, the EWS message itself and the capacity to respond to the EWS message once it has been heard and understood.

The researcher identified four key variables that affect the different responses of women and men to EWSs in the Caribbean: the differences between women and men concerning the use of time, the position of women in the household and the structure of the household, the economic activity in which women were engaged and the differences between women and men concerning risk perception. These variables did not always stand alone. When they intersected, the situation of women with regard to EWSs became more problematic.

1. HOW IMPORTANT IS TIME USE TO RECEIVING MESSAGES COMMUNICATED?

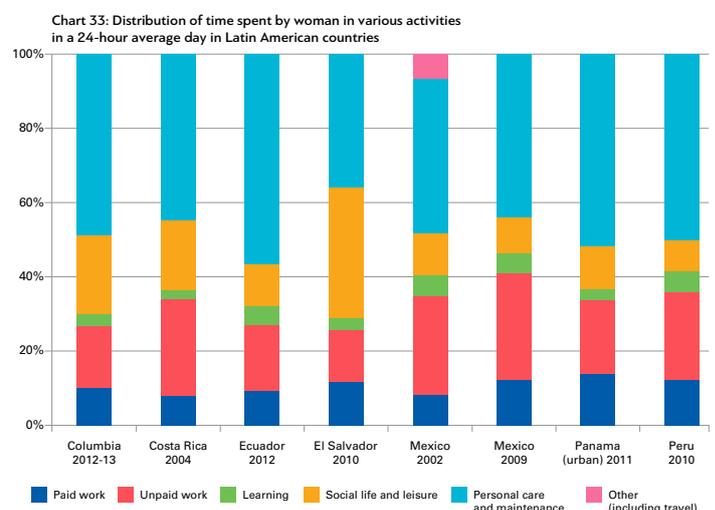
Although data for the three countries under review was not available, data for selected countries in the Latin America and Caribbean (LAC) region suggested that women spent more time in unpaid work (or reproductive work, that is taking care of household members and the household generally) than did men. A comparative analysis of Figures 19 and 20 illustrates how time is used by women and men in a 24-hour period. It suggests that women spend a larger proportion of their time in unpaid work while men spend a much smaller proportion of their time so engaged.

Figure 19. Distribution of time spent by women in various activities



Source: Charmes (2015). United Nations Development Programme, Human Development Background Paper

Figure 20. Distribution of time spent by men in various activities



Source: Charmes (2015). United Nations Development Programme, Human Development Background Paper

The opposite holds true for paid work; women spend a smaller proportion of their time in paid work while men spend a greater proportion of their time so engaged.

What are the implications of the above with respect to EWSs in the small island states of the Caribbean that were ravaged by Hurricanes *Maria* and *Irma* during the 2017 hurricane season? Women across the islands that were the subject of this investigation, when discussing the question of communication, specifically timely, accurate and actionable warnings received, shared that they had little time to pay attention to information sent via television or radio about the impending hurricane. They were busy meeting the demands of food preparation for dinner, assisting children with school work and managing other household chores at the critical hours when news about the hurricane was being aired.

Men, on the other hand, were quick to share that they shut down all other activities when it was time for the news and listened to the information being presented intently, sometimes on the radio and sometimes on television.



Prosper Paris interview: https://www.youtube.com/watch?v=Hzli_nozQ38&index=8&list=PLNaX-uTWSWrEmZBOerXkwsSgqcdJQVky9

Women noted that it was through their social media network and often through messages received from family abroad that they were made aware of the extent of the threat and the risks they faced.

Box 1. Time to listen

Men who had time to listen

Men and women were gathered in a room that was usually used to serve meals at the shelter. They were talking about the 2017 hurricane season. The women in the room outnumbered the men two to one.

The women and men were agricultural workers and fisherfolk. Women worked their gardens in the morning, sold produce in the day and came home in the afternoons in time to prepare dinner for their families and take care of other household chores.

Men mainly fished and tended to the livestock. In the afternoons, they came home and exchanged the day's experiences with their families and neighbours.

But Hurricanes *Irma* and *Maria* changed all of that.

Today, stories were being shared about where they were and what they did when the hurricane hit. One man said, "I expected it to be bad because I had lived through Hurricane *Luis* and remembered how people's roofs were blown off, but we had a strong house and we boarded up. We road it out then, and so we felt we could ride it out this time."

A woman said, "To tell you the truth, I didn't know what to expect. They said 'one', then they said 'two'. I tried to keep my children with me and hoped for the best." Another woman said, "Talk about a Category 5 hurricane, no, I did not believe it."

Then the conversation changed to what messages they heard and what they understood about them.

The women categorically said they remembered hearing some messages about stocking up on water and candles, but information on the category of the hurricane was a blur. They spoke of hearing all this information in the background, while they hustled to put dinner on the table and help children with homework.

Men, on the other hand, said when five in the afternoon came, "I went to listen to radio or watch television." They reported that they "checked the different channels to hear what was being said" about the nature of the hurricane and when it was expected to make landfall. As one man put it, "Nothing would interfere with my news time."

Source: Focus Group Discussion, Antigua and Barbuda.

2. HOW THE INTERSECTIONALITY OF HOUSEHOLD STRUCTURE AND INCOME WITH GENDER WORKS TO LIMIT CAPACITIES FOR KNOWING, UNDERSTANDING AND MONITORING RISK

Data presented in Table 3 indicate that for Antigua and Barbuda, some 28.3% of the population was at risk. For Dominica, 43.4% of the population was at risk, and for Sint Maarten, 57.1% of the population was at risk. The at-risk population included poor and vulnerable individuals. The Antigua and Barbuda Country Poverty Assessment (CPA) undertaken in 2007 reported that 18.3% of the population was poor; of those individuals, female-headed households comprised almost half (47.8%). For Dominica, where data on the poverty status of the sex of the head of the household was not available, it was reported that male and female poverty stood almost equal at 28%; however, while 20% of poor males were unemployed, the proportion of unemployed poor females was 33.8%. For Sint Maarten, 57.1% of the population was at-risk, including 34.1% of women and 23% of men.

The literature on poverty in the Caribbean suggests that where data is available, the average number of children in poorer households is larger than that in more well to do households.¹¹

It is the norm in the Caribbean for the family structure to comprise multi-generational families containing elders and children of the children of the head of the household.¹² It is important to note that when the head of the household is female, this usually connotes the absence of a male partner (Massiah, 1983). A study conducted by the Central Bureau of Statistics, Netherlands reported that around 30% of Caribbean Netherlands households with children and one parent or two unmarried parents, also comprise other members, often the mother's parent(s) (Central Bureau of Statistics, Netherlands, 2015).

When we examine female-headed households, with their high rates of unemployment, large multi-generational family structures and poverty, we also may find them living in accommodations located in high-risk areas and of poor quality.¹³

When women and men were asked about knowledge of the risks they faced either in their work environment or living environment, the differentiation between the two groups was not significant. Very few, either women or men, had participated in exercises of community risk identification or vulnerability assessment.

Where they had participated in some such exercises, it was men more often than women who shared that they had walked through their community, identifying drains that needed clearing, trees that required cutting. Where communities were long-standing, women as well as men had access to traditional knowledge of the risks posed by coastal life, ponds or rivers. This information was reportedly handed down from one generation to another.

Through focus group discussions, it became evident that the scientific knowledge which the regional and national level authorities possessed about risks and multiple hazards was frequently not transmitted to communities. This left communities with only traditional knowledge to inform their actions. Some communities did not even have that traditional knowledge.



¹¹ Study on the Changing nature of Poverty and inequality in the Caribbean by the CDB, noted that "while the Caribbean is experiencing a demographic transformation such as an aging population, reduction in the 0-14 age cohort and reduced fertility levels, some of these outcomes are not yet evident in poorer HHs who are more likely to have more young children in the 0-5 age cohort. This result implies that policies that result in smaller HH size, or reduced levels of dependency, are consistent with reduced likelihood of being poor and improved HHs' wellbeing. The Dominica Country Poverty Assessment (Kairi, 2010) also reiterates in its discussion on households that the poor have more children and have larger households than their well do to counterparts.

¹² From as early as 2003, Dr Godfrey St. Bernard, noted Caribbean demographer, identified the typology of such households, in a paper entitled: "Major Trends Affecting Families in Central America and the Caribbean". He noted in regard to Trinidad and Tobago that, "At least one fifth of all households were estimated to consist of extended family formations".

¹³ The Study on the Changing nature of Poverty and inequality in the Caribbean by the CDB, also supports this argument when it notes that "many places where poor people live present multiple disadvantages, such as missing and inadequate infrastructure and services, unfavourable geography, vulnerability to environmental shocks and seasonal exposure. Often these disadvantages combine in ways that endanger or impoverish those who live there".

Box 2. No knowledge of risk

Mother Cherrie had been prepared for the hurricane. Her family had experienced Tropical Storm *Erika*, and her house was sturdy. So she and her daughter decided they would ride out the storm. Besides, her daughter did not want to go to any shelter where many people had to sleep in the same open space, and men and women had to use the same or nearby toilet facilities. After all she was just in her teen years and was shy.

Ma Cherrie, as she was known to most in the village, heard talk about trees that could fall on your house during high winds, so she checked on the trees around her house and declared, "All looked good."

Mother Cherrie lives in a rain forest area of her island that has not one, but two waterfalls, many springs and deep pools. The waterfalls are fed by steep running rivers.

Ma Cherrie never saw these potential hazards as risks to her safety during storms or hurricanes. No one had ever advised her that her location may have been at risk for flooding or landslides. She built her little home here at the edge of the village because better could not be done.

So when Hurricane *Maria* came and she found water starting to flood her home, she did not know what to think. First she tried mopping up the water. But it was too much. Then she and her daughter each took a pot and started bailing the water out of her little house pot by pot. But the water was coming too fast.

Ma Cherrie was a single mother living in precarious living conditions.

In the end, Ma Cherrie and her daughter had to seek shelter at the home of a neighbour who lived not too far away. In the darkness and fierce winds, they held onto each other and crawled over to the home and banged on the door. The neighbour opened the door and gave them shelter. When it was all over, Ma Cherrie went to see what her house looked like. Most of her roof was gone. Everything inside the little house had been swept away – her pots and pans, but most important to her was the loss of her daughter's school books and uniforms, in her words "everything".

Source: Focus Group discussion Dominica.

3. PREPAREDNESS AND CAPACITY - CAN SOCIAL VULNERABILITY, INCLUDING LOW INCOME LEVELS, MAKE A DIFFERENCE FOR WOMEN?

Despite the fact that labour force participation rates of women and men are not significantly different and women have been performing better in the educational sector (with higher secondary school completion rates) in the three countries under review, women are still more inclined to be found in low-wage segments of the tourism or agricultural labour markets (Baskh, 2016). The data suggest that men predominate as owners and managers of hotels, guest houses and restaurants, while women predominate as administrative, housekeeping and hospitality staff and comprise an estimated 70% of market vendors. Women make up a significant share of the informal economy¹⁴; in the case of Dominica, 55% of the informal workforce is female (Kambon, 2016). All these factors result in the gender wage gap as illustrated in Figure 4, which suggests that for every dollar that men make, women earn 74 cents.

It was noted that in countries that had a high labour force in agriculture, Antigua and Barbuda being one, women

comprised a small proportion of the labour force, some 28.6%, while men comprised 71.4%. In Dominica, where agriculture also predominates, men comprise 85% of the workforce and women 15%. The CDB Report noted that men's and women's unequal participation in agriculture is linked to gender-based inequalities in their access to land, credit and other means of production. It concluded that these are hurdles which make women and their families more vulnerable to poverty (Baskh, 2016).

The data on country poverty assessments undertaken during the last decade suggested that poverty was concentrated among women who are heads of households (Baskh, 2016).

During the focus group discussions, there were stories of inability to collect the required goods - canned food and water - to take to the shelter, lack of appropriate sleep clothing for children and little cash in hand to purchase goods for storage. These and many other stories were shared as reasons why single female heads of households reconsidered going to shelters and why they were unprepared to face the onslaught of the 2017 hurricane season.

¹⁴ The informal economy refers to economic activity that is outside of state control and is not available for taxation purposes or unavailable for inclusion in the Gross Domestic Product of a country.

Box 3. Social vulnerability and capacity to prepare

Young, single mother (Margot – not her real name) in the grocery

People, mainly women, were hustling through the small grocery in the capital a few hours before the hurricane was due to make landfall. They were stocking up on bottled water, canned foods, biscuits and dried goods. Some were searching for candles, others for batteries. It was mid-afternoon, and government and private sector employees were advised to head for home to secure their property and families.

Margot, not much older than 20, had her only child, little Meche, short for Michelle, on her hip. She had no one to leave her with when she came to the grocery. Margot's mother was living on another island, working to send money home to fix up their little house and to help send the smaller children left behind to school. Margot knew it was not always easy for her mother to find work as a domestic helper and that there was no one else to rely on; her mother was a single mom just like her.

Margot began walking through the grocery. What should she buy?

She felt the note in her hand, knowing it was the last bit of cash that she had for at least another week and a half before her mom could send more.

She had heard the messages sent out by the Disaster people: "Stock up on water. Stock up on food for at least 72 hours. Buy extra medicines. Make sure you can store your valuable documents in plastic containers or plastic bags." Margot had none of these things, not even garbage bags.

The more she wandered through the store, the more frustrated and angry she became. It was hot, people were pushing and shoving, and Meche was getting cranky. The question kept haunting her: "What should she buy?": She looked at the bag of powdered milk. Should she buy this? She looked at the bottles of water. Should she consider water? She looked at the pampers, which little Meche needed desperately, as the one she had on now was the last.

Tears welled up in her eyes and she looked at the note in her hand. It was a twenty dollar note. Meche's pampers would cost \$14.99, that would leave her with just \$5.00, not enough to buy even two small bottles of water, much less food for her younger siblings waiting at home.

Source: *Dominica in depth interview.*

4. RISK PERCEPTION AND PREPAREDNESS ACTION

Disaster risk is "the potential loss of life, injury or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity" (UNISDR, 2018). It is important to consider the social and economic contexts in which disaster risks occur and that people do not necessarily share the same perceptions of risk and underlying risk factors.

Risk perception refers to people's subjective judgments about the likelihood of negative occurrences such as injury, illness, disease, and death. It is "a highly personal process of decision-making, based on an individual's frame of reference developed over a lifetime, among many other factors" (Brown, 2014).

Risk perception is important in health and risk communication because it determines which hazards people care about and how

they deal with them. Risk perception has two main dimensions: the cognitive dimension, which relates to how much people know about and understand risks, and the emotional dimension, which relates to how they feel about them.

During this review, women and men reported that risk knowledge was not widely understood and that information from national authorities had not filtered down to communities. This lack of knowledge was compounded by the emotional response to the risk. A pattern emerged which suggested different emotional responses to risk from men and women.

Because people's subjective judgements about risks affect their behaviours, it became important for the review to bring to light the different risk perceptions of men and women which became evident during the focus group discussions. The participants in the focus groups told many stories describing the anxiety women felt and the laid back demeanour of men when it came to responding to early warning messages.

Box 4. Machismo and risk perception

Men just won't take action until the last moment

"It was not until I was weeping with anger and terror that my husband agreed that yes, maybe it was time to collect mama and move us all to a safer place."

Government and private sector offices were closed. People were instructed to find a safe place to shelter. *Maria* was going to be a Category 5 storm and the island was expected to get a direct hit.

Rebecca and her husband reached home. They had been preparing. She had gotten last minute water, dried foods and candles from the grocery, and they needed to do last minute boarding up of windows and bring over mama from her home, which was old and insecure. Rebecca and her husband doubted that mama's house could withstand a Category 5 storm, and worse still, mama had sight challenges, so she needed to be moved over before the weather changed too dramatically.

Rebecca busied herself putting important documents in garbage bags and moving things to higher ground, just in case. John, her husband, was still reading the day's paper. Every request was met with the same response.

Q. "Did you check on the transistor radio?"

A. "Not to worry, will do."

Q. "Are we well boarded?"

A. "Not to worry, will check."

Q. "Are the dogs safely put up?"

A. "Not to worry, will do."

Q. "What about mama? Will you go and collect her?"

A. "Not to worry, will do."

The winds began to howl and blow fiercely. John, in a haste, decided it was time to get mama. He struggled through the blowing winds, tied mother to him and brought her over to safety.

A young man listening to this story, agreed that this was not unusual. He said, "It's a kind of a macho thing. Don't worry, we will get everybody to safety. Everything will be all right." And he, too, explained how he waited until the very last moment before he took action to safeguard property and life.

Source: *Dominica Focus Group.*

Part V

Conclusions

1. FINDINGS

This review has shed light on the changing face of managers and senior officials in regional and national institutions. The information gathered indicates that this change from male to female has not been by design, but by accident, resulting in more women achieving managerial and decision-making positions in national and regional organizations responsible for EWSs. This changing of the guards, so to speak, is taking place as there are increasingly more female graduates from tertiary institutions and as more women than men opt to meet their career goals working in the national and regional civil services. This trend is clear in the Caribbean civil service. Unfortunately, unless this change is accompanied by training in gender analysis, it does not affect the integration of gender concerns into EWSs.

Institutions at the regional level were challenged to manage EWSs with limited human and financial capacity during the 2017 hurricane season. Despite these challenges, they had excellent training capacity, facilities and convening power with respect to both NDOs and NHMSs. They were also able to set standards for agreed upon actions at the national level.

There is a recognition that gaps still exist in knowledge and understanding of how to include gender in EWSs, but there is a willingness at the national and regional levels to address these gaps. At the regional level, the most appropriate form which such action can take is through advocacy and training, which CDEMA can initiate through its regional training facility.

To date, CDEMA has worked to ensure that gender and human rights components have been included in the training which is made available through its Regional Response Mechanism. There is a recognition, however, that more has to be done.

The institutions at the national level that are required to mount successful EWS programmes face both financial and human resource constraints. These constraints acted as limiting factors in the organization's ability to fulfil its EWS mandate during the 2017 hurricane season and to further fulfil the integration of gender concerns.

1.1 Risk knowledge

The review found that much work had been done in previous years and in preparation for the 2017 hurricane season, particularly with regard to hazard mapping and risk identification. This work however, still needed to include the community-level specificity. Despite the best efforts of disaster teams and CERTs during the 2017 season, little systematic work had been undertaken at understanding risk with gender differentiation at the community level.

Where social capital was alive and strong, where communities acted on their own volition to maintain their natural or built environment and/or to assist in the care of members of the community, strong social capital also facilitated men and women's identification of risks; and an understanding and sharing of knowledge of risks themselves.

1.2 Detection, monitoring, analysis and forecasting

The hazard monitoring functions of NMHSs and NDOs need strengthening, as it was found that regular system-wide tests and exercises were minimally conducted.

It was also noted that more and systematic efforts should be undertaken to build credibility and trust in the warnings issued.

There was also an identified need to replace and maintain communication systems and equipment required for EWSs due to the recent impact of multiple hazards and destruction of property.

1.3 Warning dissemination and communication

From the focus group discussions, it was clear that men and women received the messages sent by the authorities. However, there were differences in how men and women responded to the messages. These differences related to how the different genders use time, household structure (that is, women as heads of households and households containing intergenerational families), income level and differences regarding risk perception.

Technology, either through smart phones, televisions, radios or computers, played a significant part in how information was received during the 2017 hurricane season. Women received more information via smart phones, and men through more traditional methods (television and radio). Women viewed Facebook pages that provided weather information more often than men.

Extended family members abroad were identified as credible sources of information, and women and men acted on messages received, but women more so than men.

Very little consideration was given from the national authorities to gender differences, either with regard to preparedness or messaging. This was also evident in the lack of identifiable research on the differences in the impact of messaging on women and men.

1.4 Preparedness and response capabilities

The review found that there was insufficient use of existing social vulnerability data to address the capacity of vulnerable groups to undertake the required actions for their preparedness and safety. In other words, EWSs should have a socioeconomic evidence-based design.

National authorities seemed to have yielded the task of social mobilization for preparedness and EWSs to others with insufficient oversight, resulting in a weak to absent presence on the ground and weak community and family preparedness.

Some policymakers are not convinced of the importance of EWSs as a component of disaster management nor see its relevance to development planning. One comment expressed on the ground which seemed to capture the feelings of many was, "It would seem that some policymakers see EWSs as a burden on time and resources." This view was expressed frequently by senior government technocrats across the region.

Men seemed to act out their risk perception through behaviours involving procrastination. Male focus group participants suggested that procrastination was an expression of a certain 'machismo'. However, this machismo acted as a stumbling block to men taking preparedness actions in a timely manner.

For poor, single female heads of households, limited financial and physical resources act as constraints to their being able to take required actions to safeguard themselves and their families, putting them at extreme risk in a multi-hazard environment.

RECOMMENDATIONS

As a result of the review of the 2017 hurricane season and the assessment of gender considerations in EWSs, we are reminded of the futility of an approach to EWSs that is not holistic and does not take into account social structures and vulnerabilities in the population. The following recommendations are therefore submitted to strengthen the integration of gender in EWSs in the Caribbean region:

At the regional level

1. Institutions at the regional level, such as CIMH and CDEMA should set an example through the establishment of a task force and/or committee to examine the gender dimensions of the EWS programmes for which they are responsible. In that way, a signal would be sent from the highest level regarding the importance of integrating gender concerns in EWSs, thus triggering positive actions at the national and local level.
2. CDEMA may wish to make better use of its role as the premier agency for CDM to advocate for and to encourage evidence-based gender targeting.
3. CDEMA could consider an examination of gender considerations in its entire suite of EWS products
4. CDEMA should seek to strengthen its capacity-building efforts with NDOs and NMHSs in programmes offered at its Regional Training Centre on the integration of gender considerations in alerts and warning messaging and through its standardized training material.

At the national level

5. Greater use should be made of ICT for EWS messaging, but this should be coupled with improved targeting of messages to women and men.
6. There should be more and better targeting of vulnerable groups in EWS messaging, including single female heads of households, single, elderly male heads of households; chronically ill and disabled individuals, when the preparation and dissemination of information on preparedness and responses are being considered.
7. A greater willingness is needed to undertake applied research about the sociocultural characteristics that manifest in male and female behaviour in order to better assist women and men in understanding and managing risk.
8. An effort should be made to deepen programmatic understanding of the roles and engagement of transnational families with respect to early warning systems in the Caribbean, so that national communities may receive the maximum benefit from early warning systems.
9. The Gender Bureaux should be better integrated in the work of NDOs and NMHSs in order to more efficiently use existing capacity within government structures.
10. More resources must be brought to bear on social mobilization as a tool to integrate gender considerations into EWSs.

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CHAPTER 3: Review of gender specific issues in early warning systems

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Appendices

APPENDIX I

LIST OF STAKEHOLDERS CONSULTED

Name	Country	Organization	Position
Shelter Management			
Richie Paul	British Virgin Islands	National Emergency Operations Centre	Shelter Manager
Resherma Lyons	Resherma Lyons	National Emergency Operations Centre/BVI Red Cross	Shelter Manager
Donnette Matthew	British Virgin Islands	National Emergency Operations Centre	Shelter Manager
Sharon Leonard	British Virgin Islands	National Emergency Operations Centre	Shelter Coordinator
Shirley Vanterpool	British Virgin Islands	Deputy Governor's Office	District Officer, Anegada
Tasha Bertie	British Virgin Islands	Ministry of Health	Deputy Secretary
Samantha Burnette	Antigua and Barbuda		Shelter Manager, NTC
Connie Desouza	Antigua and Barbuda		Shelter manager, Hostel
Shenigue Fortune	Antigua and Barbuda		Shelteree
Shianne Charles Thomas	Antigua and Barbuda		Shelteree
Britney Nedd	Antigua and Barbuda		Shelteree
Calena Cephas	Antigua and Barbuda		Shelteree
Idrisa Dimkuatu	Antigua and Barbuda		Shelteree
Sonnet Thomas	Antigua and Barbuda		Shelteree
Abigal Ambrice	Antigua and Barbuda		Shelteree
Dorceah Pinter	Antigua and Barbuda		Shelteree
Steve Joseph	Dominica	Ministry of Social Services, Family and Gender	Assistant Commissioner (ag) Local Government
Noel Toussaint	Dominica	Ministry of Social Services, Family and Gender	Commissioner, Local Government (ag).

National Authorities			
Sharleen DaBreo	British Virgin Islands	Department of Disaster Management	Director, Disaster Management
Cecil Jeffrey	British Virgin Islands	Department of Disaster Management	Community Relations Officer
Jennifer Hodge	British Virgin Islands	Department of Information and Public Relations	Social Media Officer
Michael Joseph	Antigua and Barbuda	Antigua and Barbuda Red Cross	President
Philmore Mullin	Antigua and Barbuda	National Office of Disaster Services	Director
Sherrod James	Antigua and Barbuda	National Office of Disaster Services	Deputy Director
Lt. Samuel	Antigua and Barbuda	National Office of Disaster Services	NEOC Logistics
Fitzroy Pascal	Dominica	Office of Disaster Management	National Disaster Coordinator
Mrs Gloria Joseph	Dominica	Ministry of Planning and Economic Development	Permanent Secretary
Mr. Severin Mckenzie	Dominica	Dominica Manufacturing Association and Dominica Business Forum	President

APPENDIX II

CDEMA/CREWS Review of Dissemination and Communication of Warnings, Disaster Risk Knowledge, Application and Preparedness for Hurricanes Irma and Maria

Regional Stakeholders Questionnaire

This survey is part of the study to assess the early warning system (EWS) performance of key actors in Antigua and Barbuda, British Virgin Islands and Dominica in the context of the 2017 hurricanes Irma and Maria.

It seeks to answer the questions as to what formal or other early warning systems arrangements existed for this hydro-meteorological hazard, the models of sharing notification, timeliness of the warnings and preparedness actions taken by different stakeholders.

The findings of the studies will be discussed by regional stakeholders to inform the nature and priorities for a regional EWS Project in the short term and a subsequent regional EWS Programme in the medium term.

We thank you for taking the time to participate in this survey and willingness to share your experiences.

The questionnaire can be completed within 30 minutes. All responses will be anonymous.

Please feel free to contact me at any of the following if you have queries: email - jeremyc699@gmail.com; cell – 2462330681 and Skype – Jeremy.collymore.

Sincerely,
Jeremy Collymore, Expert Reviewer

1. Name of institution/stakeholder
2. Do you have EWS programming that supports Dominica, BVI or Antigua or Barbuda?

	Antigua and Barbuda	British Virgin Islands	Dominica
We have programmes in these countries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. List the EWS elements covered by your programme.

	Risk Knowledge	Monitoring and Warning	Dissemination and Communication	Response Capability
Antigua and Barbuda	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
British Virgin Islands	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dominica	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4. Who do you partner with to deliver these interventions?

- | | |
|---|--|
| <input type="checkbox"/> National Disaster Office | <input type="checkbox"/> International Development Partners organizations working in the country |
| <input type="checkbox"/> Regional DRM organizations | <input type="checkbox"/> Community leaders |
| <input type="checkbox"/> Monitoring and Warning authorities | <input type="checkbox"/> Alone |
| <input type="checkbox"/> Development Partners working in the Region | <input type="checkbox"/> Other (please specify) |
| <input type="checkbox"/> Local Civil Society and CBOs | |

5. Have you undertaken any reviews of the impact of Irma and Maria on your EWS Investments to date?

- Yes
- No, but one is scheduled
- No, and no intention to do so
- Other (please specify)

6. If any reviews were done, what lessons were identified?

7. How do you plan to share these lessons?

8. Based on what you know of the Irma/Maria impact in ANU, BVI and Dominica list, in order of priority, 5 things that need to be done to improve EWS for cyclones and who should lead them.

Priority 1 (include who should lead)

Priority 2 (include who should lead)

Priority 3 (include who should lead)

Priority 4 (include who should lead)

Priority 5 (include who should lead)

9. How long after the all clear was given did it take your organization to establish contact with the impacted countries?

	Antigua and Barbuda	British Virgin Islands	Dominica
Less than 3 hours	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3-6 hours	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7-12 hours	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13-24 hours	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1-2 days	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3-5 days	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
More than 5 days	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. What was the medium through which you were able to make contact? Tick all that apply.

	Email	Fax	Telephone	Social Media	Personal Briefings	WHF
Antigua and Barbuda	<input type="checkbox"/>					
Britishi Virgin Islands	<input type="checkbox"/>					
Dominica	<input type="checkbox"/>					

APPENDIX III

CDEMA/CREWS Review of Disseminations and Communication of Warnings, Disaster Risk Knowledge, Application and Preparedness Measures for Hurricanes Irma and Maria – Meteorological Institutions Questionnaire

This survey is part of the study to assess the early warning system (EWS) performance of key actors in Antigua and Barbuda, British Virgin Islands and Dominica in the context of the 2017 hurricanes Irma and Maria.

It seeks to answer the questions as to what formal or other early warning systems arrangements existed for this hydro-meteorological hazard, the modes of sharing notification, timeliness of the warnings and preparedness actions taken by different stakeholders.

The findings of the studies will be discussed by regional stakeholders to inform the nature and priorities for a Regional EWS Project in the short term and a subsequent regional EWS Programme in the medium term.

We thank you for taking the time to participate in this survey and willingness to share your experiences.

The questionnaire can be completed within 30 minutes. All respondents will be anonymous.

Please feel free to contact me at any of the following if you have queries: email – jeremyc699@gmail.com; cell – 2462330681 and Skype – Jeremy.collymore.

Sincerely,
Jeremy Collymore, Expert Reviewer

1. Name of institution

2. Which hazards do you monitor?

- | | |
|-----------------------------------|-------------------------------------|
| <input type="checkbox"/> Cyclones | <input type="checkbox"/> Landslides |
| <input type="checkbox"/> Floods | <input type="checkbox"/> Other |
| <input type="checkbox"/> Droughts | |

3. Which countries do you provide services for?

4. Is there any alerting and notification protocol for each of the hazards you monitor?

- Yes
- No
- Other (please specify)

5. Which countries of the following do you use to share alert and notification information to your jurisdiction countries?
- Email
 - Telephone
 - Social Media
 - WHF/HF
 - Fax
 - Other (please specify)
 - Personal Briefings
6. Is there a process for confirming receipt of the information shared?
- Yes
 - No
 - Other (please specify)
7. What percentage of the time do you get confirmation of receipt after sharing alert and notification information?
- 100 per cent
 - Less than 49 per cent
 - 75-99 per cent
 - We don't share alert and notification information
 - 50-74 per cent
 - Not sure
 - 25-49 per cent
 - Other (please specify)
8. Which of the following do you use to share alert notification information to your jurisdiction countries?
- Email
 - Social Media
 - Fax
 - Personal Briefings
 - Telephone
 - WHF/HF
 - Other (please specify)
9. Which of the following do you use to alert and notify your jurisdiction countries about the threats from Irma and Maria?
- Email
 - Personal briefings
 - Fax
 - WHF/HF
 - Telephone
 - Other (please specify)
 - Social Media
10. Which of the following best describes the level of confirmation of receipt shared?
- 100 per cent
 - 25-49 per cent
 - 75-99 per cent
 - Less than 49 per cent
 - 50-74 per cent

11. Which of the following reflects the notification given?

- More than that provided for in the plan
- The same that given in the plan
- Please details on your answer

APPENDIX IV

CDEMA/CREWS Review of Disseminations and Communication of Warnings, Disaster Risk Knowledge, Application and Preparedness Measures for Hurricanes Irma and Maria – Meteorological Institutions Questionnaire

This survey is part of the study to assess the early warning system (EWS) performance of key actors in Antigua and Barbuda, British Virgin Islands and Dominica in the context of the 2017 hurricanes Irma and Maria.

It seeks to answer the questions as to what form of other early warning systems arrangements existed for this hydro-meteorological hazard, the modes of sharing notification, timeliness of the warnings and preparedness actions taken by different stakeholders.

The findings of the studies will be discussed by regional stakeholders to inform the nature and priorities for a Regional EWS Project in the short term and a subsequent regional EWS Programme in the medium term.

We thank you for taking the time to participate in this survey and willingness to share your experiences.

The questionnaire can be completed within 30 minutes. All respondents will be anonymous.

Please feel free to contact me at any of the following if you have queries: email – jeremyc699@gmail.com; cell – 2462330681 and Skype – [Jeremy.collymore](https://www.skype.com/jeremycollymore).

Sincerely,
Jeremy Collymore, Expert Reviewer

1. Name of National Authority/Country

2. Who is your monitoring and alerting authority for tropical cyclones?

3. How often do they share information with your office in normal times?

- At least 5 days a week
- 3-5 days a week
- Less than 3 days a week
- Not at all

4. How is this information provided to you? Check all that apply

- Email
- Social Media
- Other
- Fax
- Personal Briefings
- Telephone
- VHF/HF

5. How much notification did you have for Irma and Maria?

- | | |
|---|---|
| <input type="checkbox"/> More than 72 hours | <input type="checkbox"/> 23-12 hours |
| <input type="checkbox"/> 48-72 hours | <input type="checkbox"/> Less than 12 hours |
| <input type="checkbox"/> 47-24 hours | |

6. What did you do with the information on receiving it? Thick all that apply.

- | | |
|--|--|
| <input type="checkbox"/> Notified the key response agencies | <input type="checkbox"/> Partialy activated NEOC |
| <input type="checkbox"/> Notified the political directorate | <input type="checkbox"/> Seekd consultation with the forecasting authority |
| <input type="checkbox"/> Notified and discussed with the political directorate | <input type="checkbox"/> Nothing |
| <input type="checkbox"/> Disseminated to the entire country | <input type="checkbox"/> Other (please specify) |

7. Was the period of notification given enough to mobilize the country?

- Yes
- No (please specify)

8. What measures, if any, were put in place to verify that the messages were being acted upon?

9. Did you loose contact with your warning authority during this/these events?

- Yes
- No

10. What caused you to loose contact with your waringn authority during this/these events?

- | | |
|--|---|
| <input type="checkbox"/> Did not loose contact during the events | <input type="checkbox"/> Lost communications |
| <input type="checkbox"/> Power failure on our side | <input type="checkbox"/> Communications and the service provider was lost |
| <input type="checkbox"/> Lost our operations facility | <input type="checkbox"/> Other (please specify) |

11. How long was it before you were able to make contact with the Met Service?

- | | |
|--|---|
| <input type="checkbox"/> Less than 3 hours | <input type="checkbox"/> 1-2 days |
| <input type="checkbox"/> 3-6 hours | <input type="checkbox"/> 3-5 days |
| <input type="checkbox"/> 7-12 hours | <input type="checkbox"/> More than 5 days |
| <input type="checkbox"/> 13-24 hours | |

12. Please list alternative options you used for getting weather information?

13. Were you able to keep the public informed of developments immediately after the passage of Irma and Maria?

- Yes
- No (please specify)

14. Are risk maps available for floods, landslides and cyclones in your country?

	Floods	Landslides	Cyclones
National Risk Maps available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Some Local Risk Maps available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
No Risk Maps available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Risk Maps available for use in response planning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

15. Based on your Irma/Maria experience, what recommendations would you make for improving the national EWS for cyclones.

APPENDIX V

CDEMA/CREWS Review of Dissemination and Communication of Warnings, Disaster Risk Knowledge, Application and Preparedness Measures for Hurricanes Irma and Maria – Community Level Awareness of EWS (Focus Groups) Questionnaire

This survey is part of the study to assess the early warning system (EWS) performance of key actors in Antigua and Barbuda, British Virgin Islands and Dominica in the context of the 2017 hurricanes Irma and Maria.

It seeks to answer the questions as to what formal or other early warning systems arrangements existed for this hydro-meteorological hazard, the modes of sharing notification, timeliness of the warnings and preparedness actions taken by different stakeholders.

The findings of the studies will be discussed by regional stakeholders to inform the nature and priorities for a Regional EWS Project in the short term and a subsequent regional EWS Programme in the medium term.

We thank you for taking the time to participate in this survey and willingness to share your experiences.

The questionnaire can be completed within 30 minutes. All respondents will be anonymous.

Please feel free to contact me at any of the following if you have queries: email – jeremyc699@gmail.com; cell – 2462330681 and Skype – [Jeremy.collymore](https://www.skype.com/jeremycollymore).

Sincerely,
Jeremy Collymore

Expert Reviewer

1. Rank the following according to which is experienced mostly frequently in your community

- Storms
- Hurricanes
- Floods
- Landslides
- Drought
- Tsunamis
- Storm Surge

2. Rank the following according to the hazard that could create the most damage in your community

- Storms
- Hurricanes
- Floods
- Landslides
- Drought
- Tsunamis
- Storm Surge

3. Does your community have any formal or informal system of warning residents about storms, hurricanes, landslides, floods, storm surge or tsunamis?

- Storms
- Hurricanes
- Landslides
- Floods
- Storm surge
- Tsunamis
- Provide details on the warning system(s) that exist in your community

4. How do you usually learn about an upcoming hazard such as floods, hurricanes, storms, landslides? Check all that apply

- Whatsapp
- Facebook
- Text message
- Radio
- TV
- Cellphone call

- Landline telephone call
- Siren
- Visit from family, a friend or neighbor
- Loud hailer from emergency services (police or fire)
- Visit from a community volunteer or CERT member
- Other (please specify)

*5. Did you receive warning information about Hurricane Irma and Maria?

- Yes
- No

6. If you received warning about hurricanes Irma and Maria, which of the following best indicates the number of hours warning you had to prepare before impact?

- More than 72 hours
- Between 48-72 hours
- Between 36-48 hours
- Between 24-36 hours
- Between 12-24 hours
- Between 6-12 hours
- Between 1-6 hours
- Between 1 hours
- Don't remember how much time

7. Did the advice give specific information on things you should do to prepare?

- Yes
- No

8. If you receive information on how to prepare for the impact of hurricanes Irma and Maria, which of the following best describes the advice given?

- Very useful
- Somewhat useful
- Useful
- Not useful

9. What did you do with the information received? check all that apply.

- Used it to secure my home
- Used it to get my emergency supplies
- Used it to get gasoline for my vehicles
- Used it to help my family and neighbours prepare
- Ignore it
- Don't remember

10. If another hurricane was threatening in the future would you heed the warnings after the experience of Hurricane Irma/Maria?
- Yes
 - No
 - Not sure

11. How do you think the hurricane preparedness can be improved?

*12. In which country/territory do you live?

- Antigua and Barbuda
- British Virgin Islands
- Dominica

APPENDIX VI

CDEMA/CREWS Review of Dissemination and Communication of Warnings, Disaster Risk Knowledge, Application and Preparedness Measures for Hurricanes Irma and Maria –

Shelter Management Questionnaire

1. How long have you been a shelter manager?
2. Have you ever receive training in shelter management?
 - Yes
 - No
3. If you received shelter management training, where did you receive the instruction?
 - As part of a training/workshop (not CERT) held before 2017 hurricane events
 - From a workshop/orientation session held after the 2017 events
 - As part of the CERT programme held before 2017 hurricane events
 - Other (please specify)
4. List three roles you performed as a shelter manager
 - Role 1
 - Role 2
 - Role 3

5. When did you serve as a shelter manager?

- | | |
|--|---|
| <input type="checkbox"/> Before, during and after impact | <input type="checkbox"/> After impact only |
| <input type="checkbox"/> During and after impact | <input type="checkbox"/> Before impact only |
| <input type="checkbox"/> During impact only | <input type="checkbox"/> Before and after impact only |
| <input type="checkbox"/> Other (please specify) | |

6. How long did you serve as a shelter manager?

- Less than a week
- Between 1-2 weeks
- Between 2 weeks to a month
- More than a month

7. Do you know if the selection of the shelters in your country considered the risks from any of the following? Tick all that apply.

- landslides
- floods
- hurricanes
- earthquakes
- Other (please specify)

8. How are you notified about the need to activate the shelter? Tick all that apply.

- | | |
|--|---|
| <input type="checkbox"/> Email | <input type="checkbox"/> VHF/HF radio |
| <input type="checkbox"/> Whatsapp | <input type="checkbox"/> Visit to my home |
| <input type="checkbox"/> Telephone | <input type="checkbox"/> Self-activation based on the magnitude of the event(s) |
| <input type="checkbox"/> Briefing from disaster office | <input type="checkbox"/> Other (please specify) |

9. Which of the notification methodes was/were used for Irma/Maria? Tick all that apply.

- Email
- Whatsapp
- Telephone
- Briefing from disaster office
- VHF/HF radio
- Visit to my home
- Self-activation based on the magnitude of the event(s)

10. Did you have enough time to set up the shelter?

- Yes
- No
- Not sure
- Explain your answer

11. Which of the following best describes the response to the shelter availability?

- Most people came before impact
- Most people came after impact
- Most people came during impact
- Other (please specify)

12. Were the persons coming to the shelter prepared based on the guidelines that were shared?

- Yes
- No
- Not sure
- Explain your answer

13. In which community was the shelter you managed located?

14. What was the maximum number of persons who sought housing in the shelter you managed?

15. Describe the general make-up of the shelter population (adults, children, disabled, elderly) that you managed?

16. Based on your Irma and Maria experience, list at least 3 things you would recommend to improve shelter management.

#1

#2

#3

APPENDIX VII

**Lessons Learnt on Early Warning Systems
following the Caribbean 2017 Hurricane Season:
Assessment of Gender Considerations Integrated in EWS
key informant interviews – National Level**

Guide to Completing the Questionnaire

Kindly answer as many questions as possible.

Where the question is not applicable to your organisation's area of work, please indicate so by, "N/A"

Where no consideration had been given to undertaking the tasks identified in a question, please indicate so, by "N/C"

Where consideration had been given but resources were not available please indicate so, by "N/R"

1. Name of key informant:
2. Name of organization:

3. General information

3.1. Organization

Name of the organization/institution:

Nature of work:

1. Policy/strategy formulation
2. Coordination
3. Implementation
4. Technical support
5. Research
6. Other, please specify

3.2. Work

Did your Organisation have any project/activities related to early warning systems for the 2017 Hurricane Season?

If yes:

1. What were the key objectives of the project/activities?
2. What was its duration?
3. What was its geographic coverage?
4. Who were the Direct beneficiaries?
5. Who were the Indirect beneficiaries?

3.3. Human resources in the organization

1. Total number of staff:
2. Number of female staff:
3. Number of female staff in decision-making positions (section chief, head, officer level staff in the organization):

4. Gender analysis of the four key elements of people-centred EWS

4.1 Risk knowledge

- Are there provisions (in policies, strategies, and guidelines) to engage women and women's organizations in the capacity building of women and men, in developing standards and tools for EWS ? Kindly describe.
- Please describe how your organisation sought to include gender into hazard identification, vulnerability and risk assessment prior to the 2017 Hurricane Season?
- Were hazard and vulnerability maps for all communities in place prior to the 2017 Hurricane Season? If not all communities could you identify which communities were covered?
- Was there a strategy in place (as part of the preparedness for 2017 Hurricane Season) to actively engage women and men from communities in local hazard and vulnerability analyses?
- Were women's needs, concerns, and knowledge included in the community vulnerability assessments conducted in preparation for the 2017 Hurricane season ?
- Were gender-differentiated results of risk assessments integrated into local risk management plans and warning messages?

4.2 Monitoring and warning services

- Were there any provision for ensuring women's participation in all processes of EWS in preparation for the 2017 Hurricane season?
- Have institutional mechanisms been established for women's participation in monitoring and evaluation of EWS?
- Were gender perspectives mainstreamed in all of the processes, roles and responsibilities of your organization when and if generating and issuing warnings?

4.3 Dissemination of information during the 2017 Hurricane Season

- Were there efforts or provisions to ensure that the disseminated alerts/warnings/messages/information were gender-sensitive?
- Did the warning dissemination chain ensure that both women and men receive information?
- Were women and men both part of a volunteer network that is trained and empowered to receive and widely disseminate hazard warnings to remote households and communities?
- Were communication and dissemination systems tailored to the needs and social behaviour of both women and men?
- Was warning communication technology accessible and did it reach women and men equally?
- Were multiple communication mediums for warning dissemination used, including those used or preferred by women?
- Was there a two-way and interactive communication system in place to allow for verification, so it could be determined if women and men had received warnings?

- Were warning messages recognized and understood?
- Did the messages incorporate an understanding of the values, concerns, and interests of women and men?
- Can warnings/alerts be understood by both women and men (e.g., have studies been undertaken to determine how women and men access and interpret early warning messages)?
- Were gender-sensitive lessons learnt incorporated into message formats and dissemination processes?

4.4 Response capability

- What are the provisions/efforts/practices currently in place in your organizations to make sure that warnings/alerts received by female members of the society will be responded to promptly and properly?
- Have response capacity building activities been gender-sensitive?
- Did warnings distributed by credible sources reach both women and men?
- Were disaster preparedness and response plans gender-sensitive?
- Did hazard and risk maps include gender-differentiated variables for vulnerability and risk, and are they used to develop emergency preparedness and response plans?
- Was feedback from regular tests and drills collected to test if the early warning and dissemination process and responses reach women and men equally?
- Was community response capacity assessed and strengthened?
- Was women's ability to respond effectively to early warnings assessed?
- Were gender-differentiated responses to previous disasters analysed and gender-sensitive lessons learnt incorporated into future capacity building strategies?
- Were women-focused organizations engaged to assist with capacity building?
- Were gender-sensitive community and volunteer education and training programmes developed and implemented?

5. Key strengths, challenges, needs and areas for improvement

Could you please describe your experiences in relation to the key strengths, challenges and areas for improvement in EWS during the 2017 Hurricane Season, particularly in relation to the mainstreaming of the needs and concerns of women?

- Strengths
- Challenges
- Needs/areas for improvement

Guide to FOCUS GROUP
Lessons Learnt on Early Warning Systems
following the Caribbean 2017 Hurricane Season:
Assessment of Gender Considerations Integrated in EWS

My name is Dr Asha Kambon (brief introduction about self), I have been commissioned by the **World Meteorological Organization (WMO)** to engage with key constituents from at least three impacted countries of the 2017 Hurricane Season, capturing their experiences and documenting lessons learnt and developing recommendations toward strengthening the inclusion of gender specific issues in **EWS** in the region. The three countries selected for review are: Antigua and Barbuda, the Commonwealth of Dominica and Sint Maarten.

Unfortunately the time for field work is very short and I am able to spend only two or three days in each country.

I thank you very much for taking the time to meet with me and to share your experiences about the 2017 Hurricane season with me. I also want to thank (in-country colleague, organisation) for facilitating this process.

Guide to Focus Group discussions

A. Disaster risk knowledge based on the systematic collection of data and disaster risk assessments

1. Did you know that you were living in an area that may be at risk for the effects of a hurricane Cat 5 – strong winds, blown off roofs, possible sea surge, flooding, mud slides?
2. How did you find this out?
 - a. From old folks who lived here, parents, grandparents,
 - b. information received from school, radio, tv, village council?
3. Have you ever participated in an exercise to collect information about the risks that your community face?

B. Detection, monitoring, analysis and forecasting of the hazards and possible consequences

1. In preparation for the 2017 hurricane season were you involved in any exercises to examine the hazard that a hurricane could pose to your community?
2. In preparation for the 2017 hurricane season were you involved in any exercises to examine the possible consequences of such a hazard?
3. Who engaged you and how?

C. Dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact

1. In relation to the 2017 hurricane season did you receive information about the impending hurricane?
2. What was the source of your information?

3. How did you receive the information – radio, mobile phone, loud speaker, tv, newspaper, neighbour, family, faith based institution (church)
4. Was the information clear, did you understand it ?
5. What did you not understand about the information?
6. Did you think it was presented to you with sufficient time for you to do something about the information?
7. Did you think it was accurate
8. Did you believe it? Why or Why not?
9. Did you get information on the likely impact? i.e. loss of life, injury, loss of property, lack of access to services (electricity, water, health, food, transport)

D. Preparedness at all levels to respond to the warnings received

1. Do you think you were properly prepared to respond to the warnings you received?
2. Did you know how to safeguard your property
3. Did you know where to go to safeguard yourself and family
4. Did you have everything needed to take the recommended action – money to buy extra food, transport to get to safer location, help to safeguard household or materials necessary?
5. Do you think you took the best action possible...
6. If you had to respond to another hurricane warning
 - a. What would you do differently?
 - b. What would you want others to do differently?
 - i. Those in national authority/local authority
 - ii. Family – here and abroad
 - iii. Community



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