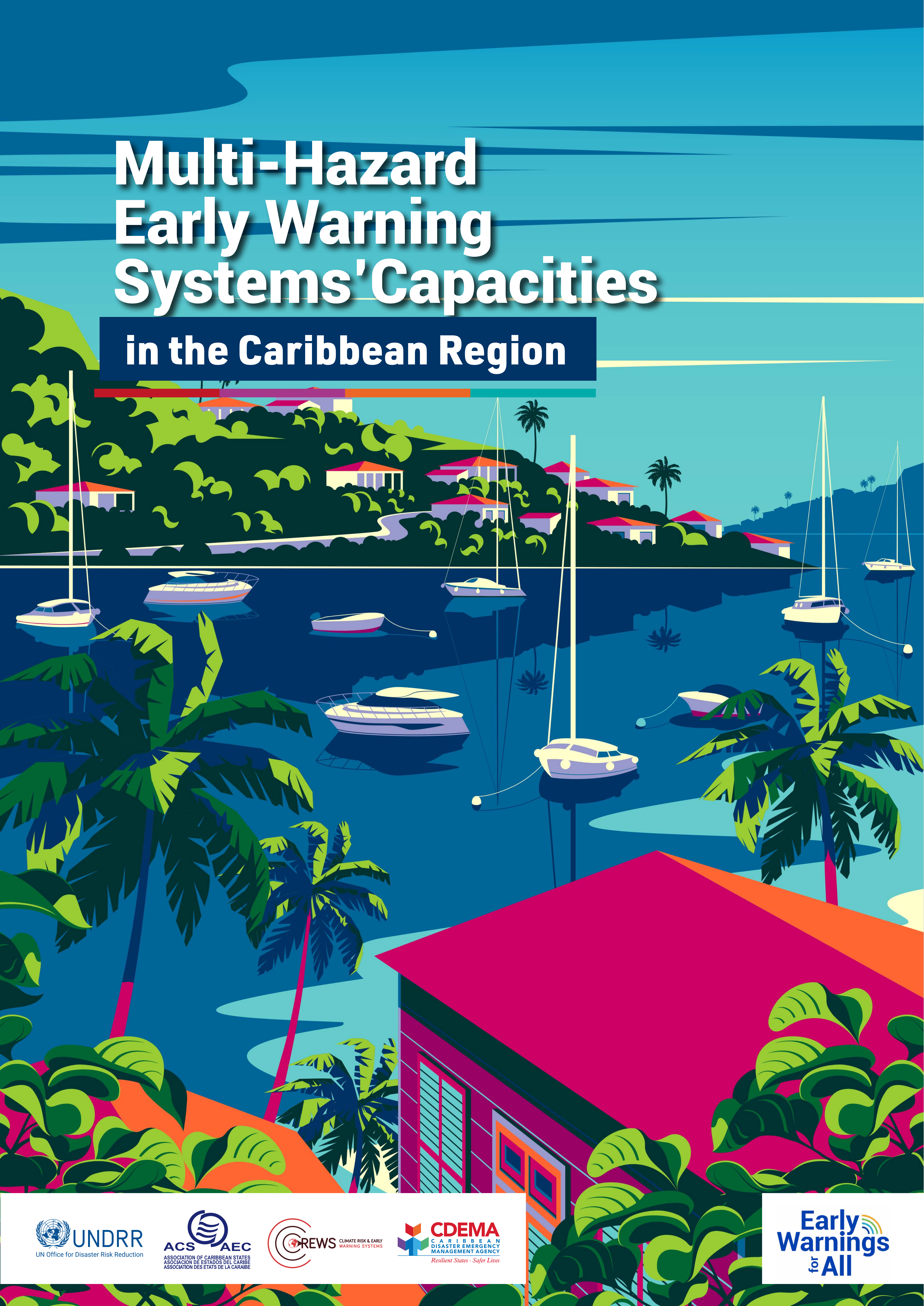
Multi-Hazard Early Warning Systems'Capacities

in the Caribbean Region



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Citation: (UNDRR, 2022) Disaster Risk Reduction, United Nations Office for Disaster Risk Reduction (UNDRR).

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Acknowledgements

This publication is the product of desktop research, literature reviews and extensive contributions from valued stakeholders at the varying levels. The UNDRR gratefully acknowledges national and regional partners for their contributions, which have enabled the production of this assessment on existing capacity, issues, and advancements with regards to multi-hazard early warning systems (MHEWS) in the Caribbean region. Two (2) consultations were convened in Barbados and Guyana respectively, to validate the accuracy of the research conducted on existing MHEWS capacity at the regional and national levels. We take this opportunity to thank all member and observer organisation of the Regional Early Warning System Consortium (RESWC) for their support in the development and review of this document. We also wish to thank the national disaster management offices (NDMOs) of the region for their contributions in validating the information at the national level.

The report was developed through a collaborative effort between the Association of Caribbean States (ACS) and the United Nations Office of Disaster Risk Reduction (UNDRR). We thank Ms. Cherisse Braithwaite-Joseph and Ms. Christal Benjamin of the ACS, and Mr. Brendon Taylor, consultant at UNDRR, for co-authoring the report together with Mr. Carlos Uribe and Mr. Jair Torres (UNDRR). We thank UNDRR Consultant Ms. Alana Lewis, as well as Ana Leticia Ramirez Cuevas of the ACS for their support in editing and reviewing the report. We also wish to express gratitude to Executive Director Ms. Elizabeth Riley, Ms. Andria Grovenor, and Ms. Susan Norgrove of the Caribbean Disaster Emergency Management Agency (CDEMA) for managing and coordinating feedback to the report following consultations. Additionally, special mention is given to representatives of organisations which comprise the REWSC for offering their expertise in comprehensively reviewing and editing the report. Such individuals include Dr. Temitope Oyedotun, the Dean of the Faculty of Earth & Environmental Sciences (FEES), the Univeristy of Guyana, Dr. Arlene Laing, Coordinating Director of the Caribbean Meteorological Organisation (CMO), Mr. Horace Glaze, Disaster Management Coordinator of the International Federation of the Red Cross (IFRC) Americas-Caribbean Cluster, Dr. Evangeline Inniss-Springer, Director of the Disaster Risk Reduction Centre (DRRC), the University of the West Indies (UWI), and Mr. Jeremy Collymore, Honorary Research Follow & Consultant at the UWI.

We also acknowledge the work of the following organisations that have informed the contents of this report: United Nations Development Programme (UNDP) - World Bank Group - International Federation of the Red Cross (IFRC). UNDRR would like to thank all donors for their support, which enabled the production of different components of the present document. UNDRR would like specially to thank the Climate Risk and Early Warning Systems (CREWS) for donor support to advancing the MHEWS agenda for the Caribbean region.

1.0 INTRODUCTION

The Caribbean region is exposed to multiple hazards which place its inhabitants at risk to injury, death, loss, and displacement. This multi-hazard context was well exemplified between 2021 and 2022, during which the region faced and was threatened by the occurrence of several simultaneous and cascading hazard events. These events included but were not limited to the onset of the COVID-19 pandemic, the La Soufriere volcanic eruption in St. Vincent and the Grenadines, a 7.2 magnitude earthquake in Haiti, tropical cyclones and flood events across the region and the threat of a marine oil spill in the Southern Caribbean. Combined with existing socio-economic vulnerabilities, the typical hazard impact is one of great losses, even to the extent of exceeding many of the countries' gross domestic products (GDP) and thus, challenging the overall sustainable development of the region.

Moreover, the effect of climate change is exacerbating the frequency, intensity, and unpredictability of hydrometeorological hazards, resulting in reduced and more variable rainfall, more frequent and extended periods of drought and more intense rainfall events. Extreme tropical cyclone events typified by Hurricanes Maria and Irma are contributing directly to the loss of lives and livelihoods, the destruction of critical infrastructure and widespread damage to the physical environment. It is important to note that these extreme events are occurring at a faster rate than the countries of the Caribbean can recover from the socio-economic impacts of the damages sustained. Consequently, it is of critical importance that all countries across the Caribbean region possess strong capacities to manage the existing and emerging risks, whilst avoiding the creation of new ones. One of the ways in which risk and losses can be reduced is through multi-hazard early warning systems (MHEWS) which enable individuals, communities, governments, business, and the society at large to take timely action and prepare for impact.

This study provides an updated assessment of the status of MHEWS for all CDEMA Participating States (PS). It highlights existing gaps and capacities in the areas of governance, disaster risk knowledge, forecasting, monitoring and detection, warning and dissemination and response capability. It also looks specifically at early warning capacities for geological, hydrometeorological, environmental, biological, chemical, and technological hazards at the country level. The body of research is intended to benefit regional agencies, national governments, donor agencies, non-governmental organisations, academics, and other relevant stakeholders. The study concludes with recommendations for addressing the gaps in regional MHEWS. Overall, it provides baseline research for future interventions and seeks to contribute to the strengthening of MHEWS towards a more resilient Caribbean region.

1.1 BACKGROUND

MHEWS are extremely important in contexts where several hazards occur simultaneously, in a cascading manner or cumulatively over time (UNDRR 2022, A). They involve the use of a system which centralises knowledge, responses, and warnings for prioritised hazards. This system increases the efficiency and scale of warnings, thereby reducing disaster impacts. It also maximises limited resources, enhances synergies among risk management agencies and promotes cooperation among a diverse range of stakeholders. As such, MHEWS are prioritised at the international and regional levels[1]. This study examines the key elements of MHEWS and provides an updated assessment of the status of MHEWS for all CDEMA participating states (PS)[2].

The Sendai Framework recognises four (4) components which comprise EWS: disaster risk knowledge based on the systematic collection of data and disaster risk assessments; detection, monitoring, analysis and forecasting of the hazards and possible consequences; dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact; and preparedness at all levels to respond to the warnings received. These components are all impacted by the cross-cutting issue of governance.

In the context of disaster risk reduction, governance refers to the system of institutions, mechanisms, policy and legal frameworks and other arrangements to guide, coordinate and oversee disaster risk reduction and related areas of policy (UNDRR 2017). Good governance creates an enabling environment for the four components of early warning. It mobilises political will and facilitates broad stakeholder participation, without which risk cannot be effectively assessed and mitigated. MHEWS governance can be measured by several indicators as outlined by the Sendai Framework. Firstly, countries and communities must ensure that a strategy for all priority hazards is developed by broad stakeholder consensus. This provides general direction for all actors and facilitates the establishment of objectives and goals against which progress can be evaluated. Furthermore, processes, roles and responsibilities of all organisations involved in early warning should be clearly mandated by legislation, policies and other authoritative instruments, thus empowering risk managers to take timely action to reduce disaster risk. Good governance is also exemplified by the establishment of agreements and interagency protocols for the exchange of data. Without these, agencies may place limits on data sharing, thus impacting negatively on the accuracy and timeliness of early warning messages. This is also applicable to cross-border exchange of warnings with neighbouring countries, in which case bilateral and multilateral agreements are necessary. Finally, the active engagement of diverse groups and effective management of risk data are also indicators of good governance.

Disaster risk knowledge is an output of effective MHEWS governance. According to the World Meteorological Organisation, disaster risk knowledge is "comprehensive information on all dimensions of disaster risk, including hazards, exposure, vulnerability, and capacity, related to persons, communities, organisations and countries and their assets (WMO 2022). It should involve the identification of hazards and related threats, risk assessments and consolidation of risk information (UNDRR 2022, C). Hazard identification focuses on the prioritisation of hazards which present the greatest risk to a country. For example, Trinidad and Tobago has identified floods, earthquakes, landslides, coastal floods, tropical cyclones, and wildfires as the country's priority hazards as these pose the greatest threat to security and socio-economic development (PDC 2020). It is also important for risk managers in this country to understand the complexities of cascading or simultaneous hazard events, so that early warning preparations are not undermined by the compounding effects of these events. Disaster risk knowledge can also be strengthened by risk assessments. This includes the use of dynamic and multi-layered hazard maps to identify exposed geographic areas, vulnerability assessments of populations disaggregated by gender, vulnerability assessments of key

1 Target G of the Sendai Framework is to "substantially increase the availability of and access to multi hazard early warning systems and disaster risk information and assessments to the people by 2030" (UNDRR 2022, B). Furthermore, the Caribbean Comprehensive Disaster Management (CDM) Strategy 2014 – 2024 underscores the importance of managing disaster risks within multi-hazard contexts and it prioritises "integrated, improved and expanded community early warning systems" (CDEMA, 2014).

2 As of December 2021, the participating states of the CDEMA system were Anguilla, Antigua & Barbuda, the Bahamas, Barbados, Belize, the British Virgin Islands, the Cayman Islands, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Lucia, St. Kitts & Nevis, St. Vincent & the Grenadines, Suriname, Trinidad & Tobago, and the Turks & Caicos.

economic sectors, the integration of indigenous knowledge into risk assessments and the integration of risk assessments into local risk management plans. Finally, the use of data architecture and repositories for storing, processing, manipulating and utilising data is also a good indicator of disaster risk knowledge.

Detection, Monitoring, Analysis and Forecasting (DMAF) is also an essential component of early warning. The first process in this component is monitoring, which is the systematic observation of hazardous situations to understand how they evolve and change over time. This is distinct from detection, which is the act of identifying something that is concealed. For example, a flood monitoring system may use sensors deployed in rivers and other bodies of water to measure water levels in real time. The data relayed from the sensors to early warning centres can be used to detect flood risk and disseminate timely warnings. However, prior to the issuance of warnings the data must be analysed by the application of scientific knowledge, modelling techniques, statistical formulae, and other tools. Once this analysis is complete, informed predictions on the likelihood, magnitude and impact of the flood can be made, which is referred to as forecasting. DMAF is an iterative process since hazard situations have the potential to evolve rapidly and unexpectedly over time. There are several indictors which may be used to evaluate the effectiveness of DMAF. These include the establishment and operation of monitoring networks for all priority hazards and the presence of monitoring data and metadata which can be used for verification and research. A monitoring network may be as complex as an automated flood warning system or as simple as a community group consisting of individuals who inform each other about emerging threats. The presence of forecasting and warning services is also a good indication of DMAF. This includes warning centres which constantly operate (24 hours per day, 7 days per week) and fail-safe systems such as power back-up and on-call personnel for all priority hazards.

Once a hazard is imminent, warnings must be disseminated and communicated to allow at-risk groups to act. A warning is simply a statement or action that indicates impending danger. However, its success is dependent upon sound institutional practices and collaboration among a diverse range of stakeholders. Firstly, this component requires effective organisational and decision-making processes. Strong relationships between risk managers and the media, as well as regular coordination, planning and review meetings are an essential part of this process. These interactions can facilitate evaluation of warning messages to gather feedback on their effectiveness, so that adjustments can be made where necessary. Furthermore, communication systems and equipment are essential for early warning. Warning systems should be tailored to meet the needs of specific groups for all priority hazards, including women and men, youth and elderly, indigenous groups, persons with disabilities and urban and rural populations. The entire population should also be reached through multiple communication channels. This includes standardised messages from official authorities via radio, websites and other media and simple dual-use tools such as public announcement (PA) systems and church bells. Additionally, warning systems should also be tested regularly, and exercises should be conducted to ensure that the public is familiarised with them. Finally, the risk managers should seek to ensure that warnings prompt action by the target group. Some key factors which influence this indicator are the use of common alerting protocols for priority hazards, the design of messages in terms of their clarity, consistency, and gender sensitivity, whether messages advise on action to be taken and whether the public trusts and understand the messages.

The fourth component of MHEWS is preparedness and response. It entails all the measures taken by disaster risk management authorities, communities, and the public to cope with the immediate impacts and aftermath of a hazardous event. Some key elements of this component are risk knowledge, physical capacity to respond, financial resources to enable response and logistical support for the response. Authorities and communities can measure the effectiveness of preparedness and response by ensuring that disaster preparedness measures such as plans or standing operating procedures are well developed and operational. This should be done in a participatory manner and should target specific vulnerabilities. Furthermore, the execution and evaluation of public awareness and education campaigns which are tailored to the needs of specific vulnerable groups is also a key measure of preparedness and response. It is also important to test and evaluate public awareness and response, by analysing previous emergency and disaster events and incorporating lessons learnt into plans and capacity building strategies. Finally, the frequent execution of drills and simulations, and the documentation of population response to alerts are important indicators of preparedness and response. This ensures that authorities and warning recipients have the requisite resources and capacities to respond effectively to warning messages.

The four main components of MHEWS are essential for disaster risk reduction. Governance mechanisms within a given country or territory significantly impact the effectiveness of these components, and therefore the successful operation of a MHEWS. It is important to conduct assessments of each component using relevant indicators as provided by the Sendai Framework. Such assessments elucidate gaps and variances in capacities among countries and highlight areas where partnership and collaboration are required for more effective MHEWS.

2.0 REGIONAL & NATIONAL LEVEL MHEWS CAPACITY ASSESSMENT

The mapping of MHEWS status at the regional and national levels for all countries comprising the CDEMA system was completed through desktop research and validated by remote contact with focal points of CDEMA PSs where possible. Additional verification of the data collected was obtained via two (2) rounds of consultations, one convened with regional stakeholders and the other with national level representatives. The mapping utilises the Sendai classification and taxonomy for all hazards and recognises the four (4) components[3] of EWS as described by the UNDRR. Since there are four (4) components which comprise an EWS, there was a conscious effort to avoid the overestimation of the existing capacity within CDEMA states. At the national level, a colour code system is used to depict which components are accounted for within each PS. The colour code and corresponding legend of each country infographic can be found in Table 1. Additionally, the assessment identifies both the regional & national agencies with responsibility for EWS for each hazard.

Table 1 The colour coding system used to depict the capacity of EWS components in CDEMA PSs.

Colour Code	EWS Components Represented
Light blue	• C1- Disaster risk knowledge based on the systematic collection of data and disaster risk assessments.
Blue	• C2- Detection, monitoring, analysis & forecasting of the hazards & possible consequences.
Dark blue	• C3- Dissemination & communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact.
Pale green	• C1- Disaster risk knowledge based on the systematic collection of data and disaster risk assessments. • C2- Detection, monitoring, analysis & forecasting of the hazards & possible consequences.
Light green	• C1- Disaster risk knowledge based on the systematic collection of data and disaster risk assessments. • C3- Dissemination & communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact.
Dark green	• C2- Detection, monitoring, analysis & forecasting of the hazards & possible consequences. • C3- Dissemination & communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact.
Yellow	• C1- Disaster risk knowledge based on the systematic collection of data and disaster risk assessments. • C2- Detection, monitoring, analysis & forecasting of the hazards & possible consequences. • C3- Dissemination & communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact.
Red	• C1- Disaster risk knowledge based on the systematic collection of data and disaster risk assessments. • C3- Dissemination & communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact. • C4- Preparedness at all levels to respond to warnings.

3 The four (4) components include 1) Disaster Risk Knowledge, 2) Detection, Monitoring, Analysis & Forecasting, 3) Dissemination & Communication of actionable warnings, and 4) Preparedness at all levels to respond to warnings.

The report defines capacity as the presence of infrastructure or a mechanism for EWS rather than the performance of the system. As a result, EWS capacity per hazard can be theoretical or fully operational. Consequently, the research provides an inventory of EWS capacity which can serve as a basis for other tools to ascertain the infrastructural and institutional functionalities of MHEWS, identifying gaps and recommendations to bridge them.

To provide an accurate representation of country capacity and ensure the validity of the study, two (2) measures were applied to guide the study as follows:

i. Data not owned by a national or regional agency with the CDEMA, or CARICOM system is not accounted for in the mapping. This is because several international organisations lead projects which create or manage data within CDEMA PSs, but the intervention of the organisation does not reflect capacity within the country

ii. Data which is older than 30 years is not accounted for in the mapping

iii. In instances where regional agreements are established for countries to offer MHEWS services for recipient countries, the dependent countries are considered to have no capacity for the specific hazard unless there is a demonstration of independent, nationally-owned services.

Given the qualitative nature of the study, the report is designed to be representative rather than conclusive in the measure of actual MHEWS capacity in Caribbean countries. The validity & reliability of the study is significantly dependent on the accuracy of research and key informant insight, which has been enhanced by more than one consultation for verification of information.

2.1 Regional MHEWS Assessment for CDEMA PSs

In 2020, the UNDRR in collaboration with the International Science Council (ISC) published a technical report which provides a review of hazard definitions and classifications. The report encompasses man-made and natural hazards, expanding the scope of disaster risk reduction (DRR) under the Sendai Framework to biological, environmental, geological, hydrometeorological, chemical, and technological hazards, and calling on a multi-hazard approach to DRR. Utilising input from stakeholders to ensure the hazards list is robust, the six (6) classifications are further broken down into individual hazards which have common characteristics. The following section uses the Sendai hazard taxonomy to map EWS capacity per hazard at the regional level for CDEMA PSs.

2.1.1 Geological Hazards

2.1.1.1 Earthquakes, Volcanic Eruptions & Tsunamis

The University of the West Indies Seismic Research Centre (UWI SRC) based in St. Augustine, Trinidad is the regional organisation which serves the Caribbean region as the focal point for early warnings on seismic hazards within the region. Currently, the UWI SRC is the authoritative source for information on the status of earthquake and volcanic activity in the English-speaking Eastern Caribbean, maintaining volcanic and earthquake surveillance as well as a warning system, including ground deformation and geothermal monitoring, and provides advice to the governments of the region on response. To achieve this, the UWI SRC operates an extensive network of over 60 fully digital, seismic monitoring stations, a number which is constantly increasing with greater emphasis on procurement by the centre. The centre continuously receives data from the stations via public Internet, facilitating real time processing and analysis. The UWI SRC also operates a Seiscomp-based, auto-solution system to alert stakeholders such as national disaster offices, and the public (Dondin et al. 2019).

The UWI SRC serves as a hub for probabilistic seismic hazards maps[4] for the Eastern Caribbean region, the extent of which cover the Leeward Islands of the north from Anguilla to Dominica, the Windward Islands of the south from Martinique to Grenada, Barbados, and Trinidad & Tobago. Individual assessment maps are also available for Barbados, Dominica, and Trinidad. Through the systematic collection of data on earthquakes in the region, a comprehensive and current earthquake catalogue has been developed by combining all available data sets. The seismic hazard maps combine these data inputs and the investigation of interplay & complexities between shallow crustal, intraplate and interface subduction seismicity in the Caribbean region, to model projected peak ground acceleration (PGA)[5] and spectral acceleration (SA) across the islands based on varying magnitudes of earthquakes (UWI SRC 2022). That is, the maps indicate the anticipated degree of ground shaking which is likely to occur across a geographical location due to an earthquake of a given magnitude. Though the assessments do not consider socio-economic vulnerabilities, the maps have been applied for computational purposes, to engineer the elastic capacity of physical infrastructure in response to earthquakes in alignment with International Building Codes (IBC).

The majority of CDEMA participating states (PSs) of the Eastern Caribbean do not possess early warning system capacity at the national level regarding volcanic hazards. Volcanic hazard risk assessment maps are available for Grenada, Monserrat, Saint Kitts, Kitts & Nevis, and Saint Vincent & the Grenadines through the UWI SRC. This is primarily due to the immediate risks posed by the volcanic nature of these islands. Detection, monitoring, and analysis services for volcanic activity are provided by the UWI SRC, which monitors 16 of the 21 live volcanoes in the Eastern Caribbean and supervises the Montserrat Volcano Observatory. Due to the convergent nature of Caribbean and Atlantic tectonic plates, volcanoes offer clear signs of impending eruptions which enable timely, actionable warnings to be given due to a slower onset rate. This was exemplified by the La Soufriere volcano, St. Vincent & the Grenadines, which recorded increased seismic activity in the immediate environs of the dome, the swelling of the dome of the volcano and changes in

4 The maps have been peer-reviewed and accepted for publication in the Bulletin of the Seismological Society of America.

5 PGA is the equivalent of the maximum ground acceleration that occurrs during earthquake shaking at a given geographical location. PGA is equal to the amplitude of the largest absolute acceleration recorded on an accelerogram at a site during a particular earthquake.

the composition of gases emitted prior to the eruption. In this example, a team from the UWI SRC conducted a scientific mission to the site of the volcano, supported by CDEMA through the procurement of helicopter services for seven (7) days to transport staff and equipment. The tracking of changes was completed through the detection of increased earthquake activity by seismic stations, the use of Global Positioning System (GPS) measurements to detect swelling of the volcanic dome because of pressure, and sampling of gases evolving from the volcano. All changes in volcanic activity are usually reported to the national disaster management offices of CDEMA PSs, which in turn communicate actionable warnings to their respective national governments. Additionally, the UWI SRC contributes to Pillar 4 of EWSs by conducting exercises and drills on volcanic eruptions within CDEMA PSs.

With regards to tsunami hazards, there is no comprehensive, regional Caribbean tsunami warning system which serves the entire Caribbean basin. Rather, the region relies on the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO-IOC) led Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG/CARIBE EWS). In the instance that an earthquake triggers a tsunami which will potentially impact the Caribbean, the Pacific Tsunami Warning Center (PTWC) will issue a bulletin to Tsunami Warning Focal Points (TWFP), the official agency responsible for receipt of the warning message in each Caribbean country. For CDEMA PSs, the focal points are either the meteorological offices, the national disaster management offices, or the police department[6]. The communication of the warning to the public is the responsibility of the national disaster management agency in each country. The PTWC also manages forecast and risk assessment data regarding the likely amplitude of waves which may impact a given geographical location under varying magnitudes of earthquakes.

The UNESCO-IOC has also advanced preparedness efforts to respond to tsunami warnings in the Caribbean region under the Tsunami-ready Recognition Programme. The main aim of the programme is to build resilient communities through awareness and preparedness strategies that will protect life, livelihoods, and property from tsunamis in different regions across the world. In December 2017, the United Nations declared that a Decade of Ocean Science for Sustainable Development would be held from 2021 to 2030 (Ocean Decade). In June 2022, the IOC Assembly approved the establishment of the IOC Ocean Decade Tsunami Programme[7]. A total of 10 CDEMA PSs have already achieved readiness certification and that number is expected to increase as the programme continues to develop.

2.1.1.4 Landslides

CDEMA has led the coordination of disaster risk data collection and assessments for landslides due to geological triggers in PSs. Since the initial risk assessments developed by the Caribbean Disaster Emergency Response Agency (CDEMA), more recent assessments have been developed through the Caribbean Handbook on Risk Information Management (CHARIM) project, funded by the World Bank and the ACP-EU Natural Disaster Risk Reduction Programme. CDEMA now manages the country-specific data developed during the project through the Caribbean Risk Information System (CRIS).

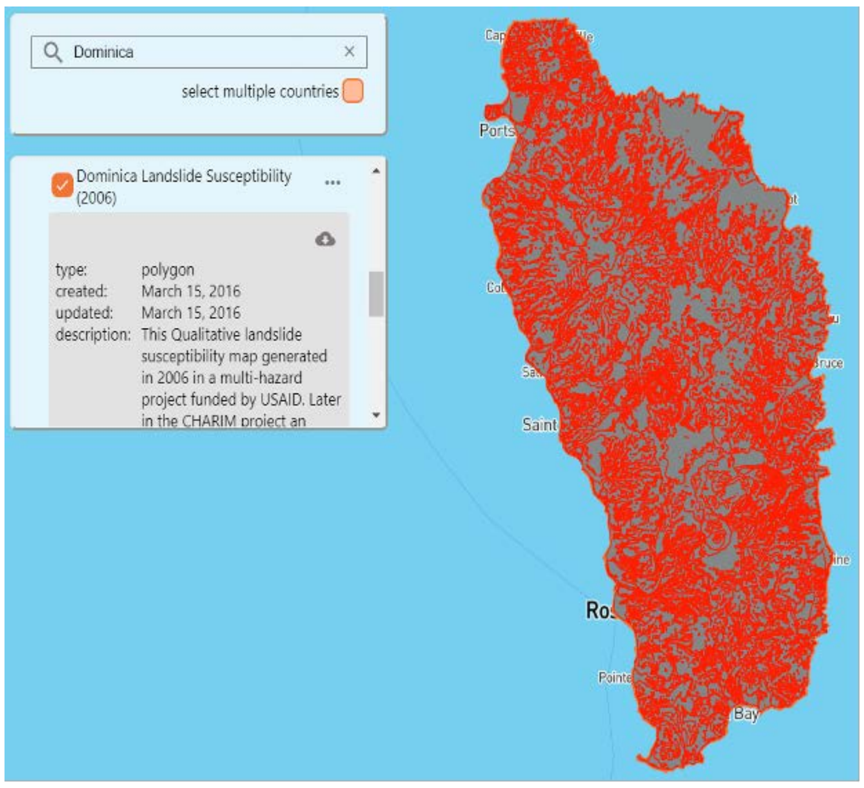


Figure 1 A snapshot of a landslide risk assessment map for Dominica available on the CRIS website. (Source: CDEMA GeoCRIS)

The database is comprised of geo-spatial data which typically provides a qualitative assessment of the probability of a landslide due to ground shaking, featuring metadata on the date of creation, date updated, the type of data and a general description of the origins of the map. One of the observed limitations of the landslide risk assessment across all PSs is the lack of socio-economic data which combines the probability of land slippage, with the exposure and vulnerability of individuals residing near zones or areas where the risk has been classified as high.

6 http://www.ioc-tsunami.org/index.php?option=com_content&view=article&id=90&Itemid=87&lang=en#:~:text=TWFP%20Caribbean&text=The%20Tsunami%20Warning%20Focal%20Point,of%20the%20Tsunami%20Response%20Plan.

7 http://itic.ioc-unesco.org/index.php?option=com_content&view=category&layout=blog&id=2234&Itemid=2758

2.1.2 Hydrometeorological Hazards

2.1.2.1 Tropical cyclones, tornadoes, floods, storm surges, cloudbursts & heat waves

The Caribbean region is supported by the Regional Hurricane Warning System, which is a critical component of the EWS for the most hazardous tropical weather systems. Established in 1977, the Hurricane Committee comprises the National Meteorological Services of North America, Central America, and the Caribbean (WMO Regional Association IV). These services collaborate very closely in operating an EWS for any tropical storms, hurricanes and related severe weather that affect the region. This involves surveillance by weather satellites, weather radars, ocean buoys, ships, aircraft, and land stations. The Caribbean Meteorological Organisation (CMO) hurricane warning system includes a back-up arrangement between the meteorological services of its member states and is operated as part of the wider regional system operated by the WMO and led by the US National Hurricane Centre. The Hurricane Committee meets annually to update both its Operational Plan and Technical Plan.

The Caribbean Meteorological Organisation Headquarters (CMO HQ) is the agency which coordinates the joint scientific and technical activities in weather, climate, and water. One of the projects coordinated by the CMO HQ was the Caribbean Radar Network Project deployed in 2009 which achieved the establishment of a modern network of five (5) radars across select Caribbean states[8] as part of the Caribbean Early Warning System for severe weather conditions. The number of radars increased to 6 in 2013, following the construction and installation of a dual-poloarised, Doppler weather radar in the Cayman Islands through funding by the 9th European Development Fund (EDF). The CMO HQ provided technical services to the Cayman Islands Airport Authority (CIAA), which had overall responsibility for the project. The radars are managed by the governments of these countries through operation by the respective meteorological offices. In addition, the Bahamas and Sint Maarten possess and manage radar systems, while Saint Lucia has a radar which is currently not functional. These countries have the capacity to detect, monitor and forecast tropical cyclones, floods, storm surges, cloudbursts (a feature of the Doppler radar used), and extreme temperatures.

The CMO HQ has emphasised advancing capacity to forecast severe weather in the region through the World Meteorological Organization (WMO) Severe Weather Forecasting Programme (SWFP) Eastern Caribbean (EC). The SWFP is focused on severe weather (heavy rain, strong winds, rough seas/swells) that is not produced by tropical cyclone and can occur at any time of the year. The CMO is co-leading the Caribbean Weather Forecasting Initiative, started in 2019 as part of the international scientific research campaign, Elucidating the Role of Clouds-Circulation Couple in Climate (EUREC4A), support the SWFP-EC. The Initiative fostered collaborative practice among regional forecasters and increased their understanding of the strengths and limitations of high-resolution numerical weather prediction (NWP) models. An additional objective of the initiative was to increase the understanding among forecasters regarding the strengths and limitations of high-resolution numerical weather prediction models. The desired outcome of the initiative was to promote knowledge exchange between regional forecasters and researchers, thereby developing field study research of the EUREC4A into an improved regional EWS for severe weather conditions. Apart from infrastructural development and capacity building, the CMO HQ has contributed to the development of an enabling legal environment which facilitates i) the explicit consideration of MHEWS for hydrometeorological hazards and ii) the definition of roles and responsibilities of agencies within national hydrometeorological hazard EWSs. Work has included the drafting of national legislation regarding meteorological services for nine (9)[9] CDEMA PSs, the development of a model hydrometeorological policy framework, and the development of Strategic Plans, including National Frameworks for Weather, Water, and Climate Services for 10[10] CDEMA PSs.

While the CMO HQ has responsibility for coordination, one of its organs, the Caribbean Institute for Meteorology & Hydrology (CIMH) provides monitoring and analytical services primarily through

8 These states include Barbados, Belize, Guyana, Jamaica, Trinidad & Tobago.

9 The countries are Anguilla, Antigua & Barbuda, Barbados, Belize, Grenada, Jamaica, Saint Lucia, St Kitts & Nevis, and St. Vincent & the Grenadines.

10 The countries are Anguilla, Antigua & Barbuda, Cayman Islands, Dominica, Grenada, Jamaica, Saint Lucia, St Kitts & Nevis, St. Vincent & the Grenadines, and the Turks & Caicos.

the modelling of tropical cyclones, floods and prevalent hazards within the marine environment. Furthermore, modelling conducted by the CIMH integrates how other hazard classifications such as geological activity or chemical pollution, may impact freshwater & marine environments, as well as how weather-related parameters affect other sectors (i.e. cloudiness on the efficiency and effectiveness of PV systems).

With regards to disaster risk knowledge, the CRIS serves as a repository for flood and storm surge risk assessments for Belize and Dominica, and flood risk analysis for Saint Lucia. The CMO HQ facilitates the collection of meteorological data used to determine climate trends and risk analysis. In support, the Caribbean Community Climate Change Centre (CCCCC) continues to play a significant role in advancing the systematic collection of climatic data and expanding the existing networks of data collection for comprehensive coverage of the Caribbean. According to the Centre, a core theme of its strategic five (5) year plan is advocacy for increased uptake of climate data and innovative tools for evidence-based decision-making in the region. In a press release by the CCCCC[11], explicit mention was made of expanding the networks of automatic weather stations (AWS) and evaporation stations across the region to collect continuous data on several weather parameters. Moreover, the CCCCC has been responding to the data and data infrastructure needs of its member states on demand. Examples of such interventions include updating the inventory of multi-hazard risk dataset and maps for Saint Kitts and Nevis, the development of a climatology database which facilitates digitised data & a storm surge model for the Bahamas, and the development of a geo-information EWS for Saint Lucia.

2.1.2.2 Drought

The CIMH is the regional agency which offers monitoring services for rainfall and temperature variability, namely through the Caribbean Drought and Precipitation Network (CDPN). Drought and general precipitation status is monitored at i) the regional level, encompassing the entire Caribbean basin and (ii) the national level using several indices and indicators. On a quarterly basis during the year, the CIMH publishes communications on drought and temperature for the region, providing a 3-month outlook of the likely conditions that PSs of both CDEMA and the CMO will experience. As part of the Regional Consortium on MHEWS, the Caribbean Agricultural Research and Development Institute (CARDI) assists with research, monitoring and modelling of drought hazards, and the dissemination of information, particularly to the agricultural community.

In some instances, the outlook information issued by the CIMH is packaged and published by the meteorological offices of the countries which issue early warnings for drought conditions. On the other hand, some countries including but not limited to Barbados, Belize, Jamaica, and Guyana issue their own drought outlooks for the dissemination of warning. The CIMH does not issue warnings since this is the responsibility of the national meteorological services. Despite advancements in establishing rainfall monitoring networks within PSs, there are still major issues to be addressed including but not limited to i) monitoring being conducted at a community level scale rather than the national level, ii) issues with the definition of roles and responsibilities for monitoring, and iii) existing paucities in data collection and risk assessments. Alternatively, CDEMA and CMO PSs use the recommended Standardized Precipitation Index (SPI) to detect and determine drought and issue warnings.

One of the notable observations is that a large percentage of the countries which issue official early warnings for drought conditions, have significant involvement in agriculture as the source of livelihood for a relatively large percentage of the population and a significant contributor to the Gross Domestic Product (GDP). In-country monitoring allows countries such as Trinidad & Tobago, Jamaica, and Guyana to collaborate with water resource management agencies and the agricultural sectors to implement proactive measures for managing drought. In other instances where countries are severely affected by drought, there seems to be a reactionary and response-driven approach to managing drought conditions rather than a trigger to implement necessary preparations.

11 https://www.caribbeanclimate.bz/blog/2022/02/24/government-of-belize-receives-automatic-weather-stations/

2.1.2.3 Landslides

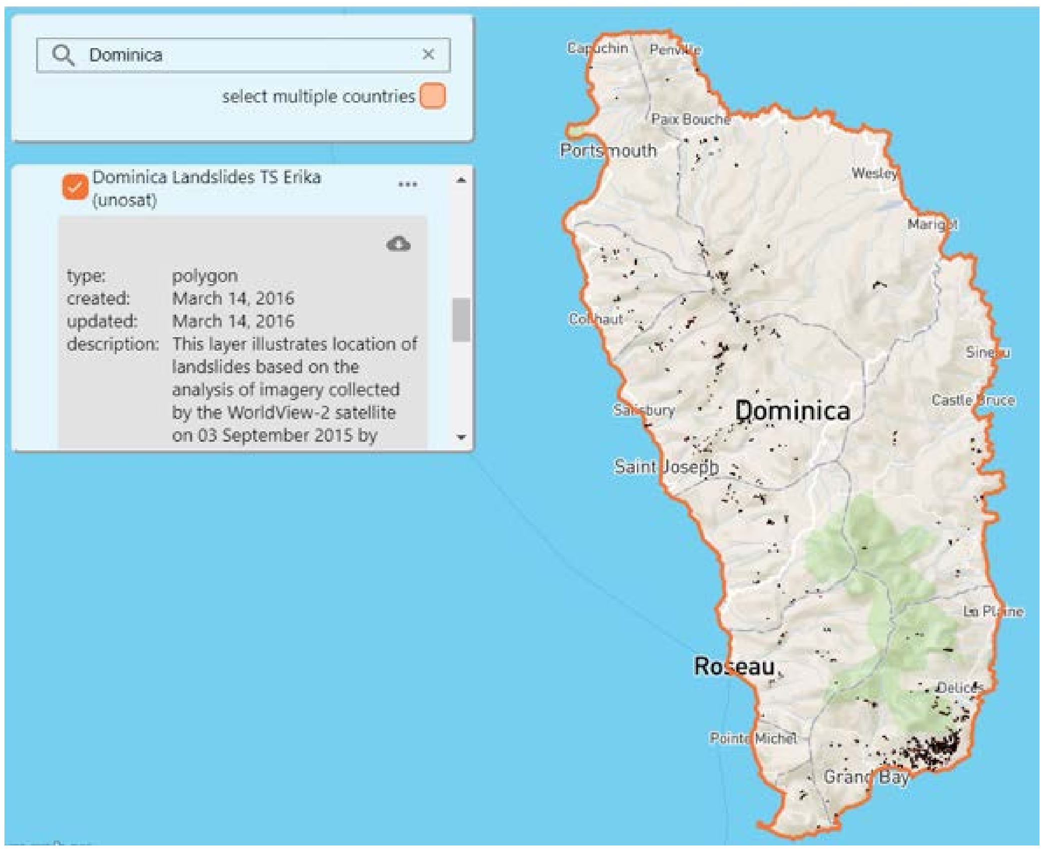


Figure 2 Historical data collected on the landslides which occurred during the passage of TS Erika in 2015. (Source: CDEMA GeoCRIS)

Like landslides due to geological triggers, the CRIS serves as a repository for landslide risk assessments due to hydrometeorological triggers. The figure shows that risk assessments are typically based on the collection of historical geo-spatial data, indicating areas of susceptibility which may be at risk during similar or greater magnitude events in the future. The maps are accompanied by metadata on the date of creation, date updated, the type of data and a general description of the sources used to develop the map.

2.1.3 Environmental Hazards

2.1.3.1 Deforestation, Land & Soil Degradation & Biodiversity Loss

At the regional level, the CCCCC is the organisation which supports the development of robust data and information systems for effective EWS, supports the coral reef EWS and leads the knowledge base for decision-making on climate change adaptation and the threat of environmental hazards. Support is provided by the CIMH through tools like the Caribbean Climate Outlook Forum (CariCOF) which provides support for information systems which facilitate EWS. The monthly and seasonal regional products provided by the CIMH directly link to taking actions to adapt to the potential climate extremes that are driven by climate change. Over the past four (4) years, the efforts of the CCCCC have been concentrated on managing risks within the marine environment. The Coral Reef Early Warning System (CREWS) network has been developed and expanded across the region. The overall objective of the network is to build capacity for relevant actors to monitor coral reef health, track changes in sea temperature, and collect other necessary data. In 2018, the CCCCC reported the procurement and installation of new buoys to expand the network in five (5) countries which included Antigua & Barbuda, Grenada, Saint Lucia, Saint Kitts & Nevis, and Saint Vincent and the Grenadines. The purchases were made through funding by the United States Agency for International Development's (USAID) Climate Change Adaptation Programme (CCAP). These installations were added to the previous four (4) stations installed in Barbados, Belize, the Dominican Republic, and Trinidad & Tobago. An agreement was established for the National Oceanic and Atmospheric Administration's (NOAA) Atlantic Oceanographic and Meteorological Laboratory (AOML), to provide information management services which include i) the programming of the data gathering buoys and transmission of the data back to AOML, ii) ecological forecasts for coral bleaching and other marine environmental events, and iii) the establishment of a web presence which displays real time data (CCCCC 2018).

2.1.3.2 Sargassum Seaweed and Saharan Dust Plumes

By the definition of pollution as the introduction of foreign contaminants which cause adverse change, Caribbean countries have been impacted by the secondary effects of natural phenomena such as global warming and climate change. Examples of secondary effects include the explosive blooms of Sargassum seaweed and Saharan dust plumes which degrade air quality. Regional organisations have developed early warning systems, which are currently being expanded to manage environmental phenomena such as the unprecedented proliferation of pelagic Sargassum seaweed and recurrent Saharan Dust Plumes. into EWSs for environmental pollution to better cope with the prevailing risks. The Centre for Resource Management & Environmental

Studies (CERMES)[12] at the University of the West Indies, Cave Hill Campus disseminates sub-regional bulletins which include impact-based forecasts that identify possible effects of Sargassum inundation.

Additionally, the CIMH has integrated monitoring for Saharan Dust Plumes which create hazy conditions for the Eastern Caribbean region, thereby adversely impacting air quality.

2.1.4 Biological Hazards

2.1.4.1 Human Epidemics & Pandemics

The Caribbean Public Health Agency (CARPHA) is the lead regional agency for human health, aiding CDEMA in responding to health needs when disasters occur. CARPHA leads preparedness and response efforts for public health across multiple hazards, including but not limited to landslides, drought, heatwaves, wildfires, and environmental pollution which specifically impacts air quality. The agency has the expertise to assist countries with the identification of potential health threats and responds to requests for assistance by CDEMA. In collaboration with partners, CARPHA serves as a repository for health data collected from its member states which range from population statistics to data on communicable & non-communicable diseases, mortality, and the causes of death in the region. The agency has also extended its scope for data collection into the tourism sector through the Regional Tourism and Health/Travelers Health Programme (THP). The programme is driven by the realisation that public health risks can be transported across borders by individuals, adversely impacts on the health & safety of tourists, nationals, and the sustainability of the tourism sector of Caribbean countries which it typically the main revenue earner. This reality was adequately reflected by the impact of the COVID-19 virus. As a result, the programme features a real time early warning & response Tourism & Health Information management System (THIS), which supports capacity building in Caribbean countries for preparedness and response to public health threats. Furthermore, CARPHA has the capacity for detection, monitoring, analysis, and the dissemination of actionable warnings to PSs as the regional focal point for health in the region. This was exemplified during the initial impact of the COVID-19 virus on the countries of the Caribbean. CARPHA laboratories conducted testing, monitoring, and analysis for 18 PSs until countries were able to procure testing kits.

It is significant to note that CARPHA also serves as the lead health partner on the Consortium of Regional Sectoral Early Warning Information Systems Across Climate Timescales (EWISACTs) Coordination Partners. Under the agreement, CARPHA collaborates with consortium partners to develop climate early warning products and services which can be accessed by regional health practitioners to enhance preparation for climate-driven health risks, such as those posed by mosquito-borne diseases.

2.1.4.2 Animal Epidemics & Pandemics

With regards to animal health, CARDI comprises the REWSC as the agency which conducts research and monitoring for biological hazards, generating data and risk information for the agricultural community. Despite not being a member of the Consortium, CaribVET is another regional organisation which makes a significant contribution to early warning systems for animal health. In fact, the main aim of CaribVET is to work in close collaboration with national agents mandated by legislation to manage animal and zoonotic diseases, i) strengthening national capacities for monitoring, surveillance, and control of diseases and ii) assisting with the implementation of early warning, early detection, and quick response mechanisms[13]. The majority of CDEMA PSs has a department or unit within their respective Ministry of Agriculture, typically a veterinary service, which is tasked with detecting, controlling, and minimising both internal and external risks of disease for livestock, the by-products of livestock and other domesticated animals considered as pets. Therefore, CaribVET liaises with these departments to fulfil its mandate.

2.1.5 Chemical Hazards

2.1.5.1 Oil Pollution (Marine)

At the regional level, CDEMA is the regional agency responsible for monitoring the risks of a potential marine oil spill which would impact the countries of the Caribbean. The region has been fortunate to avoid such occurrences in recent years. However, in the instance that the risk surpasses the determined threshold, the regional response mechanism (RRM) is triggered to respond to reduce the impact of oil pollution on CDEMA PSs. In September 2020, a potential oil spill posed a significant risk to the PSs

12 Sargassum Outlook Bulletin Volume 2 | Issue 3_MAM_CERMES_15Mar2022 (uwi.edu)

13 https://www.caribvet.net/about-the-network/objectives

of the eastern Caribbean when the FSO Nabarima (Floating Storage and Offloading unit), operated by Venezuelan oil company Petróleos de Venezuela (PSVSA) began to experience challenges. Carrying 1.3 million barrels of crude oil, the ballast system valve of the vessel failed, causing the vessel to lean to its starboard side. CDEMA took several precautionary steps in the preparedness and the DRR aspect as several PSs were in the danger zone of this potential hazard. These steps included the creation of a regional oil spill contingency plan for the effective management of the threat and placing the CDEMA CU RRM and regional response teams on standby. The CDEMA CU also proposed a disaster risk management (DRM) approach to managing the threat. This involved the organisation, planning and applying measures to mitigate, prepare, respond, and recover from a disaster or emergency event.

The regional framework for early warnings on marine oil spills is enhanced by all CDEMA PSs having a national oil spill response plan which details an early warning mechanism to trigger a national response. The mechanism typically consists of two partner agencies: i) one responsible for the detection, monitoring, and surveillance of the potential oil pollution hazard and ii) the lead agency for coordinating response which also has the responsibility for disseminating actionable warnings to supporting agencies as well as the public. It is important to note that though some PSs have an operationalised plan, the year in which the plan was developed suggests that there is a need for review and update to enhance the validity of the plans and improve the capacity within the country through training and simulation. Additionally, the plans highlight a lack of capacity with data collection on potential sources of pollution, routes of marine and terrestrial transport sources, maximum storage capacities of vehicles transporting oil, and the likely impacts of spills on the environment. The paucity of data hinders the development of comprehensive disaster risk assessments which can further inform responses. Some plans do attempt to provide historical data on oil spills which impacted the respective country and do hint at future initiatives to systematically collect data for the development of risk scenarios and assessments. Notwithstanding, all CDEMA PSs require strategic intervention to implement an adequate system for the data collection on both marine and terrestrial oil pollution risks.

2.1.5.2 Persistent Organic Pollutants (POPs)

There is no organisation which comprises the REWSC that specifically deals with the risks of Persistent Organic Pollutants (POPs). However, the Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean) is the lead regional organisation which is building capacity on a project basis in Caribbean countries to meet their obligations to the Basel, Rotterdam, Stockholm and Minamata Conventions and other multilateral environmental treaties. The BCRC-Caribbean reports that two (2) projects to address the management of POPs have been launched to benefit nine (9)[14] CDEMA PSs. With regards to the contribution to an EWS for POPs, the first project is geared towards building risk knowledge through developing an inventory of potentially contaminated sites and conducting risk assessments for selected sites. The second project focuses on Guyana only and seeks to develop a national implementation plan which involves building the country capacity for the monitoring and evaluation of POPs risks[15].

2.1.6 Technological & Societal Hazards

EWSs generally do not exist for technological hazards in the region due to a lack of relevant data collection and the nature of the hazards. With regards to data collection, one of the primary reasons for the paucity of data is the seldom occurrence of such events in countries. Notwithstanding, national plans recognise the risks of technological hazards and the potential impact of these events. Still, greater emphasis is given to response involving emergency services (police, fire, and ambulance) in the instance that the impact of technological hazard is reported. Similarly, the risk of societal hazards is recognised by national DRR strategies, but EWS does not exist at the national levels for these hazards. At the regional level, the CARICOM Implementation Agency for Crime & Security (IMPACS) was established with direct responsibility for research, monitoring and evaluation, and analysis of the crime and security agenda for the Caribbean region while other financial institutions in the Caribbean assume responsibility for monitoring and issuing communications on the risk of financial shock.

14 The beneficiary countries include Antigua and Barbuda, Barbados, Belize, Guyana, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad & Tobago.

15 https://www.bcrc-caribbean.org/our-projects/persistent-organic-pollutants/

2.2 National MHEWS Assessment for CDEMA PSs

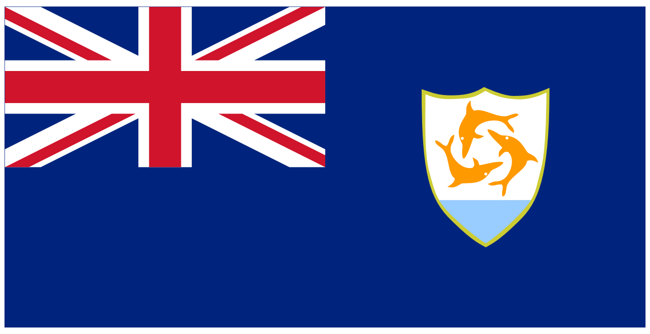
National frameworks for EWS provide the foundation for the strengthening and expansion of regional systems through collaborations and synergies. Furthermore, it is important that individuals possess EWS capacity which is adopted to the local context of the country, including but not limited to considerations of institutional structures, social vulnerabilities, and technological capabilities. The following sections assess the MHEWS capacity for all hazards across 19 CDEMA PSs, indicating which components of EWS are present in each state.

In addition to the four (4) components of EWS identified by the UNDRR, this report considers a fifth component which is the national level governance of EWS. The first CDEMA Early Warning Checklist was developed in 2006, to provide practical governance on the standards, actions, and initiatives to be considered when developing or evaluating EWSs (Gazol 2019). Following revisions and adjustments for finalisation, the Checklist serves as the primary governing tool for EWSs in CDEMA PSs which i) conceptualizes EWSs and the four (4) pillars of an efficient, people-centred EWS, ii) contains an individual checklist for each pillar with guiding questions and a series of standards, end points or key actions that would need to be assessed and/or put in place to build a robust EWS, iii) include gender considerations across the four (4) pillars of the checklist for further strengthening, as well as minimal amendments of language to improve the clarity of the Checklist and iv) contains a description of key actors that are involved in EWS, including their roles and responsibilities, as well as a list of key actors specific to each EWS pillar. The latter also serves as a guide to selecting the relevant actors to invite for the completion of each checklist and the assessment process.

In 2018, the Early Warning Checklist was applied to four (4)[16] CDEMA PSs under the leadership of the national disaster offices, supported by regional partners. A further three (3)[17] PSs benefitted from the application of the checklist in 2021, bringing the total number of PSs with a MHEWS governance mechanism to seven (7). Following the validation of the checklist assessment, a report of the gaps in the national EWSs was developed and a subsequent roadmap was developed to govern priority actions. The roadmaps outlined actions to address identified gaps and identified the lead and supporting agencies for each action during the same year. However, there is still a need for a long-term governance mechanism which is supported by national policy, the explicit definition of MHEWS roles and responsibilities through legislation, strengthened institutional arrangements to enhance EWS capacity and a sustainable source of relevant resources.

16 The Early Warning Checklist was implemented in Antigua & Barbuda, Dominica, Saint Lucia, and St. Vincent & the Grenadines in 2018.

17 In 2021, the checklist was applied in Barbados, Guyana, and Trinidad & Tobago.



2.2.1

Anguilla

Anguilla is susceptible to both natural and anthropogenic hazards which can potentially cause the loss of life, destruction of property & the environment, and disruption to the economy. The impact of earthquakes is not frequent but as one of the more northerly islands of the eastern Caribbean, Anguilla is located close to the boundary between the Caribbean and North American plates. This poses a risk to the potential of the island experiencing earthquakes between 7.5 to 8.5 magnitudes. The UWI SRC online database[18] shows that three (3) earthquakes were recorded north of Anguilla during June 2022, one of which was a magnitude of 5.2 at a depth of 43 km. Though there is no evidence of tsunamis impacting the country, the potential risk of earthquakes corresponds to the potential risk of tsunamis being generated. An established mechanism for communicating actionable warnings to the public on tsunamis exists, where if an earthquake triggers a tsunami, the Pacific Tsunami Warning Center (PTWC) will issue a bulletin to the Royal Anguilla Police Force which will then forward the information to the Department of Disaster Management for public dissemination. Volcanic and landslide hazards are virtually non-existent due to the absence of volcanoes on the islands, the large distance from islands with active volcanoes and the homogenously flat terrain of the islands.

Perhaps the most significant hazard to Anguilla is tropical cyclone activity in the form of tropical storms and hurricanes. The most significant of these in recent times was Hurricane Irma which made landfall during September 2017, as a Category 5 system. Irma was responsible for the destruction or damage of several public sector buildings, particularly education and health facilities. The Anguillan (2021) reports that the damages due to the hurricane were estimated at over US $320 million. This was the equivalent of 97% of the annual revenue earnings for the country. As a result, Anguilla experienced one of the biggest setbacks in recent history, forcing the economy and tourism sector into recession. Furthermore, localised flooding events are much smaller in geographical extent and intensity but occur more frequently. On the other extreme of the spectrum, drought has historically impacted the island as Anguillan residents were requested to relocate to neighbouring Caribbean countries because of drought and famine during the 1840s. The CDM Policy of Anguilla (2013) notes that drought is of increasing concern, creating water shortages, and exerting extreme stresses on the agricultural sector. Anguilla is dependent on the meteorological services of Antigua & Barbuda for the detection, monitoring and forecasts of potential hazards which may impact the island. Under the CMO Resolution 1[19], Antigua & Barbuda takes responsibility for issuing warnings regarding adverse weather conditions to Anguilla through its meteorological department.

The Department of Environment, Anguilla is the public agency mandated by legislation to manage the risks of environmental hazards. EWS capacity lies with the agency to detect, monitor, analyse and forecast the impacts of deforestation, land & soil degradation, and biodiversity loss. Additionally, the national CDM policy explicitly recognises coastal erosion as a significant risk to beach resources. In 2014, the department coordinated a national level project to assess the status, trends, and changes of ecosystems across the island. The project was part of the Anguilla National Ecosystem Assessment, designed to demonstrate the changes in ecosystems and their services, develop forecast scenarios that represent timelines, and uncertainties and to establish an integrated framework for the creation of a National Development Plan.

EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. There is no national EWS mechanism for the management of animal pandemics & epidemics, but the Office of Plant

18 https://acortar.link/U3IB8U

19 Resolution 1 of the Caribbean Meteorological Council details arrangements for CMO member states with weather forecasts & warning offices to adopt responsibility for issuing forecasts & warnings to other states without capacity (http://cmo.org.tt/docs/Resolutions/CMC51/Resolution1_CMC51_2011.pdf).

Quarantine regulates the entry of pest through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials.

With regards to chemical hazards, Anguilla has a National Oil Spill Contingency Plan revised for operationalisation in 1996. The EWS mechanism identifies the Anguilla Police Force and the National Disaster Preparedness Office (now known as the Department of Disaster Management) as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. Technological hazards recognised by the national CDM policy include boating accidents and minor oil spills, while societal hazards lack due consideration in the national landscape. There is no EWS capacity for both technological and societal hazards.

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented
(light blue)	C2-Hazard detection, Monitoring & Forecasting
(dark blue)	C3- Warning dissemination & Communication
(green)	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication

Figure 3 Status of MHEWS in Anguilla.

2.2.2
Antigua & Barbuda

Minor earthquakes are relatively frequent in Antigua & Barbuda and earthquakes have been common throughout the country's hazard history. In 1974, a large earthquake resulted in building damages and land slippage[20]. The country rests in a geologically active region, on the subduction zone in the Caribbean that results in volcanic and earthquake hazards. While there are no volcanoes on the islands, NODS confirms that the country can be affected by eruptions of nearby volcanoes in Montserrat and Saint Vincent and the Grenadines[21]. As part of the Global Seismographic Network (GSN), there is one operational seismological station situated to the north of Barbuda. The sensor is a Kinemetrics FBA ES-T EpiSensor Accelerometer which serves as a multi-use scientific facility and societal resource for earthquake monitoring, research, and education. However, Antigua & Barbuda has no EWS capacity for volcanic and landslide hazards. Capacity is present for tsunami hazards as the National Office of Disaster Services (NODS) has the responsibility for disseminating & communicating actionable warnings to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin to the Antigua & Barbuda Meteorological Service, which will then forward the information to NODS for public dissemination. Though national level preparedness for tsunamis has not been achieved, NODS has carried out tsunami drills with pre-schools, schools, and government offices in identified tsunami impact zones. The drills test the ability of a given community to receive alerts, and community knowledge of evacuation routes and established safe meeting zones, as well as identify the weaknesses of the community with regards to following the procedures of the drills so that the necessary adjustments to evacuation plans can be made. A whole community-level tsunami drill was completed in the Bethesda Christian Hill community, located on the southeast of the island of Antigua (NODS 2019). This community was selected as a small, simple location with homogeneous demographics among residents, to serve as a pilot which could be upscaled for drills in larger, more complex communities. Having fulfilled the requirements of the Pilot Community Performance Based Tsunami Recognition Programme implemented by the UNESCO/IOC, the capital St. John's received recognition as tsunami-ready in 2020. Outputs included the creation of inundation and evacuation maps, as well as the provision of communication equipment, and signage for evacuation routes, assembly points and tsunami hazard zones.

The most common hazards occurrences are tropical cyclones, floods, and droughts. Hydrometeorological hazards dominate the national hazard landscape. One of the most recent and prevalent disasters to have affected the country was the compounding effect of Hurricanes Irma and Maria in 2017. Flood risk is very prevalent, typically synonymous with tropical storms and hurricanes. Beyond cyclonic influences, flooding also occurs when the country experiences riverine, coastal, and flash flooding. Due to the natural topography, run-off in Antigua is quick following downpours, which often results in flash flooding. The Antigua & Barbuda Meteorological Service can detect, monitor, and forecast hydrometeorological hazards. Under the CMO Resolution 1, Antigua & Barbuda provides meteorological services for Anguilla, the British Virgin Islands, Montserrat, and St. Kitts & Nevis. However, the capacity is compromised by minimal system-wide tests of monitoring and detection systems and the limited number of trained technicians to conduct system tests (Evanson 2021). This is a cause for concern given that systems can fail or encounter issues. For instance, in 2020 the Antigua & Barbuda Meteorological Service reported technical issues which prevented the office from detecting a significant rainfall event and issuing a flood warning to the public. The meteorological service also has the responsibility for disseminating warnings to the public. The reach of warnings is enhanced by information being sent through the Common Alerting Protocol, familiarly known as the CAP system which can interface with smart technological devices.

Drought is a well-recognised hazard in the national

20 https://www.uwi.edu/ekacdm/node/38.

21 National Office for Disaster Services. http://nods.gov.ag/hazzards/volcanoes/.

risk planning landscape. The 2015 Nationally Determined Contribution reiterates that the country is vulnerable to water shortages because of droughts which tend to occur every 5-10 years. With climate change expected to reduce annual rainfall by 30%-50% by 2090 to an already water-scare country, coupled with increased temperatures, and with sea level rise expected to increase saltwater intrusion and contamination of freshwater supplies, the risk of drought for the twin island is of grave concern (Government of Antigua & Barbuda 2015). There is therefore a need for considering planning for the hazard, especially in the context of climate change. The Antigua & Barbuda Meteorological Service has responsibility for monitoring & forecasting, as well as communicating & disseminating actionable warnings for drought conditions.

Biological hazards have gained global attention recently due to the COVID-19 pandemic. The impact of the virus revealed that there is much needed improvement to build country capacity to manage pandemics. Moreover, there is a need for widening the scope of biological hazards that are considered in the national risk landscape. While well-recognised in the health profile of the country, infectious diseases are not often considered hazards, except for communicable disease outbreaks of influenza, foodborne, water-borne, and vector-borne illnesses. The National Strategic Plan for Health (2016-2020)[22] further recognises health concerns such as varicella, conjunctivitis, sexually transmitted infections, HIV and AIDS. Vector-borne diseases such as Chikungunya and Zika are very prevalent risks with noted efforts to minimise their prevalence. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Veterinary & Livestock Division of the Ministry of Agriculture, Lands, Housing & the Environment performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. To achieve this, the division regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Plant Protection Unit regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. However, there is no EWS capacity to manage the threat of invasive species. The Antigua & Barbuda National Strategic Biodiversity Action Plan[23] identifies alien invasive species which have impacted the country over the last two (2) decades and recognises the potential impacts of alien invasive species on biodiversity, but there is no strategic EWS in place.

Environmental hazards occur because of the degradation of natural systems. Development processes often compete with the natural environment and can result in unsustainable practices that create environmental hazards. For Antigua & Barbuda, these include air pollution, biodiversity loss, sea level rise, loss of mangroves, coastal and soil erosion, coral bleaching, eutrophication, wildfires, and soil degradation. Climate change has proven to be an underlying driver of risk, with cascading impacts across varying areas, which can result in system failure if not appropriately planned for, mitigated against, and adapted to. The 2020 Biennial Update Report confirms that Antigua & Barbuda has already started experiencing the impacts of climate change namely through intensified storms, extended droughts, and saltwater intrusion[24]. There is therefore an urgent need for consolidated efforts to combat climate change. The Department of Environment, Forestry Division and Development Control Authority are the public agencies mandated by legislation to manage the risks of environmental hazards. EWS capacity lies with the agencies to detect, monitor, analyse and forecast the impacts of deforestation, land & soil degradation, biodiversity loss, and environmental pollution. The Antigua & Barbuda National Strategic Biodiversity Action Plan provides baseline data on forestry, the status of watersheds, and an inventory of flora & fauna species on which changes can be detected through follow-up analyses by the agencies. Environmental pollution is monitored and detected by the Department of Environment as mandated by the Environmental Protection and Management Act. There is no EWS capacity for the management of wildfires.

22 Ministry of Health, Wellness & Environment. 2016. " National Strategic Plan for Health 2016-2020". https://pancap.org/pc/pcc/media/pancap_document/National-Strategic-Plan-for-Health-Antigua-and-Barbuda-29-March-2016-1.pdf.

23 Government of Antigua & Barbuda. 2014. "Antigua & Barbuda National Strategic Biodiversity Action Plan." https://sustainabledevelopment.un.org/content/documents/1436antigua.pdf.

24 Government of Antigua & Barbuda. 2020. "Antigua & Barbuda's First Biennial Update Report." https://unfccc.int/sites/default/files/resource/Antigua%20and%20Barbuda%20-%20UNFCCC%20Biennial%20Up.

The Pesticides and Toxic Chemicals Act, 2008 identifies a range of chemicals that are considered hazardous, some of which are controlled, and others prohibited. POPs constitute a significant chemical hazard, and the Government of Antigua & Barbuda has taken deliberate efforts to manage these through its National Implementation Plan for the Management of POPs (2007). There is, however, the absence of a consolidated chemical hazard risk database to acknowledge the varying chemical hazards that pose a risk to the country. Notwithstanding, Antigua & Barbuda is one of the beneficiary countries of a project coordinated by the BCRC Caribbean to build risk knowledge for POPs through developing an inventory of potentially contaminated sites and conducting risk assessments for selected sites, while the Department of Environment manages the detection of POPs in terrestrial or marine ecosystems. Oil spills occur occasionally within the marine environment because of bunkering activities (Omarde 2017). With regards to marine oil pollution, Antigua & Barbuda has a National Oil Spill Contingency Plan for which a final draft was completed in 2016. The plan details an EWS mechanism for oil spills, identifying the Antigua & Barbuda Defence Force, Coast Guard and NODS as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. Oil spills on land are less frequent but occur in small amounts[25].

Technological hazards are recognised as waste hazards and fires which occur due to industrial activities and non-compliance and building collapse (Omarde 2017). While road traffic accidents are common and result in fatalities annually, air and marine accidents are less frequent. Fires are relatively common, predominantly taking the form of house fires. There is little evidence to support the consideration of other technological hazards within the national risk landscape. Emerging risks such as cyber hazards are much less considered in national hazard risk documents. Notwithstanding, there is no EWS capacity for technological hazards.

Societal hazards lack due consideration in the national landscape and there is no EWS capacity. Economic shock is largely the main societal hazard that has been given due consideration. Between 2008 and 2009, the country experienced one of its worst recessions, due to challenges in the global financial market, reinforcing the potential for economic shocks (Ministry of Finance & Corporate Governance 2015). Violence while acknowledged, is only considered in the context of its risk to the development within the Medium-Term Development Strategy (2016-2020)[26].

25 O'Marde, Dorbrene. 2017. Country Document for Disaster Risk Reduction: Antigua and Barbuda, 2016. National Office of Disaster Services. St. Johns, Antigua.

26 Ministry of Finance and Corporate Governance. 2015. " Medium-Term Development Strategy (2016-2020)".

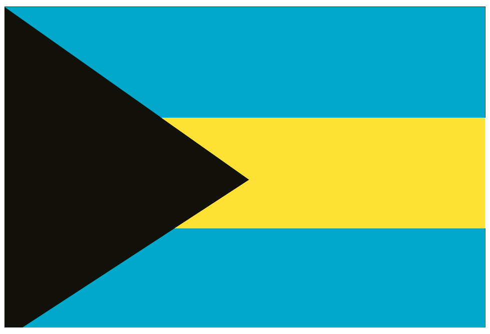
GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
Blue	C2-Hazard detection, Monitoring & Forecasting	Light green	C1- Disaster Risk Knowledge C2- Hazard detection, monitoring & forecasting
Green	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication	Red	C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings

Figure 4 Status of MHEWS in Antigua & Barbuda.

2.2.3
The Bahamas



While the islands of The Bahamas themselves are not on a tectonic plate margin, they are very close to the margins of the Cocos, Caribbean, North and South Atlantic Plates. As a result, The Bahamas occasionally registers ground accelerations due to earthquakes. However, these have not been destructive as indicated through historical records[27]. In keeping with the limited threat, the Bahamas has no EWS capacity for earthquake, volcanic and landslide hazards. Sole capacity lies with tsunami hazards, where the National Emergency Management Agency (NEMA), the Bahamas has the responsibility for disseminating & communicating actionable warnings to the public as the official source. Due to the location of the country within a seismologically active region, the tsunami hazard is present, though the probability is relatively low, based on historical data. Despite the low risk, the Bahamas has a national EWS mechanism for communicating and disseminating actionable warnings ahead of tsunami impacts. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the Pacific Tsunami Warning Center (PTWC) will issue a bulletin to the Bahamas Department of Meteorology, which will then forward the information to NEMA for public dissemination. The research indicates that there is not much documentation regarding the extent to which community-level preparation through simulations and drills is conducted. However, the Bahamas participates in the annual exercise "Caribe Wave", which is designed to validate preparedness response to tsunamis through the testing of protocols and communication systems between tsunami warning centres and the tsunami warning focal points. The completion of the exercise typically features NEMA, the Bahamas Department of Meteorology, Bahamas Information Services, the Royal Bahamas Police Force, the Royal Bahamas Defence Force, the Broadcasting Corporation of the Bahamas, media houses and telecommunications companies to monitor developments and disseminate information to the public.

Hydrometeorological hazards are the main hazards which have affected the country. These include tropical cyclones, lightning strikes, droughts, and tornados[28]. During the annual hurricane season, the Bahamas is affected by as many as two hurricanes, with one hurricane carrying significant disruptive potential. This was evident in September 2019, when Hurricane Dorian made landfall, leaving a path of destruction on the islands of Abaco and Grand Bahama. The hurricane not only affected over 29,000 persons but claimed 74 lives during its impact (Deopersad et al. 2020). In recognition of the frequency of impact, the Bahamas Department of Meteorology manages a radar network system which provides capability in detecting, monitoring, and forecasting hydrometeorological hazards. The department provides similar services for the Turks & Caicos Islands. The meteorological department also has the responsibility for disseminating warnings to the public of the Bahamas and forwarding relevant information to authorities in the Turks & Caicos Islands. Beyond the radar mosaic, which is accessible via the website of the department, satellite imagery is accessed through the data provided by the National Hurricane Centre. Monitoring & forecasting services for drought conditions are provided by the Bahamas Department of Meteorology, which also issues warning to the public. Outlook regarding drought provide both quantitative and qualitative forecasts on drought and mean temperatures which can facilitate informed decision-making across sectors for drought management. However, there is no EWS capacity within the country for susceptibility to landslides induced by hydrometeorological events.

Environmental hazards in the Bahamas include air pollution, biodiversity loss, sea level rise, loss of mangroves, coastal and soil erosion, coral bleaching, eutrophication, and soil degradation. Wildfire hazard is classified as very low in the Bahamas, with only a minor chance of fires causing disruption in any given year. However, as for other environmental hazards, modelled projections of future climate identify a likely increase in the frequency of wildfire

27 Bahamas Country Risk Profile, Think Hazard Web-based Tool. https://thinkhazard.org/en/report/20-the-bahamas.

28 Inter-American Development Bank. 2011. Indicators of Disaster Risk and Risk Management, Program for Latin America and The Caribbean, The Bahamas; Inter-American Development Bank - Environment, Rural Development and Disaster Risk Management Division, Technical Note No. IDB-TN-169.

hazard risk in the Bahamas, including an increase in temperature and greater variance in rainfall. In areas already affected by wildfires, the fire season is likely to increase in duration, and include a greater number of days with weather that could support wildfire spread due to longer periods without rainfall. The Department of Forestry and the Department of Environmental Health Services are the public agencies mandated by legislation to manage the risks of environmental hazards. EWS capacity lies with the agencies to detect, monitor, analyse and forecast the impacts of deforestation, biodiversity loss, and environmental pollution. Environmental pollution is specifically monitored and detected by the Department of Environmental Health Services. There is no EWS capacity for the management of wildfires.

The ongoing COVID-19 pandemic has reminded both regional and international countries of the threat of biological hazards. The Inform COVID-19 Risk Index (2022)[29] low risk rating of the island indicates that exposure to the virus has declined. However, the 3.2 coping capacity rating suggests that there is much needed improvement to build the country capacity to manage pandemics in general. Beyond the virus, the Bahamas has been susceptible to a range of biological hazards, namely vector-borne diseases throughout history. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Veterinary Service Division of the Bahamas Agricultural Health & Food Safety Authority performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. The division regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Plant Protection Unit regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. The Bahamas National Invasive Species Strategy (2013) acknowledges that there is a system of detection for invasive species across the island which is based on risk knowledge on species inventory & geo-spatial locations, monitoring, and surveillance. All three (3) elements were exemplified and employed during the early detection of the Pink Hibiscus mealy bug (*Maconellicoccus hirsutus*). The Strategy also identifies that the monitoring of species must occur on a regular basis. This is facilitated through collaboration between governmental & non-governmental agencies within the country. More specifically, monitoring is lead by actors who operate regularly in the field such as researchers and birdwatchers, to maximise human and financial resources.

The risk of oil spills from existing energy plants is another significant hazard to the coastal and marine environment. The Bahamas Freeport is a deep-water port that services very large ships and is the fourth largest oil terminal for trans-shipment in the world. Hurricane Dorian ripped the roof off several tanks at the South Riding terminal which held 1.88 million barrels of oil, leading to an oil spill estimated at 119,000 barrels (Reuters 2019). The spill contaminated both the surface layer of soil (estimated at 5 centimetres) and vegetation across a significant area. The country has a National Oil Spill Contingency Plan which was approved at the level of cabinet in 2002 and revised in 2011. The plan details an EWS mechanism for marine oil spills, identifying the Port Department, the Ministry of Transport & Aviation and NEMA as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. The Bahamas Vision 2040 calls for the development of an enabling environment to facilitate industrial development in pre-identified industrial areas thereby indicating that chemical and technological hazards will remain part of the hazard landscape as part of the planned developments[30]. There is no EWS capacity for managing risks associated with POPs

Technological hazards such as cyber-crime, are increasing, and according to the Royal Bahamas Police Force, there has been a 36% increase in hacking and extortion in the Bahamas between January 1 to June 30, 2020, compared to the same period in 2019[31]. The Government of the Bahamas recognises this emerging hazard and is promptly responding to it, partly through the creation of a Data Protection Commission and a cyber-crime unit within the Royal Bahamas Police Force[32]. Other technical

29 https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk/Country-Risk-Profile.

30 The Bahamas Vision 2040 National Development Plan (NDP) of The Bahamas, 2nd working draft NDP Secretariat, 2017, Home - Vision 2040 - National Development Plan of the Bahamas (vision2040bahamas.org).

31 Caribbean Financial Action Task Force (CFATF). 2020. "Increase in Cyber-crime Reports in The Bahamas". Accessed August 2, 2020. https://www.cfatf-gafic.org/es/home/what-s-happening/664-increase-in-cyber-crime-reports-in-the-bahamas.

32 NDP Secretariat. 2016. "State of The Nation Report, The Bahamas Vision 2040 National Development Plan of The Bahamas"

hazards include waste, and infrastructure failures such as transportation accidents. The Bahamas, as an archipelago, relies on sea transportation for its administration and its economy. However, the mail boat system that serves the surrounding islands also needs to be upgraded as passenger safety is a concern, particularly after the mail boat accident in August 2003. The combination of high income per capita, inequality, unemployment, and poverty, threaten social cohesion and create societal hazards manifesting themselves in the form of violent crime and high murder rates[33]. The COVID-19 crisis with its impact on the tourism and real-estate sector challenged the financial stability of countries worldwide. These if not addressed promptly, may further threaten social cohesion, decrease state-society trust and can increase the risk of civil unrest. With regards to EWS, there is no capacity for both technological and societal hazards.

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
(blue)	C2-Hazard detection, Monitoring & Forecasting	(light green)	C1- Disaster Risk Knowledge C2- Hazard detection, monitoring & forecasting
(green)	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication	(red)	C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings

Figure 5 Status of MHEWS in the Bahamas.

33 NDP Secretariat. 2016. "State of The Nation Report, The Bahamas Vision 2040 National Development Plan of The Bahamas".

2.2.4
Barbados

Barbados is situated as the most easterly island which rests close to the subduction zone of the Caribbean and Atlantic plates. As a result, minor earthquakes and tremors impact the island occasionally. As part of the GSN, there is one operational seismological station situated at the Gun Hill Signal Station, St, George. Installed in 2006 by the United States Geological Survey (USGS), the sensor is a Kinemetrics FBA ES-T EpiSensor Accelerometer which can monitor earthquake activity. The convergence of the tectonic plates also contributes to volcanic hazards, and while there are no volcanoes on the island, the country can be affected by eruptions of nearby volcanoes in Montserrat and Saint Vincent & the Grenadines. The eruption of the La Soufriere volcano in 2021 triggered a national level response to the significant deposition of ash emitted during eruption. Barbados has an established mechanism for communicating actionable warnings to the public on tsunamis. If an earthquake triggers a tsunami, the PTWC will issue a bulletin to the Meteorological Office which will then forward the warning to the Department of Emergency Management (DEM) for public dissemination. Though national level preparedness for the entire country has not been achieved, the DEM and the Coastal Zone Management Unit (CZMU) have collaborated to attain tsunami- ready certification for coastal communities through funding provided by the European Union (EU). In 2020, coastal communities from Shermans, St. Lucy to Mullins, St. Peter received certification[34]. The outputs of the certification included the creation of inundation and evacuation maps, as well as the provision of communication equipment, and signage for evacuation routes, assembly points and tsunami hazard zones. Coastal communities from Porters to Holders Hill, St. James, and St. Matthias to Rendezvous, Christ Church have been earmarked to receive the certification by 2023[35].

Since the passage of category two (2) Hurricane Janet in 1955, the most recent impact of a hurricane was in 2021 by Hurricane Elsa. The island has been fortunate to avoid frequent disaster level impacts by tropical cyclonic systems, but does suffer damage from passing tropical storms. Due to the flat terrain, poor drainage, and the inadequacy of urban drainage infrastructure, Barbados is susceptible to flooding. Low-pressure systems that bring torrential rainfall often cause flooding in areas along the west and south coasts. Storm surges can also account for flooding in low-lying areas and erosion, causing damage to coastal infrastructure critical to the tourism sector. Furthermore, the island is vulnerable to drought. During the 2010 drought, which impacted countries of the Eastern Caribbean, Barbados recorded significant stress on its water resources.The Barbados Meteorological Service (BMS) manages a radar system which can detect and monitor adverse weather conditions approaching the island within a 400 km radius. Due to the range of the radar, the BMS has capacity to provide meteorological services to the Grenadine islands, Dominica, and Grenada. Moreover, the BMS has developed several modelling products for analytical and forecasting purposes. Primarily through its website, the office serves as the authoritative & official source of actionable warnings on cyclonic systems, floods, storm surge and drought for the disaster office and the public. With regards to agricultural & hydrological drought, forecast and impact-based warnings which feature probable outcomes for an average period of four (4) months, are developed through a collaborative effort between the BMS, the Barbados Water Authority (BWA), the CIMH, and the Barbados Agricultural Management Company (BAMC). Landslides induced by hydrometeorological events can occur particularly in the Scotland District to the northeast of the island in the form of earthflows, slumps, and debris flows.

Environmental hazards in Barbados take the form of land degradation, pollution, sea level rise, biodiver-sity loss, coastal erosion, and coral bleaching. The Ministry of Environment & National Beautification is the public agency mandated by legislation to ma-nage risks associated with land & soil degradation

34 http://itic.ioc-unesco.org/index.php?option=com_content&view=category&id=2678&Itemid=3059.

35 Barbados Government Information Service. 2022. " Two More Tsunami-ready Communities Possibly by Yearend". https://gisbarbados.gov.bb/blog/two-more-tsunami-ready-communities-possibly-by-yearend/.

and biodiversity loss in terrestrial ecosystems. For marine ecosystems, the CZMU is tasked with managing the risks of biodiversity loss. Through continuous data collection and systems of monitoring, both agencies have EWS capacity to detect, analyses and forecast the impacts of the hazard which threaten biodiversity.Furthermore, the Environmental Protection Department (EPD) collaborates with the Sanitation Service Authority to manage environmental pollution. This includes detection, monitoring, and analytical services on pollution sources, ranging from solid waste to the contamination of potable water sources. If an actionable warning is required, official communications on environmental pollution will be disseminated by the Barbados Government Information Service (BGIS). With the onset of climate change, air quality has been adversely impacted by Saharan dust plumes, which affect the country predominantly during the drier months of the year. In the instance that air quality declines beyond the threshold, the Barbados Meteorological Services issues a haze & dust warning to the public. In addition, influxes of Sargassum seaweed are persisting along the coastal communities of Barbados more than a decade later following the first abnormal inundation event. The Sargassum Information Hub reports that the country has benefitted from the interventions of CERMES, at The UWI Cave Hill Campus, which spearheads research on sargassum. The proliferation of pelagic sargassum along the nation's coastlines is widely considered an environmental nuisance with implications for marine and public health and the economic productivity of the tourism sector. There is no EWS capacity for the management of wildfires.

EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Ministry of Agriculture & Food Security performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. To achieve this, the division regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Support is provided by the Barbados Veterinary Service for domesticated animals or pets, while the BGIS is used to enhance the reach of warnings to the public. The Plant Protection Department regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. Barbados has suffered damages within the crop production and fisheries sectors due to the introduction of the Giant African Snail and the Lionfish respectively. Yet, there is no structured EWS mechanism to manage the threat of invasive species. Rather, alien species are managed through response, more specifically through the launch of campaigns geared towards eradication. However, the most recent national biodiversity strategy & action plan for Barbados does recognise invasive species as a threat to sustainable development, as Target 6 prioritises the implementation of measures to prevent the introduction and establishment of new invasive alien species by 2030.

With regards to chemical hazards, Barbados has a National Oil Spill Contingency Plan which was approved at the level of cabinet in 2013. The plan details an EWS mechanism for oil spills, identifying the Barbados Coast Guard and the EPD as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. The state has also benefitted from a project coordinated by the BCRC Caribbean to build risk knowledge for POPs through developing an inventory of potentially contaminated sites and conducting risk assessments for selected sites. Technological hazards are recognised as waste hazards, oil spills and fires which occur due to industrial activities and non-compliance and building collapse. While road traffic accidents are common and result in fatalities annually, air and marine accidents are less frequent. However, there is no EWS capacity for technological hazards.

The significant dependence of the island on the tourism sector for revenue generation renders the economy vulnerable to external shocks. The COVID-19 pandemic caused a severe setback to the economic development of the country in 2020, grounding tourism arrivals and stalling economic activity. The United Nations Economic Commission for Latin America and the Caribbean (ECLAC, 2021) reported that the economic recession persisted through to June 2021, with economic activity contracting 9% in the first half of the year compared to the same period of the prior year. Reduced economic activity in 2020, particularly in the tourism sector, led to a rise in the unemployment rate to 13.1%, which was accompanied by an increase in inflation to 4.5%, with higher prices for fish, vegetables, and oil. Much downside risk remains, owing to persistent uncertainty over the pandemic, with a possible slower than expected recovery in tourist arrivals from traditional source markets and other external shocks. The country has also struggled to cope with the upsurge in violence and crime, recording a spike in several firearm incidents in 2022 which resulted in several deaths and injuries. Like technological hazards, there is no EWS capacity for societal hazards.

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
	C1- Disaster Risk Knowledge		C2-Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
	C2-Hazard detection, Monitoring & Forecasting		C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings
	C3- Warning dissemination & Comunication		

Figure 6 Status of MHEWS in Barbados.

2.2.5
Belize

Due to its proximity to the boundary of three tectonic plates, Belize faces minor seismic and tsunami risks, particularly in the south-eastern region, away from the main population centres. Earthquakes present the greatest threat of geological hazards, contributing to an annual average loss (AAL) of US $ 883,000 (or 0.05% of GDP) as calculated by the World Bank (2016). However, Belize has no EWS capacity for earthquake, volcanic and landslide hazards. Sole capacity lies with tsunami hazards, where the National Emergency Management Organisation (NEMO) has the responsibility for disseminating & communicating actionable warnings to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the Pacific Tsunami Warning Center (PTWC) will issue a bulletin to the National Meteorological Service of Belize, which will then forward the information to NEMO for public dissemination.

Hydrometeorological hazards present the primary risk from natural hazards to the island. Belize is prone to cyclonic events which usually result in flooding, wind damage and storm surges, with tremendous damage to the agriculture and tourism sectors specifically. In comparison to earthquakes, the World Bank (2016) determined that the risk of cyclones is greater, recording an AAL of US $ 7.7M (or 0.45% of GDP). Outside the scope of storms, flooding can be caused by heavy torrential rainfall, leading to the inundation of the floodplains of an extensive river network. Compounding the situation is the fact that most of the critical infrastructure such as public buildings, health, commercial and transportation facilities is located on or near the coast, which makes them extremely susceptible to cyclones and sea level rise. In 1961, Hurricane Hattie, a Category 5 system, made impact and was responsible for the death of hundreds as well as the destruction of the former capital Belize City. Retrospective action was taken through the establishment of a new administrative capital city, Belmopan, further inland.

The National Meteorological Service of Belize is the lead public agency which provides meteorological and climate-based products and services to the public, aviators, and marine operators, through systematic and accurate data monitoring and collection, data analyses and forecasts, and the dissemination of warnings on weather and climate-related events and hazards. The department maintains a network of weather observing stations, a Doppler Weather Radar and an upper air observing station. Risk assessments on flooding and storm surges for Belize are also available through the CRIS platform. Additionally, some areas of Belize experience drought conditions on a yearly basis. The projected increases in temperature make it highly likely that these areas will experience drought conditions. Drought hazard monitoring capacity is managed by the meteorological service which provides monitoring & forecasts, and functions as the authoritative voice on the dissemination of actionable warnings related to drought conditions.

Climate change contributes to the manifestation of the most obvious environmental hazards affecting Belize. Both sea level rise and increasing ocean temperatures are intensifying coastal erosion, coral bleaching, wildfires, and the decline of marine species. Anthropogenic activities including but not limited to high deforestation rates, improper solid-waste management, and rapid coastal development also pose significant risks to the sustainability of Belizean ecosystems. The Department of Environment, the Belize Forest Department, and other non-governmental organisations collaborate to facilitate EWS capacity in the form of detection, monitoring, and analysis of changes within terrestrial and marine ecosystems. Notably, Belize is one of the few CDEMA PSs with a strategic EWS mechanism for wildfires. Several projects have benefitted the Forest Department, particularly through the procurement of technological devices such as drones and computer hardware which can operate remote sensing software. Consequently, monitoring patrols traverse remote areas using aerial vehicles and the use of the MODIS & FIRMS remote sensing platforms facilitate real-time detection of heat signatures which may result in fires across forested environments.

In addition to the recent impact of the COVID-19 pandemic, vector-borne diseases dominate the biological hazard landscape of the country. Dengue fever, malaria and Chagas diseases all pose a threat to both residents and tourists. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases. The communication of actionable health warnings & possible consequences to the public are facilitated by the Government of Belize Press Office. The Belize Agricultural Health Authority performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock, domesticated animals, and plant material. To fulfil this mandate, the authority regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products as well as for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. However, there is no EWS capacity to manage the threat of invasive species.

In relation to chemical hazards, a National Oil Spill Contingency Plan was developed in 2016 for Belize but is still in the draft stage of development. Notwithstanding, the plan details an EWS mechanism for oil spills, identifying the Belize Port Authority and the Department of Environment as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. Belize has also benefitted from a project coordinated by the BCRC Caribbean to build risk knowledge for POPs through developing an inventory of potentially contaminated sites and conducting risk assessments for selected sites.

Technological hazards are recognised as waste hazards, oil spills and fires which occur due to industrial activities and non-compliance and building collapse, but there is no EWS capacity. While road traffic accidents are common and result in fatalities annually, air and marine accidents are less frequent.

There is no EWS capacity for societal hazards. Still, there are inextricable links between the impact of climate change and socio-economic setbacks which are projected to continue. Sea level rise is expected to contribute to the displacement of coastal communities while also adversely impacting critical natural resources such as freshwater through saline intrusion. Moreover, climate change will continue to threaten the local economy and livelihoods dependent on the tourism and fisheries sectors. This is in addition to the economic impacts of singular hazards like the COVID-19 pandemic which contributed to the contraction of the economy by 15.5% in 2020 (ECLAC 2020). Consequently, the literature suggests that there is a need for the country to better consider the socio-economic risks which stem from climate change and hazards by extension. The International Monetary Fund (IMF 2018) considers the financial risk management of Belize as virtually non-existent, recommending that the ad-hoc responses to post-disaster financing should be replaced by the strategic development of improved fiscal and international reserve buffers.

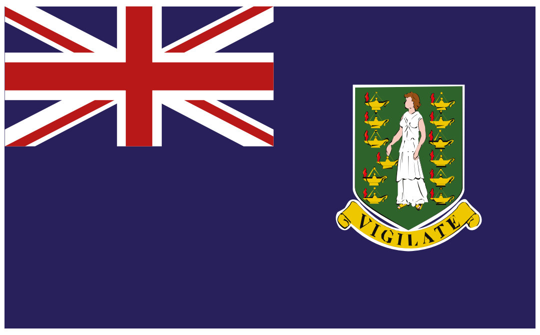
GEOLOGICAL HAZARDS	HIDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
(light blue)	C2-Hazard detection, Monitoring & Forecasting	(pale blue)	C1- Disaster Risk Knowledge
(dark blue)	C3- Warning dissemination & Communication	(yellow)	C1- Disaster Risk Knowledge C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
(green)	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication		

Figure 7 Status of MHEWS in Belize.

2.2.6
British Virgin Islands (BVI)



Hurricanes and earthquakes are the natural hazards that are the greatest threat to the BVI. Though the impact of earthquakes is uncommon, PAHO (2022) notes that the location of the BVI within a geologically active region, translates to the potential of experiencing earthquakes between 7.5 to 8.5 magnitudes. In comparison, the effects of hurricanes and tropical storms such as wind damage, inland flooding and coastal surge are of significant concern. The state suffered consecutive impacts by Hurricanes Irma and Maria in September 2017 as a Category 5 systems, which caused widespread destruction and the loss of lives.

Having fulfilled the requirements of the Pilot Community Performance Based Tsunami Recognition Programme implemented by the UNESCO/IOC, the BVI received recognition as tsunami-ready in 2017. The primary objective of the programme is to develop an end-to-end tsunami EWS, enabling vulnerable coastal communities to take effective action in the event of a potential tsunami and save lives. Outputs included the creation of inundation maps and evacuation maps for communities, as well as signage for evacuation routes, assembly points and tsunami hazard zones, murals, and an animated public awareness video. The Department of Disaster Management also undertook extensive public education, conducted drills, and formulated an emergency operations plan (EOP). In November 2022, the state renewed its recognition as Tsunami-ready[36]. In addition to tsunami preparedness, there is an established mechanism for communicating actionable warnings to the public on tsunamis. If an earthquake triggers a tsunami, the PTWC will issue a bulletin directly to the Department of Disaster Management for public dissemination.

There is no EWS capacity for hydrometeorological hazards. Rather, the BVI is dependent on the meteorological services of Antigua & Barbuda for the detection, monitoring and forecasts of potential hazards which may impact the island. Under the CMO Resolution 1, Antigua & Barbuda takes responsibility for issuing warnings regarding adverse weather conditions to the BVI through its meteorological department.

The sole capacity for environmental hazards lies with the Environmental Health Division which has responsibility for the surveillance and monitoring of all risks associated with environmental pollution. The Ministry of Health manages EWS for human pandemics & epidemics, being mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Department of Agriculture & Fisheries performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. The department regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. The department also manages the risk of pest infestation through the regulation of systematic certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. However, there is no EWS capacity to manage the threat of invasive species.

With regards to chemical hazards, PAHO (2022) posits that oil spills pose the greatest risk to the BVI. A National Oil Spill Contingency Plan was approved by the government in 2008. The plan details an EWS mechanism for oil spills, identifying the Conservation & Fisheries Department and the Department of Disaster Management as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively.

The islands are also prone to man-made hazards such as exposure to hazardous chemicals, explosions, and transportation accidents., while societal hazards lack due consideration in the national landscape. There is no EWS capacity for both technological and societal hazards.

36 http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=2025&Itemid=2809.

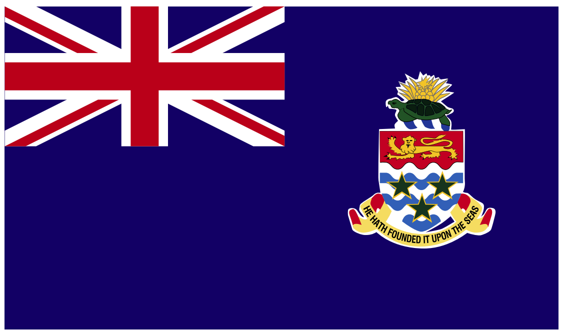
GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Rrespresented
Blue	C2-Hazard detection, Monitoring & Forecasting
Green	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
Red	C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings

Figure 8 Status of MHEWS in the British Virgin Islands.

2.2.7
Cayman Islands



There is no evidence in the historical record of a major destructive earthquake occurring very close to these islands. However, ground movement has been felt on the island, providing a reminder that the Cayman Islands are situated within a geologically active region. On January 28, 2020, a 7.7 magnitude earthquake occurred with the epicentre being 130 km ESE of Cayman Brac, while another 6.8 magnitude earthquake was recorded south of Georgetown, Grand Cayman in 2004[37]. Volcanic and landslide hazards are virtually non-existent due to the absence of volcanoes on the islands, the large distance from islands with active volcanoes and the homogenously flat terrain of the islands. Though there is no evidence of tsunamis impacting the country, the potential risk of earthquakes corresponds to the potential risk of tsunamis being generated. There is an established mechanism for communicating actionable warnings to the public on tsunamis. If an earthquake triggers a tsunami, the PTWC will issue a bulletin to the Department of Public Safety Communications, which will then forward the warning to Hazard Management Cayman Islands for public dissemination.

Novelo-Casanova and Suarez (2010) rank tropical cyclones as the primary risk to the socio-economic development of the Cayman Islands. Of the secondary impacts associated with cyclonic systems, wind damage poses the greatest threat along with storm surge. Due to the flat terrain of the islands, flooding is considered a minor concern. The National Weather Service (NWS) is mandated under the National Weather Service Law to provide meteorological and climate-based products and services to the public, aviators, and marine operators, through systematic and accurate data monitoring and collection, data analyses and forecasts, and the dissemination of warnings on weather and climate-related events and hazards. The NWS manages a radar system which can detect and monitor adverse weather conditions approaching the island within an estimated 460 km radius. This is complemented by several data sources, including but not limited to satellite data which provides infrared imagery and allows for the monitoring of water vapour and air masses. EWS capacity for the drought is managed by the NWS which develops outlooks with a qualitative forecast on drought which can facilitate informed decision-making across sectors for drought management. In the instance that drought conditions are determined an emergency, the NWS has responsibility for disseminating warnings.

Anthropogenic activities are mainly responsible for environmental risks present on the islands. Mining and quarrying operations contribute to land & soil degradation, biodiversity loss and water & air pollution. The Department of Environment is the public agency mandated by legislation to manage risks associated with land & soil degradation and biodiversity loss in both terrestrial & marine ecosystems. Through continuous data collection and systems of monitoring, the agency has capacity to detect, analyse and forecast the impacts and their possible consequences. With regards to environmental pollution, the Department of Environment collaborates with the Department of Environmental Health to provide detection, monitoring, and analytical services on pollution sources. There is no EWS capacity for the management of wildfires.

EWS capacity for human pandemics & epidemics is managed by the Ministry of Health & Wellness, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Department of Agriculture performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock, domesticated animals, and plant species. To achieve this, the department regulates the potential entry of disease through a system of certification and inspection of animals, animal by-products and agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. There is no EWS capacity to manage the threat of invasive species.

37 https://www.caymanprepared.gov.ky/hazards/earthquake.

Chemical hazards are present through a combination of fuel terminals, storage tanks and fuel distribution pipelines all contribute to potential risks of explosion, combustion, and toxicity through leakages, threatening public and environmental health. The Cayman Islands has a National Oil Spill Contingency Plan which was enabled through legislation in 2001. The plan details an EWS mechanism for oil spills, identifying the Emergency Communication 911 Centre and the Department of Environment as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively.

Technological hazards identified include cybercrime, infrastructure failure, and major transportation accidents. There is no major industrialization or industries which involve toxic chemicals on Grand Cayman. On the other hand, societal hazards lack due consideration in the national landscape. There is no EWS capacity for both technological and societal hazards.

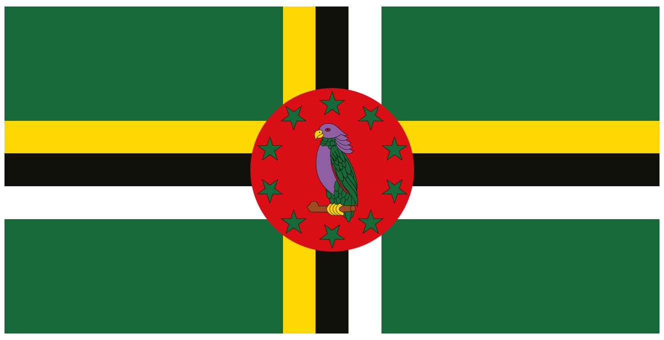
GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented
Light blue	C2-Hazard detection, Monitoring & Forecasting
Dark blue	C3- Warning dissemination & Communication
Green	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication

Figure 9 Status of MHEWS in the Cayman Islands.

2.2.8
Dominica



This volcanic island was formed from the activity of tectonic plates, which continue to produce seismic activity on the island. The island has nine (9) volcanoes, seven (7) of which are located in the south of the island, within ten (10) kilometres of the capital city of Roseau. While there has been no volcanic eruption in recent history, the county is at significant risk of an eruption by Morne Anglais within the next 100 years (ODM 2018). Earthquakes are a relatively common occurrence. Nine (9) seismographic stations are in operation by the UWI SRC across the island, collecting data on seismic activity. In 2004, a 6.3 magnitude earthquake to the north of the island coincided with prolonged rainfall and triggered numerous landslides throughout the island[38]. The risks associated with geological hazards have prompted the state to conduct risk assessments which can be integrated into planning and response strategies. The Physical Planning Division is the national agency responsible for the storage and management of earthquake, volcanic eruption, and landslide risk assessment data. The ODM serves as the official source of actionable warnings regarding the potential impact of volcanic eruptions. Likewise, with regards to tsunami hazards, ODM has the responsibility for disseminating & communicating actionable warnings to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin to ODM.

One of the most prevalent hazards Dominica faces is tropical cyclone activity in the form of tropical storms and hurricanes that have created a history of destruction for the country. The most significant of these in recent times was Hurricane Maria which made landfall on September 18, 2017, as a Category 5 system. The system left a path of destruction, accounting for 31 deaths and economic costs amounting to 226% of GDP at the time (Government of the Commonwealth of Dominica 2017). Dominica has had a long history of flooding and landslides. While floods are direct impacts of tropical cyclones, they are often triggered by rainfall patterns, on the water-rich island. The 2013 Christmas Floods (December 24, 2013) were triggered by a trough and resulted in flash flooding that brought direct damages to housing and other infrastructure (ODM 2013). Droughts are also an increasing risk for islands of the Caribbean due to the complex challenges brought on by climate change. A severe drought between 2009 and 2010 resulted in major agricultural losses for the island[39]. The Dominica Meteorological Office manages a network of weather and rainfall stations which monitor weather variables including but not limited to rainfall and temperature, as well as instruments to monitor sea level. The meteorological office, therefore, has capacity to monitor hydrometeorological hazards, but detection and analytic services for cyclones, flooding and storm surges are outsourced using the Barbados radar. The office serves as the authoritative & official source of actionable warnings on cyclonic systems, floods, storm surge and drought for the disaster office and the public. The reach of warnings is enhanced by information being sent through the Common Alerting Protocol, more familiarly known as the CAP system which can interface with smart technological devices. Evanson (2021) states that the capacity to monitor and forecast is compromised by minimal system-wide tests of monitoring and detection systems and the limited number of trained technicians to conduct system tests. Disaster risk assessment data on flood, storm surges and landslides due to rainfall events are stored by the Physical Planning Division, while rainfall and wind risk assessment data are managed by the meteorological office.

Despite the lush natural forests and rich biodiversity which characterises the island, environmental degradation is often triggered by anthropogenic activities. The 2010 Environmental Summary highlighted the environmental challenges facing the small island developing state which included i) land degradation due to logging practices, ii) deforestation for agricultural use and use of forest product for charcoal, firewood and other products,

38 Global Facility for Disaster Risk Reduction (GFDRR). Disaster Risk Management in Latin America and the Caribbean Region. GFDRR Country Notes.

39 Paul-Rolle, Amonia. 2014. Commonwealth of Dominica Disaster Risk Reduction Country Profile. Office for Disaster Management Dominica, ECHO, UNISDR.

iii) biodiversity loss due to deforestation and habitat reduction, overexploitation of wildlife, encroachment, the introduction of foreign species, uncontrolled use of biotechnology iv) pollution, v) destruction of coastal ecosystems including coral reefs as a result of strong ocean currents and pollutants entering the coastal waters and vi) the exploitation of the coastal flora and fauna and improper development (United Nations Environment Programme 2010). The island also faces threats of sea level rise, eutrophication and other direct environmental impacts brought on by climate change[40]. The Forestry, Wildlife & Parks Division, Environmental Coordinating Unit and Fisheries Division are the public agencies mandated by legislation to manage the risks of environmental hazards. EWS capacity lies with the agencies to detect, monitor, analyse and forecast the impacts of deforestation, land & soil degradation, biodiversity loss, and environmental pollution. Environmental pollution is monitored and detected by the Environmental Coordinating Unit, which also disseminates actionable warnings to the public. Wildfires are also common and are typically monitored and detected through in-situ patrols by forest officers. The management of wildfires is a collaborative effort between the Forest Department, and the Fire Service which offers response to resolve emergencies. Between 2012-2014, several bush fires required response by the Fire & Ambulance services[41].

Beyond the risks associated with the COVID-19 pandemic, Dominica has demonstrated high vulnerability and exposure to infectious and vector-borne diseases. An assessment of the response to the pandemic indicated that there is a need for improvement to build the country capacity in the health sector, to manage pandemics at large. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Livestock Development Unit, Ministry of Blue and Green Economy, Agriculture and National Food Security performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. The unit regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Plant Protection & Quarantine Unit regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. In the most recent national biodiversity strategy and action plan, invasive species are recognised as a significant threat to biodiversity. Monitoring and surveillance services for invasive species are provided by the Forestry, Wildlife & Parks Division. Still, the document states that in order to improve management of the adverse impacts of invasive species "the Ministry of Agriculture needs to strengthen its quarantine procedures" (Ministry of Environment, Natural Resources, Physical Planning and Fisheries 2013, 26).

Chemical hazards are as a direct result of anthropogenic activities and occur as POPs, heavy metals, and hydrocarbons. While there have been no major oil spills affecting the country to date, this remains a recognised hazard in country risk documents. Dominica has a National Oil Spill Contingency Plan which was approved by the government in 1996. The plan details an EWS for oil spills, identifying the Dominica Air & Sea Port Authority and the Office of Disaster Management as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. There is no EWS capacity for managing risks associated with POPs.

Technological and societal hazards are well recognised within the National Disaster Plan (National Emergency Planning Organisation 2001). House fires and road traffic accidents are common and have required the services of national response agencies. Other technological hazards, such as air transportation accidents, although less common, are considered in national risk documents. Societal hazards take the form of civil unrest. Social vulnerabilities are exacerbated by poverty, as women, the Kalinago and children make up the majority of those who are classified as poor. This statistic may have been misquoted in the ODM report[42]; 49.8 percent of the 3000 Kalinago people live in poverty, but this not account for 49.8 percent of the total number of people who live in poverty in Dominica. The Kalinago people comprise approximately 3-5% of the population.

40 Commonwealth of Dominica. 2012. Second National Communication under the UNFCCC. Environmental Coordinating Unit Ministry of Environment, Natural Resources, Physical Planning and Fisheries.

41 Paul-Rolle, Amonia. 2014. Commonwealth of Dominica Disaster Risk Reduction Country Profile. Office for Disaster Management Dominica, ECHO, UNISDR.

42 https://reliefweb.int/report/dominica/dominica-country-profile-june-2022

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
	C1- Disaster Risk Knowledge		C1- Disaster Risk Knowledge C3- Warning dissemination & Communication
	C2-Hazard detection, Monitoring & Forecasting		C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
	C3- Warning dissemination & Communication		C1- Disaster Risk Knowledge C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication

Figure 10 Status of MHEWS in Dominica

2.2.9

Grenada

Earthquake risk for Grenada is categorised as moderate to low. Notwithstanding, a seismological station is in operation at Glenville. Under the management of the National Disaster Management Agency (NaDMA), the sensor is a Kinemetrics FBA ES-T EpiSensor Accelerometer which serves as a multi-use scientific facility and societal resource for earthquake monitoring, research, and education. Grenada features two main volcanoes which are Mount Saint Catherine on mainland Grenada, and Kick 'em Jenny, a submarine volcano located north of the island. There are no historical records of an eruptive past for Mount Saint Catherine but Kick 'em Jenny shows greater activity. Since its discovery in 1939, Kick 'em Jenny has erupted 14 times with the most recent eruption in 2017[43]. Rock falls and landslides are common where rocks and boulders along steep slopes become dislodged, posing a risk to people and property. The UWI SRC and the CRIS serve as the repository for national level volcanic eruption and landslide risk assessments respectively. The NaDMA is the official source for actionable warnings on volcanic eruptions. Likewise, NaDMA has the responsibility for disseminating & communicating actionable warnings on tsunami hazards to the public as the official source. Tsunamis are recognised within the hazard planning environment due to the seismology of the Caribbean region, although these occurrences are uncommon, with no known tsunami affecting the country in modern history. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin to the Grenada Meteorological Service, which will then forward the information to NaDMA for public dissemination. In September 2018, the parish of St. Patrick, Grenada received recognition as Tsunami-ready under the Pilot Community Performance Based Tsunami Recognition Programme being implemented by the UNESCO/IOC[44]. In the following year, the communities of Carriacou and Petite Martinique, Grenada received similar recognition in September 2019[45]. The recognition process was implemented under the leadership of NaDMA.

43 https://uwiseismic.com/volcanoes/kick-em-jenny/kej-volcanism/.

44 http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=2030&Itemid=2968.

45 http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=2090&Itemid=2969.

Outputs of the programme included the creation of inundation maps and evacuation maps for communities, as well as signage for evacuation routes, assembly points and tsunami hazard zones, murals, and an animated public awareness video.

Hydrometeorological hazards are the most frequently occurring hazards which impact the island. Grenada is located within the southern part of the Atlantic Hurricane Belt which results in the threat of tropical cyclones. Tropical cyclones affecting the country have taken the form of tropical depressions, tropical storms, and hurricanes, which bring the risk of strong winds, storm surges and flooding from heavy rainfall. In 2004, Hurricane Ivan made landfall as Category 3 system, bringing prolonged and intense rainfall, storm surge and strong winds which accounted for 90% of the buildings across the islands suffering damage or destruction (OCHA 2004). Flooding is also a common hazard occurrence, either through direct association with tropical clones or outside of these systems due to heavy rainfall events, coupled with the steep terrain and low-lying coastal area of the island. The Grenada Meteorological Service utilises the Barbados radar system for the capacity to detect, monitor, and forecast hydrometeorological hazards. The meteorological service also has the responsibility for forecasting. With regards to early warnings, Trinidad & Tobago has the responsibility for issuing tropical cyclone warnings for Grenada and its dependencies under CMO Resolution 1. Disaster risk assessment data on landslides due to hydrometeorological triggers are stored through the CRIS managed by CDEMA. Droughts are another common hydrometeorological event affecting the islands. Between 2009 and 2010, the Caribbean experienced one of its most significant drought occurrences on record, which resulted in a 17% decline in banana production in Grenada[46]. Drought risk is especially high for Carriacou and Petite Martinique within the tri-island state, that receive lower rainfall amounts during the dry season. With climate change projections suggesting reduced annual rainfall and increased temperatures, drought risk is expected to increase. EWS capacity for drought conditions is limited to the communication & dis-

46 Grenada | EKACDM (uwi.edu).

semination of actionable warnings by the meteorological service to the public. The service utilises the outputs of CARICOF produced by the WMO Caribbean RCC. The outlooks provide both quantitative and qualitative forecasts on drought and mean temperatures which can facilitate informed decision-making across sectors for drought management. Environmental hazards occur in the form of pollution, biodiversity loss, deforestation, soil/ land degradation, wildfires, mangrove loss, coral reef destruction, sand mining, coastal erosion, and sea level rise. These environmental hazards are often the result of anthropogenic activities and are exacerbated by climate change. The National Climate Change Adaptation Plan (Government of Grenada 2017) further highlights the risk of climate change to biodiversity loss, coastal erosion, and coral reef destruction. Coral reefs are also damaged during harvesting and tourism-related activities. Furthermore, the Land Degradation Neutrality Report (Ministry of Agriculture, Lands, Forestry, Fisheries & the Environment 2015) identifies deforestation and sand mining as two of the main direct drivers of land degradation facing the country. The Forestry & National Park Department and Fisheries Division are the public agencies mandated by legislation to manage the risks of environmental hazards. EWS capacity lies with the agencies to detect, monitor, analyse and forecast the impacts of deforestation, and biodiversity loss in terrestrial & marine ecosystems. Environmental pollution is specifically monitored and detected by the Environmental Health Division. While forest fires are recognised in national hazard documents[47], there is limited available data on the damages and losses associated with these occurrences. There is no EWS capacity for the management of wildfires.

Biological hazards are wide-ranging, affecting plants, animals and humans and creating cascading effects across sectors. The COVID-19 pandemic placed significant strain on the health sector, signalling the need for enhancement of country capacity to manage pandemics. Historical records show that a range of biological hazards that have affected the human population including acute respiratory infection, cholera, gastroenteritis, chicken pox, dengue fever, the Chikungunya virus and scabies (Charles 2014). EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public.

Moreover, NaDMA records indicate that organisms within the agricultural sector are at risks as seen during 2011, when banana crops were affected by a fungus which significantly reduced yields. The National Adaptation Plan (2017-2021) and the Nationally Determined Contribution (Government of Grenada 2020) also outline the risk of insect infestation and invasive species, acknowledging the role of climate change in exacerbating these risks. The Livestock Division, Ministry of Agriculture, Lands & Forestry functions to detect, monitor, and analyse the risk of new diseases which have the potential to impact livestock and domesticated animals. To achieve this, the division regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Plant Management Unit regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. The Grenada National Strategic Biodiversity Action Plan (Thomas 2016) recognises alien invasive species as one of the root causes of biodiversity loss, but there is no strategic mechanism to manage the threat of invasive species at the national level.

Chemical hazards require greater attention within national instruments. Despite this, the Pesticides and Toxic Chemical Control Bill (2015) provides a useful indication of some of the harmful chemicals that pose a risk to health and safety. Oil pollution is also a recognised chemical hazard although uncommon. The country does not have a history of oil spills but acknowledges the risk of these occurrences if a significant spill occurred in the marine environment. Hydrocarbon storage facilities also pose a risk if events result in a spillage of oil. As a preparatory measure for these risks, Grenada has a National Oil Spill Contingency Plan which was drafted in 1996. The plan details an EWS mechanism for oil spills, identifying the Grenada Coast Guard and NaDMA as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. There is no EWS capacity for managing risks associated with POPs.

Technological hazards are recognised in the context of spills and leaks in industrial areas (such as storage plants), fires, road traffic accidents and waste. Other technological hazards, such as infrastructural failure, while present are not recognised within national hazard documents. Cyber hazards are

47 Charles, Leon. 2014. Country Document on Disaster Risk Reduction for Grenada, 2014. ECHO, UNISDR.

a growing concern but are absent from national disaster risk documents, the key to these is the National Disaster Plan. Societal hazards take the form of civil unrest and violence. In 1983, civil unrest led to an unknown number of deaths and while these occurrences are uncommon, they continue to be recognised in national hazard documents due to their significance and sometimes underlying triggers. There is a general need to reconsider how hazards are viewed in the national context, with greater consideration for other high-severity events that have not been contemplated within national hazard instruments. One such example is financial shock. While Grenada was significantly impacted by the financial crisis in 2008, these threats are absent from national documents. With regards to EWS, there is no capacity for both technological and societal hazards.

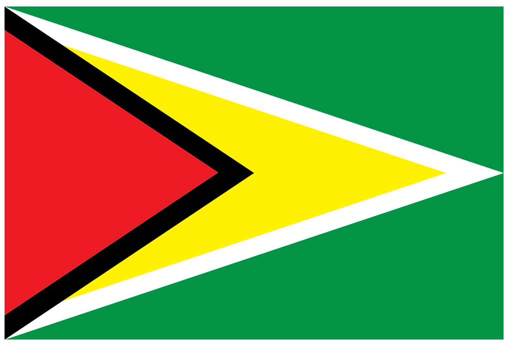
GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Rrespresented	Colour	EWS Components Rrespresented
(light blue)	C1- Disaster Risk Knowledge	(light green)	C1- Disaster Risk Knowledge C3- Warning dissemination & Communication
(blue)	C2-Hazard detection, Monitoring & Forecasting	(green)	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication

Figure 11 Status of MHEWS in Grenada.

2.2.10
Guyana



Geological hazards, though occurring less frequently, still comprise the national hazard landscape, most notably in the form of earthquakes. In January 2021, a magnitude 5.7 earthquake affected the island, prompting the Civil Defence Commission (CDC) to consider strengthening the national capacity for seismic monitoring[48]. Currently, Guyana has no EWS capacity for earthquake, volcanic and landslide hazards. The sole capacity lies with tsunami hazards as the CDC has the responsibility for disseminating & communicating actionable warnings to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin to the Hydrometeorological Service, in the Ministry of Agriculture, which will then forward the information to the CDC for public dissemination.

As part of the South American continent, Guyana is situated outside of the Atlantic Hurricane Belt. However, some parts of the country are still affected by high winds and storm surges because of meteorological disturbances in the Atlantic Ocean. Flooding is often referred to as the primary hazard affecting the country with varying degrees and types being experienced on an annual basis. Between May and June 2021, Guyana experienced its most recent significant flooding that affected all ten regions throughout the country, with regions 5, 6, 9 and 10 being the most significantly affected, and over 34, 500 persons across 6, 900 households impacted (IFRC 2021). EWS capacity lies with the Hydrometeorological Service, which manages a Doppler Radar System to provide capacity for detecting, monitoring, and forecasting hydrometeorological hazards. The meteorological service also has the responsibility for disseminating warnings to the public. Moreover, the service disseminates warnings on impending drought conditions to relevant stakeholders and the public. Monthly drought bulletins are developed based on using input data on the Standardized Precipitation Index (SPI) created by the WMO. In instances when there is a possibility of landslides occurring due to heavy rainfall, the CDC will issue public warnings to individuals residing in vulnerable geographical locations.

Climate change and its direct influence on the hazard environment create the risk of sea level rise and its knock-on effects, increased coastal erosion, and temperature extremes that have the potential to create cascading impacts. Environmental hazards in Guyana are evident by sea level rise, coastal erosion, soil degradation, and mangrove loss. The Guyana Forestry Commission, Guyana Lands & Surveys Commission, and Guyana Wildlife Management Authority Forestry are the public agencies mandated by legislation to manage the risks of environmental hazards. EWS capacity lies with the agencies to detect, monitor, analyse and forecast the impacts of deforestation, land & soil degradation, and biodiversity loss in terrestrial & marine ecosystems. Notably, the Forestry Commission possesses risk assessment data for deforestation through the continuous collection of data on forest resources. Environmental pollution is monitored and detected by the Environmental Protection Agency, which also disseminates actionable warnings regarding pollution to the public. In addition, wildfires are experienced, predominantly in the savannas of region 9 and agricultural fields in coastal regions during dry periods where vegetation is set alit due to intense heat, lightning, or friction. The Guyana Forestry Commission has the capacity to detect and monitor wildfires through a range of traditional and technological methods, including but not limited to fire patrols, watches from observation towers, the computerized monitoring of relevant environmental parameters, and spotter plane patrols.

Vector and waterborne diseases such as gastroenteritis, malaria, dengue, leptospirosis, and the chikungunya virus are prevalent because of poor hygiene and environmental conditions and practices, including improper solid waste management and

48 Department of Public Information Guyana. CDC monitoring earthquake aftermath, January 31, 2021. https://dpi.gov.gy/cdcmonitoring-earthquake-aftermath/.

water quality[49]. The ongoing pandemic COVID-19 pandemic is one of the more worrying biological hazards currently affecting the country. Since the confirmation of the first positive case in March 2020, COVID-19 has resulted in the death of 1,278 persons of the 70,841 total confirmed cases as of August 12, 2022[50]. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. Since its advent, the pandemic has placed extensive strained on the resources of the health sector, indicating that there is a need to enhance the capacity to manage the risk of future pandemics. With agriculture as one of the main economic activities, the sector is also affected by biological hazards in the form of crop diseases and pests, in addition to epidemics in livestock. Regions 2, 3, 5 and 9, which have primarily agriculturally based economies, highly prioritised pests, and diseases in the conducted Regional Risk assessments. Typical diseases affecting livestock include rabies spread by bats, botulism, bovine spongiform encephalopathy, equine encephalomyelitis, and in the case of poultry hypo glycaemia, coccidiosis, fowl pox, and parasitism[51]. The Guyana Livestock Development Authority, Ministry of Agriculture detects, monitors, and analyses the risk of new diseases which have the potential to impact livestock and domesticated animals. The authority regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the National Plant Protection Organisation regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. The Guyana National Biodiversity Strategy & Action Plan (Ministry of Natural Resources & the Environment 2014) does not recognise alien invasive species as one of the root causes of biodiversity loss. Rather, the plan explicitly mentions climate change, deforestation, land degradation, overfishing, the depletion of mangroves and the expansion of extractive industries as factors which pose threat to the biodiversity of the state. Still, the Guyana Forestry Commission monitors the threat of invasive species at the border between Guyana and Brazil where transboundary transmission is common.

Chemical hazards are the main threats linked to the mining sector, due to the high possibility of a spill of pollutants such as mercury and cyanide which, despite being restricted, are sometimes used in different stages of small, medium, and large-scale gold and diamond extraction. As one of the main economic activities of Guyana, the mining sector offers an opportunity for economic development but poses several hazards for those involved and the areas within which these activities are conducted. Both cyanide and mercury, in addition to several other chemicals, are pollutants that pose a high risk to human health and the environment (Velasco 2014). Contamination from mining activities is a major source of water pollution, especially in river-dependent communities situated near mining activities. With regards to marine oil pollution, Guyana has a National Oil Spill Contingency Plan which was operationalised in 2020. The plan details an EWS for oil spills, identifying the Maritime Administrative Department (MARAD) as the agency responsible for detection & surveillance, and the dissemination of public warnings. Additionally, the BCRC Caribbean is executing a project which seeks to develop a national implementation plan which involves building country capacity for the monitoring and evaluation of POPs risks.

Technological hazards occur in the form of mining hazards, air, river and road transportation accidents, and industrial failure that leads to spills, leaks, explosions, and fires. Oil spills and pollution have been linked with the mining and timber industries in the interior Regions of Guyana where these activities are prominent. Historically, mine dredging operations and spillage during small and medium-scale gold mining were the primary areas of concern with regards to this hazard. However, the threat of oil spills has drastically increased in recent times with the commencement of oil and gas exploration and extraction in the offshore environment. Societal hazards are widely absent from key disaster instruments such as the National Multi-Hazard Disaster Preparedness and Response Plan (2013) and the Disaster Risk Management Policy but must not be forgotten. The Draft National Tourism Policy (2017) recognises unrest and crime as deterrents to economic growth through tourism, thereby providing insights into these societal hazards that are present. High levels of crime and violence tied to low levels of interpersonal trust and social cohesion and low trust in criminal justice institutions are recognised as a hindrance to development. In 2015,

49 Civil Defence Commission. 2014. "Progress and Challenges in Disaster Risk Management in Guyana, 2014". United Nations Office for Disaster Risk Reduction.

50 https://covid19.who.int/region/amro/country/gy.

51 Civil Defence Commission. 2014. "Progress and Challenges in Disaster Risk Management in Guyana, 2014". United Nations Office for Disaster Risk Reduction.

Guyana reported a homicide rate of 19.4 per 100,000, considered relatively high and above the global average of 6.2 per 100,000 (Sutton & Baxter 2017). Other serious crimes of armed robbery are also considered common. As such, national hazard risk assessments must consider the varying nature of hazards. Notwithstanding, there is no EWS capacity for both technological and societal hazards.

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
(light blue)	C2-Hazard detection, Monitoring & Forecasting	(light green)	C1- Disaster Risk Knowledge C2-Hazard detection, Monitoring & Forecasting
(dark blue)	C3- Warning dissemination & Communication	(green)	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication

Figure 12 Status of MHEWS in Guyana.

2.2.11

Haiti

The disaster history of Haiti has been dominated by the occurrence of earthquakes which have caused significant setbacks to the development of the nation. The southern region of Haiti was impacted by a 7.2 magnitude earthquake on August 14, 2021. The estimated number of deaths was 2,248 with another 329 persons listed as missing and approximately 12,763 more reported to be injured (International Medical Corps 2021). After the impact of the 2010 Haiti earthquake, the USGS aided the country with building capacity for earthquake monitoring and awareness in collaboration with USAID. Through the assistance, Office of Mines & Energy (BME) has established a Seismology Technical Unit which manages a total of 15 seismic stations currently operating in Haiti, including six (6) Net Quakes instruments owned and operated by the BME, seven (7) USGS instruments that remain in Haiti on long-term loan, and two (2) instruments installed by National Resources Canada. For any earthquake large enough to be felt, the NetQuakes instruments transmit triggered data via the Internet to the BME as well as several international data centres, providing rapid-assessment capacity that was absent at the time of the 2010 earthquake[52]. As a result, Haiti is the only CDEMA PS with the national capacity to detect, monitor and assess earthquakes.

Tsunami risks are present and are projected to increase as global mean sea levels rise. On 28 September 2018, the community of Fort-Liberté received Tsunami-ready ICG/CARIBE EWS recognition, valid for 4 years[53]. The coastal community fulfilled all the requirements, including the development of tsunami inundation and evacuation maps, signs posts, 24/7 local focal points, public awareness sessions and a full-scale tsunami drill. The process was supported by the Department of Civil Protection (DPC). Beyond this, there is an EWS mechanism for disseminating & communicating actionable warnings to the public regarding tsunami hazards. If an earthquake triggers a tsunami which will potentially impact Haiti, the PTWC will issue a bulletin to the Meteorological Centre, which will then forward the information to the DPC for public dissemination.

With reference to hydrometeorological hazards, Haiti is highly exposed to tropical cyclones, coastal flooding, urban & fluvial flood, lightning strikes, storm surges, droughts, and heatwaves. On October 4, 2016, Hurricane Matthew impacted Haiti as a Category 4 system. The major hurricane accounted for flooding, and the destruction of critical infrastructure, crops, and natural ecosystems. In total, 546 people were killed, more than 175,500 people sought refuge in shelters, and about 1.4 million people required immediate humanitarian assistance (World Bank 2017). The capital city, Port-au-Prince, is particularly vulnerable to flooding, with a large portion of its inhabitants residing on flood plains in informal, urban, poorly constructed housing settlements. Moreover, rain-induced landslides are common along all river valleys where years of deforestation have left the upper reaches of the wester basins bare. On the other extreme of the hydrological spectrum, the North-West, Artibonite, North-East, and Central departments frequently experience repeated droughts, brought about by a combination of erratic rainfall patterns coupled with limited water management infrastructure. The Hydrometeorological Unit of Haiti (UHM) offers forecasting and warning services for severe weather-related events and drought, which are relayed to the public, aviators, and marine operators. The warnings typically include information on the probability of hazards events impacting the island. The UHM operates a network of AWS which collect climate data but there is no radar system to detect and monitor adverse weather. Rather, the UHM utilises satellite imagery provided by the NOAA to track changes in weather.

Haiti is also exposed to a myriad of environmental hazards such as air pollution, land and soil degradation, biodiversity loss, deforestation, wildfires, desertification, soil erosion, coastal erosion & shoreland change, and sea level rise. A combination of factors including the steep gradient of slopes, limited vegetation cover, unsustainable agricultural practices, and deforestation all contribute to the overall degradation of terrestrial

52 https://www.usgs.gov/media/images/earthquake-education-and-outreach-haiti-1

53 http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=2031&Itemid=3277.

and coastal ecosystems. The continuous decline is supported by the statistics. Haiti is one of the most deforested countries in the world, with an estimated forest cover of only 1-3% of the country's area[54]. More than 50% of Haiti is subject to a significant threat of soil erosion and no less than 6% of the land is currently affected by irreversible erosion[55]. From a governance perspective, the National Risk and Disaster Management Plan (PNGRD) 2019-2030 acknowledges the existence of these hazards without addressing them in a detailed manner. The Ministry of Environment is mandated by legislation to manage the risks of environmental hazards. EWS capacity lies with the agency to detect, monitor, analyse and forecast the impacts of deforestation, land & soil degradation, biodiversity loss and environmental pollution.

There is no EWS capacity for the management of wildfires, despite an increasing probability of climate change exerting an impact on more frequent wildfire occurrences in the country. In the areas already affected by wildfire hazard, the fire season is likely to increase in duration and severity and include a greater number of days with prevailing weather conditions that support fire spread because of longer periods without rain during fire seasons. While the PNGRD 2019-2030 acknowledges the threat of climate change extending periods of drought, an explicit reference to wildfire hazard in its Strategic Axes is needed.

In recent history, Haiti was impacted by a cholera epidemic prior to the impact of the COVID-19 pandemic. Following the impacts of the 2010 earthquake, Haiti recorded a cholera outbreak which spanned the period October 2010 to January 2019, affecting over 820,000 people and causing the death of 9,792 persons (PAHO 2020). EWS capacity for the epidemic was managed by the Ministry of Public Health & Population, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. However, the resources of the ministry were exhausted, requiring humanitarian support from regional and international organisations. Rapid detection and testing were supported by PAHO through the Laboratory Moto project, which enabled field nurses at decentralised testing centres to rapidly transport samples from treatment centers to laboratories on motorcycles. The COVID-19 pandemic has further reinforced the need for Haiti to enhance its capacity to manage epidemics and pandemics. The social vulnerabilities of the country typically result in the exaggeration of the impact, since more than one-third of the population lack access to potable water while two-thirds have limited or no sanitation services.

The Ministry of Agriculture, Natural Resources & Rural Development performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. The ministry regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Quarantine Unit within the ministry regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. However, there is no EWS capacity to manage the threat of invasive species.

With respect to chemical hazards, the Haitian population is exposed to several toxic gases, heavy metals, POPs, hydrocarbons, and other toxins. Exposure to these chemical hazards is discussed in National Chemical and Waste Management Profile (2008). The profile provides an assessment of the legal, institutional, administrative, and technical capacities to manage chemicals and waste. The orders of August 2012 and July 2013, prohibit the production, import, marketing and use of polyethylene bags and objects made of expanded polystyrene. However, the degree of enforcement of these orders is low. However, there is a need for the PNGRD to integrate chemical hazards in its Strategic Axes and the National Chemical and Waste Management Profile (2008) must be revised to consider new issues with chemical and waste management. Moreover, the country requires an institutional mechanism for oil spill prevention and response, such as a National Oil Spill Contingency Plan.

There is no EWS capacity for technological or societal hazards in Haiti. Regarding technological hazards, Haiti is highly exposed to construction and structural failure, industrial failure, hazardous waste, and transportation accidents. A National Building Code was published in 2012, by the Ministry of Public Works, Transport & Communications but requires strengthening for the implementation of the Code. Transportation hazards related to road traffic and air transportation accidents are regulated by the National Police and the National Office for

54 Ibidem.

55 Op. cit., Terrier M., Rançon, J. F., Bertil D., Chêne F., Desprats J. F., Lecacheaux S., Le Roy S., Stollsteiner P., Bouc O. (BMRGM), Raynal, M. (CIAT) (2017).

Civil Aviation[56]. With regards to societal hazards, the PNGRD 2019-2030 acknowledges them without providing many details. From a social standpoint, the security situation of the state has deteriorated significantly since 2019 with an increase in crime, delinquency, and confrontations between gangs and kidnappings. In 2020, several events aggravated the humanitarian situation in the country. At the socio-political level, there have been violent popular demonstrations against corruption, the absence of a functioning legislature, and repeated strikes at the level of the judiciary.

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
(light blue)	C2-Hazard detection, Monitoring & Forecasting	(green)	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
(dark blue)	C3- Warning dissemination & Communication	(red)	C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings

Figure 13 Status of MHEWS in Haiti.

56 E. g.: République d'Haïti, OFNAC (2017), Règlement de l'aviation civile, Partie 14 – Aéroport, Annexe K, Plan d'urgence, URL :https://ofnac.gouv.ht/wp-content/uploads/2020/11/RACH-Partie-14-Annexe-K-Plan-Urgence.pdf; Police Nationale d'Haïti, Manuel d'utilisateur du système d'information sur les accidents, URL : https://www.mtptc.gouv.ht/media/upload/doc/publications/StrategieNationale3.pdf

2.2.12
Jamaica

Jamaica is situated near the northern boundary of the Caribbean plate which interacts with the Gonâve microplate. The risk of impact by earthquakes was evidenced in January 2020, when the USGS[57] reported a 7.7 magnitude earthquake occurred in the Caribbean Sea to the south of Cuba and northwest of Jamaica as the result of strike-slip faulting on the plate boundary between the North America and Caribbean tectonic plates. The Earthquake Unit (EQU), the Department of Geology & Geography, the Faculty of Science & Technology at the Mona Campus of the UWI is funded directly by the Government of Jamaica through the Ministry of Transport and Mining. The EQU serves as the hub for earthquake monitoring and research in Jamaica. The functions of the EQU include but are not limited to i) the operation & management of the Jamaica Seismograph Network (JSN), which consists of 13 stations and 42 accelerographs, ii) the collection of data and maintenance of a database of all earthquakes recorded by the JSN, and iii) the dissemination of information to the public about earthquakes felt in Jamaica[58].

With regards to the potential secondary impacts of earthquakes, capacity lies with tsunami hazards as the Office of Disaster Preparedness & Emergency Management (ODPEM) has the responsibility for disseminating & communicating actionable warnings to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin directly to ODPEM. Efforts have been on-going to achieve tsunami readiness at the community level. Having fulfilled the requirements of the Pilot Community Performance Based Tsunami Recognition Programme implemented by the UNESCO/IOC, Old Harbour Bay, St Catherine received recognition as tsunami-ready in September 2021[59]. The primary objective of the programme is to develop an end-to-end tsunami EWS, enabling vulnerable coastal communities to take effective action in the event of a potential tsunami and save lives. The research revealed that landslide susceptibility maps are available for the Kingston Metropolitan Area (KMA), which were prepared by the University of the West Indies, Mona as a part of the Kingston Multi-Hazard Assessment administered by the Caribbean Disaster Mitigation Project (OAS/USAID). The landslide risk assessments were prepared under two (2) scenarios of shallow and deep landslides. Two of the limitations of the assessment are that i) it does not represent the entire island and ii) it was created in 1999 and therefore would need to be updated to consider changes and new risks.

Cyclonic systems are a recurring threat to Jamaica as well as associated heavy winds and rains. These natural hazards have often left Jamaica with lingering effects like flooding and landslides. Between 2002 to 2012, nine (9) systems impacted the island, of which one was a Category 4 hurricane[60]. Flooding can also occur during the passage of low-pressure systems characterised by heavy and prolonged rainfall. The National Meteorological Service (NMS), also a member of the Regional Early Warning System Consortium (REWSC), manages a Doppler Radar System which provides capacity for detecting, monitoring, and forecasting hydrometeorological hazards. The radar can detect weather conditions approaching the island within a 240 km radius and is complemented by an AWS for the collection of climate-related data. The meteorological service also has the responsibility for disseminating warnings to the public, primarily through its website. In addition, the service disseminates warnings on impending drought conditions to relevant stakeholders and the public. Of note is that instances of drought are recorded but the impact of the occurrence is not well articulated. Monthly drought bulletins are developed using input data on the Standardized Precipitation Index (SPI) created by the WMO.

The National Environment & Planning Agency (NEPA) is the lead public agency mandated by legislation to manage risks associated with land & soil degradation and biodiversity loss within ecosystems. Continuous

57 https://earthquake.usgs.gov/earthquakes/eventpage/us60007idc/executive

58 About Us | Earthquake Unit (uwi.edu).

59 http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=2189&Itemid=3281.

60 https://nlj.gov.jm/history-notes/History%20of%20Hurricanes%20and%20Floods%20in%20Jamaica.pdf.

data collection and systems of monitoring allow the agency to provide EWS capacity for the detection, analysis and forecasting of the impacts of these hazards. The Forestry Department has responsibility for managing approximately 117, 000 hectares of forested lands across Jamaica. The department provides monitoring & evaluation services for the risks associated with deforestation and coordinates public-private partnerships which emphasise the reforestation of lands for commercial wood production and soil conservation. With regards to environmental pollution, the NEPA collaborates with the National Solid Waste Management Authority to provide detection, monitoring, and analytical services on pollution sources. The Solid Waste Management Authority offers surveillance and monitoring specifically for solid waste pollution, to remediate issues to prevent the possible contamination of natural resources or the spread of vector-borne diseases. Furthermore, NEPA operates an Air Quality Management Branch (AQMB), which monitors and assesses the impact of air pollution, analysis the potential for public health impacts. Resilience to wildfires was boosted in 2022 through the development of a Bush Fire Warning Index and Management System. The digital platform, initiated by the Meteorological Service Division in collaboration with the Jamaica Fire Brigade (JFB), is expected to improve stakeholder capability to monitor developments relating to bush fires[61]. The platform processes rainfall, temperature, soil type and land use data to determine the risk of fire in targeted areas prior to actual impact.

The biological risk landscape of the country has been marked by epidemics of vector-borne diseases, most notably Dengue fever, the Zika virus and the Chikungunya virus. In 2014, an epidemic with several thousands of suspected cases of chikungunya virus (CHIKV) infections were reported (Lue et al. 2022). Dengue outbreaks have increased in frequency and intensity over the 40 years of active dengue surveillance in Jamaica, with increased intensity, severity and reported cases in recent years. Jamaica experienced an upsurge in cases in late 2018 with an epidemic declared on January 3, 2019 (Lue et al. 2022). More recently, the impact of the COVID-19 pandemic revealed that there is much needed improvement to build the country capacity to manage pandemics. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Veterinary Services Division of the Ministry of Agriculture & Fisheries performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. Similarly, the Plant Quarantine Produce Inspection division regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. The disaster risk profile of Jamaica recognises the threat of invasive species. Under the UNEP-GEF project "Mitigating the Threats of Invasive Alien Species in the Insular Caribbean", one of the interventions was the development of a database on invasive alien species with photographs for identification. Recommendations were made towards the advancement of a national early detection mechanism which is supported by monitoring and surveillance. However, there is no evidence within the literature to suggest that such a mechanism has been established. The National Invasive Alien Species Strategy & Action Plan (NIASSAP) for Jamaica 2014-2020 identifies that the state does not have comprehensive legislation to manage invasive species or biosecurity. Rather, laws with implications for EWS in relation to invasive species are scattered across multiple governing authorities, yielding gaps in the legal and policy structures.

With regards to chemical hazards, Jamaica has National Oil Spill Contingency Plan which was approved by the government in 2014. The plan identifies the Jamaica Defence Force Coast Guard and ODPEM as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively, within the EWS mechanism.

Technological hazards are recognised in the form of fires, explosions, toxic spills, and mining extraction in highly sensitive environmental areas. From a societal perspective, high population densities in urban areas with inadequate basic-service provision (water, electricity, health, education, transportation) promote vulnerability to hazard risks where informal settlements are located. One of the challenges that Jamaica has encountered is building financial resilience to external shocks. The frequent impacts of storm events have always required the reallocation of revenues from social development programmes, towards the repair of critical infrastructure. The

61 Jamaica now has a Bush Fire Warning Index and Management System – Jamaica Information Service (jis.gov.jm)

pandemic has further exacerbated the socio-economic development of the country, contributing to the decline of the tourism industry coupled with rising unemployment and rates of inflation. The disaster risk profile also recognises that armed conflict, civil unrest, and related consequences can arise from internal displacements and migrations. There is no EWS capacity for technological and societal hazards within Jamaica.

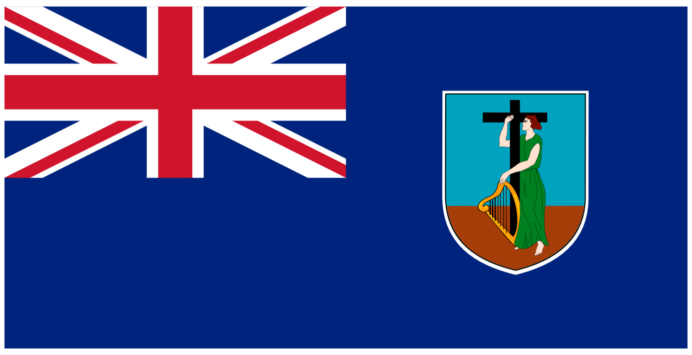
GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
	C1- Disaster Risk Knowledge		C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
	C2-Hazard detection, Monitoring & Forecasting		C1- Disaster Risk Knowledge C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
	C3- Warning dissemination & Communication		C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings

Figure 14 Status of MHEWS in Jamaica

2.2.13
Montserrat



The eruption of the Soufriere Hill volcano is well-documented in the historical records of Montserrat. From 1995 to 1997, several eruptions contributed to 60% of the island being determined uninhabitable, 70% of arable lands being lost and the contamination of 50% of the available freshwater resources on the island (OCHA 2022). The UWI SRC serves as a repository for the storage and management of volcanic risk assessments for the island, while the Disaster Management Coordination Agency (DMCA) serves as the official source of actionable warnings regarding the potential impact of volcanic eruptions. The UWI SRC database on tsunamis indicates that the volcanic eruptions pose a tsunami risk, as a major avalanche of debris along the slope of the volcano into the sea, generated tsunami waves that inundated up to 80 m inland. The DMCA manages the responsibility for disseminating & communicating actionable warnings to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin directly to DMCA for public dissemination.

Though the risk still exists, the impact of cyclonic systems has been less frequent in comparison to neighbouring Caribbean countries. According to the historical data, the last significant impact was caused by Hurricane Earl in 2010. In addition to damages by the wind speed of 35 to 40 mph, the system triggered floods, and landslides, resulting in the destruction of physical infrastructure estimated at US $3 million (UWI EKACDM 2022). Montserrat has a meteorological office but there is no EWS capacity for hydrometeorological hazards. Montserrat is dependent on the meteorological services of Antigua & Barbuda for the detection, monitoring and forecasts of potential hazards which may impact the island. Under the CMO Resolution 1, Antigua & Barbuda takes responsibility for issuing warnings regarding adverse weather conditions to Montserrat through its meteorological department.

The Department of Environment offers detection, monitoring, and analytical services for managing risks associated with deforestation, biodiversity loss, pollution, and land & soil degradation. More specifically, the department is responsible for environmental data collection and management as well as environmental monitoring and assessment. These responsibilities are mandated by legislation in the areas of sustainable forestry management, biodiversity conservation and watershed management.

The Ministry of Health & Social Services manages EWS for human pandemics & epidemics, being mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Ministry of Agriculture, Lands, Housing and Environment performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact both livestock & domesticated animals, and plant species. The ministry regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products, as well as the inspection, and analysis of agricultural commodities including but not limited to agricultural crops, flowers, cuttings, and soil materials. This is commonly conducted at the airport. However, there is no EWS capacity to manage the threat of invasive species.

Though uncommon, technological hazards are recognised as waste hazards, oil spills and fires, transportation accidents, and building collapse. Montserrat has a draft National Oil Spill Contingency Plan which was developed in 1996. Despite not being finalised, the plan still identifies the DMCA as the agency responsible for both the detection & surveillance, and the dissemination of public warnings, within the EWS mechanism. The aftermath of the volcanic eruption has made the country extremely vulnerable to the risk of external economic shocks. Montserrat is highly dependent on the importation of food due to the degradation of arable lands by the eruption. The country has one of the highest poverty rates among Eastern Caribbean countries, with more than 36% of its population living in poverty and 3% in extreme poverty (OCHA 2022). As a result of the COVID-19 pandemic, unemployment in Montserrat significantly increased from 4.6% in 2018 to 8.7% in 2020 (OCHA 2022). There is no EWS capacity for technological and societal hazards within Montserrat.

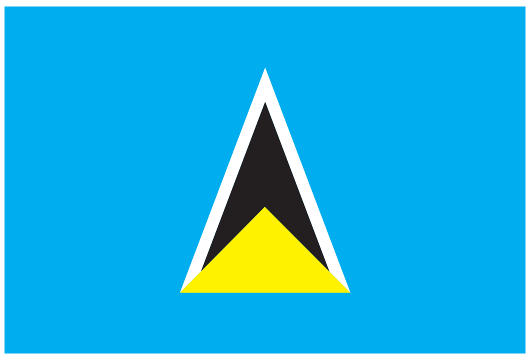
GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
(light blue)	C2-Hazard detection, Monitoring & Forecasting	(light green)	C1- Disaster Risk Knowledge C3- Warning dissemination & Communication
(dark blue)	C3- Warning dissemination & Communication	(green)	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication

Figure 15 Status of MHEWS in Montserrat.

2.2.14
Saint Lucia



Geological hazards comprise the country risk landscape, though they are less prevalent. Earthquakes contribute to the geological risk profile of the island. In November 2007, several islands within the Eastern Caribbean, including Saint Lucia, felt the shaking of a 7.4 magnitude earthquake, which resulted in structural damage reported for Saint Lucia. The island is home to the Soufrière volcano which is nestled within the southwestern part of the island. Despite the last major eruption being over 200 years ago, the UWI SRC affirms that the occurrence of earthquake swarms in the area with activity within the sulphur springs indicate that the area is still potentially active, and Saint Lucia can still be at risk of future volcanic eruptions. There is no EWS capacity for earthquakes and volcanic eruptions in Saint Lucia, but the CRIS serves as a repository for landslide risk assessment data at the national level. With regards to tsunami hazards, Saint Lucia participates in the annual Caribe Wave exercise conducted across the region. The simulation provides an opportunity for the testing of EWSs, namely the automated sirens in Castries and Canaries, the radio broadcast interruption capability, and the provision of early warnings through a mobile phone application. Past simulations have emphasised the evacuation of primary and infant schools situated in the basin of the capital city, Castries and the voluntary participation of businesses and residents at predetermined evacuation and assembly points (NEMO 2018). NEMO, Saint Lucia has the responsibility for disseminating & communicating actionable warnings to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin to the Saint Lucia Meteorological Office, which will then forward the information to the NEMO for public dissemination.

The historical data for Saint Lucia indicates that between 1955 and 2020, the island has been significantly impacted by at least five (5) tropical cyclone systems. In comparison to the other states of the Caribbean region, the impact of tropical cyclonic systems on Saint Lucia is infrequent. However, when such systems impact the island, they account for significant damages and losses. With climate change expected to contribute to increased intensities of tropical cyclones within the Atlantic Hurricane belt, Saint Lucia may continue to experience widespread and devastating losses that accompany tropical storms and hurricanes. Most recently, Hurricane Tomas in 2010 resulted in US $350 million in losses and 8 fatalities[62]. Furthermore, flooding due to cyclones or through independent weather systems, as well as rainfall-induced landslides pose significant concern to the country. The Saint Lucia Meteorological Office has monitoring networks for meteorological hazards. Forecasting and warning services are offered by the office for severe weather events, which are relayed to the public via NEMO. The warnings typically include information on the probability of hazards events impacting the island. Disaster risk assessment data on flooding and landslides are stored by the CRIS. There is no national level EWS capacity for drought hazards. However, drought conditions are well-recognised within the national risk landscape. In fact, drought risk over the years has motivated the development of the Water Management Plan for Drought Conditions, developed in 2009 to provide a framework for response to managing droughts.

Environmental hazards are recognised by the country in the form of land & soil degradation, biodiversity loss, deforestation, pollution, loss of mangroves, wildfires, sea level rise, loss of mangroves, coastal & soil erosion, coral bleaching, and eutrophication. Saint Lucia has a Biodiversity Unit and Fisheries Division which collaborate to detect and monitor the loss of biodiversity in terrestrial & marine ecosystems. Environmental pollution is specifically monitored and detected by the Department of Sustainable Development & Environment. There is no EWS capacity for the management of wildfires.

The COVID-19 pandemic is a reminder of the need for adequate biological hazard planning. Under the Inform COVID-19 Risk Index (2021), Saint Lucia was listed as medium risk from the health and humanitarian impacts of COVID-19 that

62 Pasch, Richard J., and Todd B. Kimberlain. 2011. "Tropical Cyclone Report Hurricane Tomas". Report published by the National Hurricane Center.

could overwhelm national response capacity and require additional international assistance[63]. Saint Lucia has also been affected by the 1854 cholera epidemic that severely affected some Caribbean countries. While country documents refer broadly to biological hazards (most commonly vector-borne, water-borne diseases and select communicable diseases), the biological risk landscape is diverse. Consequently, there is much needed improvement to build the country capacity to manage pandemics and infectious diseases. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health & Wellness, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Veterinary & Livestock Services, in the Ministry of Agriculture, Fisheries & Food Security performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. The service regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Plant Quarantine Unit regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. The Saint Lucia National Biodiversity Strategy & Action Plan does not recognise alien invasive species as one of the root causes of biodiversity loss. In contrast, the issues of climate change, deforestation, land degradation, overfishing, the depletion of mangroves and the expansion of extractive industries are explicitly mentioned. The last edition of the plan developed in 2000 implies the need for revision and update to better include current threats and trends associated with biodiversity, as well as to articulate the roles and responsibilities of stakeholders. Under the UNEP-GEF project "Mitigating the Threats of Invasive Alien Species in the Insular Caribbean", one of the interventions was the development of a database on native and invasive species. Recommendations were made towards the advancement of a national early detection mechanism which is supported by monitoring and surveillance. However, there is no evidence within the literature to suggest that such a mechanism has been established.

Chemical hazards are less explored within the country framework, though they are recognised. The Country Risk Reduction (2014) document broadly outlines chemical hazards and briefly refers to the harmful release of chemical substances within the National Risk Register, but this hazard category is less explored within the framework of the wider hazards for the country. Saint Lucia does have a National Oil Spill Contingency Plan which was approved by the cabinet in 2007. The plan details an EWS for oil spills, identifying the Saint Lucia Air & Sea Port Authority and the NEMO as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. In the second instance, Saint Lucia is one of the beneficiary countries of a project coordinated by the BCRC Caribbean to build risk knowledge for POPs through developing an inventory of potentially contaminated sites and conducting risk assessments for selected sites.

Technological hazards for Saint Lucia are documented within plans and policies in the context of infrastructural failure, structural failure and industrial failure or non-compliance relating to fires, explosions, and spills. Interestingly, however, there is limited evidence within the country framework to support planning and considerations for cyber hazards, including within the National Risk Register. Country policies, plans and strategies consistently reference a range of societal hazards including civil unrest, armed conflict and financial shock that can affect the people, resources, and systems of the island. Saint Lucia's Contingency Plan for Civil Unrest (2010) was motivated by street protests and widespread vandalism. However, there is no EWS capacity for technological or societal hazards.

63 https://drmkc.jrc.ec.europa.eu/inform-index/inform-covid-19#:~:text=The%20INFORM%20COVID%2D19%20Risk

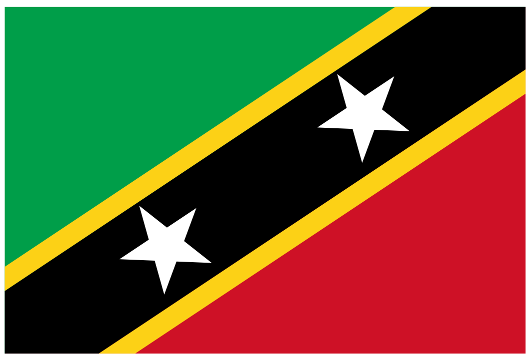
GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
	C1- Disaster Risk Knowledge		C1- Disaster Risk Knowledge C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
	C2-Hazard detection, Monitoring & Forecasting		C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings
	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication		

Figure 16 Status of MHEWS in Saint Lucia.

2.2.15
St. Kitts & Nevis



The twin island state is characterised by volcanoes on both islands with Mount Liamuiga, an active volcano located on the northern end of Saint Kitts, and Mount Nevis which is situated within the central landscape of Nevis. Information about the eruption history of both volcanoes is incomplete. However, there are records of earthquake activity monthly, generally associated with the volcanic centres. Large earthquakes are uncommon but due to the proximity of plate boundaries (the Caribbean and North American plates), they are a possibility for the islands. The UWI SRC serves as a repository for volcanic eruption risk assessment data at the national level while the National Emergency Management Agency (NEMA), St. Kitts & Nevis acts as the official source for warnings regarding the hazard. However, there is no national level EWS capacity for the management of earthquakes.

With regards to tsunami hazards, NEMA has the responsibility for disseminating & communicating actionable warnings to the public as the official source. Considering the proximity of the country to active seismic plate boundaries and the volcanic centres of neighbouring islands, tsunamis pose a threat to St. Kitts & Nevis. The main risk is associated with the potential eruption of Kick- 'em-Jenny, the underwater volcano located off the coast of Grenada. The existing systematic flow of information is that if an earthquake triggers a tsunami, the PTWC will issue a bulletin to the Royal St. Christopher & Nevis Police Force which will then forward the information to the NEMA. Having fulfilled the requirements of the Pilot Community Performance Based Tsunami Recognition Programme implemented by the UNESCO/IOC, St. Kitts & Nevis received recognition as tsunami-ready in 2016. The primary objective of the programme is to develop an end-to-end tsunami EWS, enabling vulnerable coastal communities to take effective action in the event of a potential tsunami and save lives. Outputs included the creation of inundation maps and evacuation maps for communities, as well as signage for evacuation routes, assembly points and tsunami hazard zones, murals, and an animated public awareness video. NEMA and the Nevis Disaster Management Department also undertook extensive public education, conducted drills, and formulated an emergency operations plan (EOP). During February 2022, the state renewed its recognition as Tsunami-ready[64]. Landslide hazards are largely concentrated in areas where slope and soil stability present appropriate conditions, due to the terrain. The probability of occurrence is low. However, the geology and in particular, the topography of St. Kitts along with favourable conditions such as heavy rainfall and saturated soil conditions are prevailing risk factors.

The main hazard affecting St. Kitts & Nevis is tropical cyclones. Due to the small size of the islands, systems do not need to pass directly over the islands to cause significant damage and losses, as they bring high winds, rains, and storm surges. The islands also experience coastal and inland flooding. Flood risk is largely associated with storm surges in low-lying coastal areas. Flash flooding from mountain streams coupled with storm surges events presents the greatest risk. Furthermore, drought has been identified as a critical hazard for Nevis. The mean annual rainfall for the island is approximately 1,170 mm per year[65]. Although short periods of drought may occur throughout the year, extended periods are often experienced from February to April. Notwithstanding, St. Kitts & Nevis does not have the capacity to detect, monitor, and forecast hydrometeorological hazards. All meteorological services for the country are provided by Antigua & Barbuda under the CMO Resolution 1.

Environmental hazards arise through the degradation of the natural systems and ecosystem services. Coastal ecosystems and resources in Saint Kitts and Nevis are subject to a range of anthropogenic stressors that contribute to their continued deterioration. According to the Government of St. Kitts & Nevis (2005), the state retains one of the hi-

64 http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=1976&Itemid=2776.

65 https://climateknowledgeportal.worldbank.org/country/st-kitts-and-nevis/climate-data-historical#:~:text=Kitts%20and%20Nevis%20have%20a,is%20strongly%20related%20to%20altitude.

ghest percentages of forest cover in the Caribbean. However, there is much evidence of human disturbance in forest ecosystems. Present anthropogenic threats to the forest ecosystem arise mainly from deforestation, extraction for fuel, and uncontrolled burning as a method of clearance to support crop cultivation. The Department of Environment, St. Kitts & Nevis detects and monitors the loss of biodiversity, deforestation, land & soil degradation, and environmental pollution.

The country is affected by biological hazards such as mosquito-borne diseases and more recently, the COVID-19 virus. Unlike other neighbouring Caribbean islands, the Inform COVID-19 Risk Index (2022)[66] determined the country to be at low risk of the pandemic. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Ministry of Agriculture, Fisheries & Marine Resources performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. The ministry regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Plant Quarantine Unit regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. In contrast, St. Kitts & Nevis has a national biodiversity strategy and action plan which recognises invasive species as a significant threat to biodiversity, but there is no strategic EWS in place for the management of invasive alien species.

The National Oil Spill Contingency Plan is under revision. Nevertheless, the plan details an EWS mechanism for oil spills, identifying NEMA as the agency responsible for detection & surveillance, and the dissemination of public warnings. The research indicates a paucity of data to conduct comprehensive mapping and inventory of chemical hazards in the country. Notwithstanding, the POPs Implementation Plan, 2014-2024 identifies several toxic chemicals that are currently being used in several sectors relating to power generation, industrial and commercial processes, and agriculture. The BCRC Caribbean is bridging the gap by building risk knowledge for POPs through developing an inventory of potentially contaminated sites and conducting risk assessments for selected sites. Other toxic chemicals that are currently in use in the country include heavy metals such as lead and mercury as well as heavy metal containing products.

The National Disaster Plan (NEMA 2013) has identified several technological hazards that pose a risk to the country. These may arise from aircraft and major marine accidents, oil spills, high-jacking, bomb threats, fires, and explosions. New and emerging technological hazards, such as cyber hazards are largely absent from national risk documents such as the National Disaster Plan. Societal hazards are recognised in the form of civil unrest, armed conflict, and behavioural hazards. Violence is also on the rise, presenting an inherent threat to national development. There is no EWS capacity for either technological or societal hazards.

66 https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk/Country-Risk-Profile.

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Rrespresented	Colour	EWS Components Rrespresented
	C1- Disaster Risk Knowledge		C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
	C2-Hazard detection, Monitoring & Forecasting		C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings
	C1- Disaster Risk Knowledge C3- Warning dissemination & Communication		

Figure 17 Status of MHEWS in St. Kitts & Nevis.

2.2.16

St. Vincent & the Grenadines

Historically, the islands of St. Vincent & the Grenadines, more specifically the mainland St. Vincent, have been exposed to a range of naturally induced and anthropogenic hazards. There is evidence to support susceptibility to hydrometeorological, geological, environmental, biological, chemical, technological, and societal hazards. Both volcanic and non-volcanic earthquakes are common in the country due to the seismic activity of the region. Perhaps the most prominent hazard facing the country is the eruption of the La Soufrière volcano. Following months of activity which commenced in December 2020, the volcano entered the explosive phase of eruption on April 9, 2021[67]. Prior to this, the alert level was placed at red in response to the effusive phase, prompting the Government of St. Vincent & the Grenadines to issue evacuation orders initially for the red zone and subsequently for the orange zone. The eruption resulted in 20,000 persons displaced and over US $235 million in damages and losses (UNDP 2021). The National Emergency Management Organisation (NEMO), St. Vincent & the Grenadines and the CRIS serve as repositories for volcanic eruption and landslide risks assessment data respectively. Additionally, NEMO acts as the official source for warnings regarding volcanic hazards.

The Grenadine Island, Union Island, received recognition as Tsunami-ready under the Pilot Community Performance Based Tsunami Recognition Programme being implemented by the UNESCO/IOC[68]. Outputs included the creation of inundation and evacuation maps for Union Island, as well as the provision of communication equipment, and signage for evacuation routes, assembly points and tsunami hazard zones. Furthermore, NEMO and the Union Island District Disaster Committee undertook extensive public education, conducted drills, and formulated an emergency operations plan (EOP). NEMO also has the responsibility for disseminating & communicating actionable warnings to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin directly to NEMO.

Like the other islands situated within the eastern Caribbean archipelago, St. Vincent & the Grenadines lies within the Atlantic Hurricane Belt, exposing the islands to the impact of tropical cyclonic systems. Floods can occur as a secondary impact of heavy rains associated with cyclones or through other weather systems. The latter was exemplified by the December 2013 floods, often referred to as the Christmas floods, which were triggered by a low-level trough, affecting over 10,000 persons, damaging approximately 600 homes, and resulting in 12 death (NEMO 2014). St. Vincent & the Grenadines has monitoring and forecasting services for weather-related events situated primarily at the Argyle International Airport and the meteorological service serves as the authoritative & official source of actionable warnings on cyclonic systems, floods, and storm surges. With regards to warnings for cyclones, the Common Alerting Protocol (CAP) software and application has allowed for the dissemination of early warnings from the Meteorological Services and NEMO to a wider range of the population utilising a common format and alerting process. Disaster risk assessments on landslides due to hydrometeorological events are stored by the CRIS, while EWS capacity for drought hazards is limited to the communication & dissemination of actionable warnings by the Meteorological Service to the public. The department utilises the outputs of CARICOF produced by the WMO Caribbean RCC. The outlooks provide a qualitative forecast on drought and mean temperatures, accompanied by advisories for the water, agricultural and health sectors.

St. Vincent & the Grenadines is susceptible to environmental degradation in the form of soil degradation, air pollution, biodiversity loss and deforestation. The Sustainable Development Unit, Fisheries Division, and Forestry Department detect and monitor the loss of biodiversity in terrestrial & marine ecosystems. Environmental pollution is specifically monitored and detected by the

67 https://uwiseismic.com/volcanoes/la-soufriere-eruption-2020-2021-hub/.

68 http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=2116&Itemid=3063.

Environmental Engineering Unit in collaboration with the Fisheries Division. Despite the lack of a structured mechanism to monitor changes within forested environments, the Environmental Management Framework (Ministry of Economic Planning, Sustainable Development, Industry, Labour, and Information 2016) estimated that deforestation was occurring at an average rate of 17 hectares per year. Additionally, there is no EWS capacity for the management of wildfires.

While national policies, plans and activities do not explore the complete range of biological hazards under the United Nations Classification System, greater consideration needs to be given to these given the ease of transboundary movement and climate change biological risks. The state is exposed to a range of infectious diseases such as vector-borne diseases including dengue, leptospirosis, and malaria that the country has been facing for years. The Inform COVID-19 Risk Index (2021) placed the country at medium risk when exposure to the virus was greater, indicating that there is much needed improvement to build the country capacity to manage pandemics at large. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, Wellness & the Environment, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Animal Health & Production Division, Ministry of Agriculture, Forestry, Fisheries, Rural Transformation, Industry & Labour performs a similar function in detecting, monitoring, and analyses the risk of new diseases which have the potential to impact livestock and domesticated animals. The division regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Plant Protection & Quarantine Unit regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. Pest infestations and plant diseases pose continuous risks to the agricultural sector and the resultant revenue that can be generated for economic development. However, there is no EWS capacity to manage the threat of invasive species. St. Vincent & the Grenadines has a national biodiversity strategy and action plan which recognises invasive species as a significant threat to biodiversity, but there is no strategic EWS in place.

The National Chemical Profile outlines that the chemical hazards which affect the country include oil pollution, asbestos and hazards arising from POPs. With regards to marine oil pollution, St. Vincent & the Grenadines has a National Oil Spill Contingency Plan which was operationalised in 2009. The plan details an EWS for oil spills, identifying the St. Vincent & the Grenadines Coast Guard and the NEMO as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. Moreover, St. Vincent & the Grenadines is one of the beneficiary countries of a project coordinated by the BCRC Caribbean to build risk knowledge for POPs through developing an inventory of potentially contaminated sites and conducting risk assessments for selected sites.

Less emphasis is given to technological hazards, but the risk is still present. The Disaster Risk Reduction Country Profile for St. Vincent & the Grenadines produced by the UNDRR in 2014, found that while there was limited documented impact evidence for technological hazards, the risk was present as evidenced by the presence of an oil storage area in the middle of a housing community. There is also a need for the risk profile to recognise emerging technological hazards such as cyber hazards which accompany socio-economic and technological developments. Societal hazards are recognised by conflicts in the risk profile of the country. While recent years have produced limited societal disruptions, the 1935 riots in St. Vincent are a staunch reminder of this risk. Consequently, civil unrest is well-recognised, but other societal hazards such as violence and armed conflict require greater recognition within the national risk planning profile. There is no EWS capacity for both technological and societal hazards.

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Rrespresented	Colour	EWS Components Rrespresented
	C1- Disaster Risk Knowledge		C1- Disaster Risk Knowledge C3- Warning dissemination & Communication
	C2-Hazard detection, Monitoring & Forecasting		C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
	C3- Warning dissemination & Communication		C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings

Figure 18 Status of MHEWS in St. Vincent & the Grenadines.

2.2.17
Suriname

Geological hazards are less common although earthquakes remain an uncommon but present risk. The 2021 Inform Risk Index produces a very low value of 0.1 for earthquake exposure for Suriname[69]. In addition, the country has no direct threat from volcanic hazards. Suriname has no EWS capacity for earthquake, volcanic and landslide hazards. Tsunami risk is, however, higher, producing a value of 3.2 in comparison to earthquakes. The National Coordination Centre for Disaster Relief (NCCR) has the responsibility for disseminating & communicating actionable warnings for potential tsunami impacts to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin to the NCCR, which will relay the warning to the public.

Hydrometeorological hazards are the most common occurrences affecting the country. Although Suriname lies outside the Atlantic hurricane belt, it sometimes experiences rainfall and winds brought on by outer band activities and atmospheric disturbances created by tropical cyclones, especially within its coastal region which borders the Atlantic Ocean. The country is mainly affected by coastal and inland flooding, and many of the disasters in Suriname have been exacerbated by climate change. During April 2021, floods affected all 10 districts of the country, showing severe flooding, not only in the coastal area but also in the interior leading to disruption in services and damages to assets and infrastructure (IFRC 2021). Drought is a major concern for the country, particularly in the agriculture sector. Suriname relies on radar coverage from both French Guiana & Guyana for the detection of meteorological hazards. The Meteorological Service then uses the data to monitor, forecast and issue warnings on hazards to the public. However, EWSs for hydrological hazards are currently working inefficiently. There are therefore networks in place to monitor the risks associated with floods and drought, but these networks are ineffective due to unclear roles and responsibilities. With regards to landslides, mining activities can increase the risks during periods of heavy rainfall.

Environmental degradation is an ongoing challenge, especially in the interior which is characterised by mining. Mining activities are the main drivers of deforestation, as well as land & soil degradation in the country (Government of Suriname 2018). The Foundation for Forest Management and Forest Supervision and the National Institute for Environment & Development are the organisations which manage the risks of environmental hazards. EWS capacity lies with the agencies to detect, monitor, analyse and forecast the impacts of deforestation, land & soil degradation, and biodiversity loss in terrestrial & marine ecosystems. Instances of environmental pollution are specifically monitored and detected by the National Institute for Environment & Development. Mining has significantly contributed to environmental pollution, contaminating creek forests which subsequently flow into the main rivers. Many freshwater resources previously utilised for human consumption are now deemed unsuitable, and the fish populations which inhabited the waters have gradually declined (Rahm et al. 2015). Risks associated with wildfires are managed by the Foundation for Forest Management which utilises the traditional practice of fire patrols for monitoring and detection.

EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Department of Agriculture, Livestock and Fisheries, Ministry of Agriculture, Animal Husbandries & Fisheries performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. To achieve this, the division regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Plant Protection Department regulates the entry of pests through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops,

69 https://www.volcanodiscovery.com/earthquakes/suriname/largest. html

flowers, cuttings, and soil materials. However, there is no EWS capacity to manage the threat of invasive species. The Suriname National Biodiversity Action Plan does not recognise alien invasive species as one of the root causes of biodiversity loss. The most recent iteration of the plan suggests that pressures on biodiversity are relatively minimal and exerted primarily by population growth.

Plans have been developed for near-shore oil drilling by Staatsolie N.V. and off-shore oil drilling by international exploration companies, increasing the risk of oil spill and possible consequences for the marine environment, fish populations, and coastal communities[70]. Other chemical hazards include the risks associated with pesticides which are common in the agriculture sector. Suriname has a National Oil Spill Contingency Plan which was drafted in 2016. The plan details an EWS mechanism for oil spills, identifying the Maritime Authority of Suriname and the NCCR as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. Moreover, Suriname is one of the beneficiary countries of a project coordinated by the BCRC Caribbean to build risk knowledge for POPs through developing an inventory of potentially contaminated sites and conducting risk assessments for selected sites.

Technological and societal hazards constitute the risk profile of the country, though they are less recognised as compared to the common hazards. The financial crisis of 2015 created significant economic fallout, driving the economy into a sharp recession at the time (Khadan 2020). The history of Suriname indicates that between 1986 and 1992, civil war broke out between the maroons and the army[71]. Hundreds of citizens and military personnel were killed, as the disruption resulted in the damage and destruction of interior assets including roads, schools, health facilities and electricity and water infrastructure. Consequently, there is a need for violence and civil unrest to be included in the national risk context. There is no EWS capacity for technological and societal hazards.

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
	C1- Disaster Risk Knowledge		C3- Warning dissemination & Communication
	C2-Hazard detection, Monitoring & Forecasting		C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication

Figure 19 Status of MHEWS in Suriname.

70 https://www.staatsolie.com/en/news/main-contracts-staatsolie-nearshore-drilling-project-successfully-tendered-and-awarded/

71 https://humanityhouse.org/en/rampen-conflicten-suriname-binnenlandse-oorlog-1986-1992/.

2.2.18
Trinidad & Tobago

The Office of Disaster Preparedness & Management (ODPM) recognises earthquakes, mud volcanoes and landslides as geological hazards which can potentially affect the country. Major fault lines associated with the interaction between the Caribbean and South American plates pass through the landscape of Trinidad. These faults have the potential to cause large magnitude earthquakes. With the impact of earthquakes, there is the risk of tsunamis as a secondary impact. Having fulfilled the requirements of the Pilot Community Performance Based Tsunami Recognition Programme implemented by the UNESCO/IOC, Carenage, Diego Martin received recognition as tsunami-ready in June 2020[72]. Outputs included the creation of inundation and evacuation maps, as well as the provision of communication equipment, and signage for evacuation routes, assembly points and tsunami hazard zones. The ODPM has the responsibility for disseminating & communicating actionable warnings to the public as the official source. In the instance that an earthquake triggers a tsunami which will potentially impact the country, the PTWC will issue a bulletin to the Trinidad & Tobago Meteorological Service, which will then forward the information to both the ODPM and the Tobago Emergency Management Agency (TEMA). Landslide risks are also present through rock falls, topples, and the lateral flows of soil materials. ODPM serves as a repository for landslide risk assessment data at the national level.

The geographical location of Trinidad & Tobago places it to the south of the Atlantic Hurricane Belt. The direct impact of tropical cyclones is therefore less frequent in comparison to other states situated within the belt. Flooding presents the greatest hydrometeorological risk. During the wet season, intense or prolonged rainfall events can trigger landslides along the slopes of mountains and flooding in low-lying urban regions. Flood risks have been exacerbated by the significant increase in informal urban settlements on flood prone areas of the capital city and other unsustainable land management practices, which typically reduce forested and green spaces which promote the infiltration of rainfall. (Clarke et al. 2019). The Trinidad & Tobago Meteorological Service manages a Doppler Radar System which provides capability in detecting, monitoring, and forecasting hydrometeorological hazards. Issues presented by drought contribute to the disruption of livelihoods and are projected to intensify due to the continuous onset of climate change. Beharry et al. (2019) note that between 2001 and 2010, the four (4) main reservoirs in Trinidad and Tobago recorded lower than average water levels. The meteorological service is guided by a drought policy which addresses hydrological, agricultural, and socio-economic drought through the application of the Standard Precipitation Index (SPI) for monitoring and forecasting local dry spells and meteorological droughts. Colour-coded CAP early warnings include drought as one of the hazards for which warning notifications are issued. The meteorological service also issues monthly rainfall projections for all the water resource reservoir sites. The meteorological service also has the responsibility for disseminating warnings to the public. With regards to disaster risk knowledge, the ODPM manages and maintains national risk assessment data for floods and landslides.

In addition to the effects of climate change, anthropogenic activities are the primary contributor to environmental hazards which impact Trinidad & Tobago. Deforestation, unregulated urban development, indiscriminate burning, improper solid waste disposal and the overuse of synthetic chemicals in the agricultural sector all contribute to the issues experienced. The Forestry Division and the Environmental Management Authority collaborate as the public agencies mandated by legislation to manage the risks of environmental hazards. EWS capacity lies with the agencies to detect, monitor, analyse and forecast the impacts of deforestation, land & soil degradation, and biodiversity loss in terrestrial & marine ecosystems. Environmental pollution is specifically monitored by the Environmental Management Authority (EMA), while forecasts regarding air quality and dust haze are developed by the Meteorological

72 http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=2112&Itemid=3279.

Service. Furthermore, the meteorological service has capacity to detect and monitor volcanic ash as well as sulphur dioxide gas via the use of infrared technology. The EMA has responsibility for the dissemination of actionable warnings regarding pollution to the public. In addition, the Forestry Division has capacity to detect and monitor wildfires through traditional methods, including but not limited to fire patrols and watches from observation towers.

The Vulnerability & Capacity Assessment (Clarke et al. 2019) acknowledges pandemics and epidemics as well as water-borne diseases and transboundary vector-borne diseases such as Zika, Chikungunya, Malaria, Dengue, and diarrheal-related infections. Furthermore, the assessment recommends that national health systems be restructured to handle the large number of persons that can be infected when there is an outbreak. EWS capacity for human pandemics & epidemics is managed by the Ministry of Health, which is mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Animal Production & Health Division, Ministry of Agriculture, Lands & Fisheries performs a similar function of detecting, monitoring, and analysing the risk of new diseases which have the potential to impact livestock and domesticated animals. To achieve this, the division regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. Similarly, the Plant Quarantine Service regulates the entry of pest through a system of certification, inspection, and analysis at airports for agricultural commodities including but not limited to crops, flowers, cuttings, and soil materials. There is the recognition of invasive species as a significant threat to biodiversity in the national biodiversity strategy & action plan. Trinidad & Tobago has an existing database of invasive alien species according to classification, taxonomy, and the status of impact on the biodiversity of the islands. One of the limitations of the database is the lack of photographs to aid identification, as well as description and photos of similar species to avoid confusion or misidentification (Hosein 2011). On the other hand, there is no EWS for monitoring & surveillance in-country as well as communication with neighbouring countries and, where appropriate, trading partners. An Invasive Alien Species Strategy for Trinidad & Tobago was proposed by Hosein (2011) which makes recommendations for the establishment of an early detection system, identifying the agencies which would be involved in operating and maintaining the system.

Technological hazards identified include infrastructure failures, major transportation accidents, explosions, and fires. Trinidad & Tobago is the largest producer of oil and natural gas in the Caribbean, with a petroleum sector involved in the exploration of oil & gas within the land and shallow water environments. As a result, the state is exposed to the threat of significant spills, leaks and emissions of gases, chemicals, and other toxic substances. The transport of oil via sea has also proven to be a risk as evidenced by the threat of an oil spill in the eastern Gulf of Paria near the maritime border with Trinidad and Tobago. In 2020, the FSO Nabarima (Floating Storage and Offloading unit), operated by Venezuelan oil company Petróleos de Venezuela (PSVSA) began to experience challenges. Having been abandoned in the Gulf of Paria since 2019 with 1.3 million barrels of crude oil, the ballast system valve of the vessel failed, causing the vessel to lean to its starboard side. However, The PSVSA took steps to offload the oil from the tanker, thus averting the crisis[73]. A National Oil Spill Contingency Plan for Trinidad & Tobago was approved by the cabinet in 2013. The plan details an EWS mechanism for oil spills, identifying the Trinidad & Tobago Coast Guard and the Ministry of Energy Affairs as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. In the second instance, Trinidad & Tobago is one of the beneficiary countries of a project coordinated by the BCRC Caribbean to build risk knowledge for POPs through developing an inventory of potentially contaminated sites and conducting risk assessments for selected sites.

Societal hazards are identified in the form of looting, terrorism, cybercrime, and the interruption of critical services such as telecommunication and power failures. However, there is a need to consider emerging risks due to climate change to socio-economic development. Within the past five (5) years, coastal erosion specifically has resulted in the displacement of coastal communities and prompted the relocation of several households. Notwithstanding, there is no EWS capacity for technological and societal hazards.

73 https://oilnow.gy/featured/guyana-caribbean-agencies-monitoring-venezuelan-oil-tanker-on-verge-of-sinking-near-trinidad-tobago/.

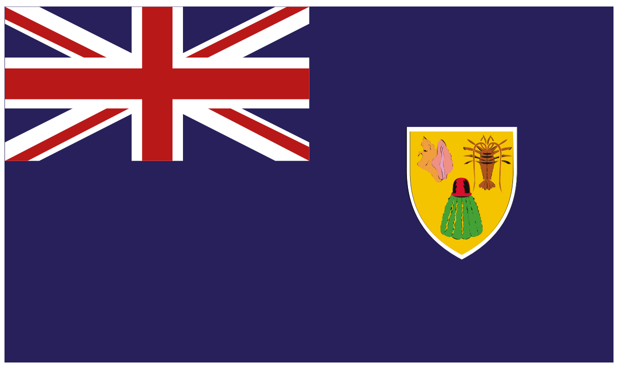
GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
	C1- Disaster Risk Knowledge		C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
	C2-Hazard detection, Monitoring & Forecasting		C1- Disaster Risk Knowledge C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication
	C3- Warning dissemination & Communication		C1- Disaster Risk Knowledge C3- Warning dissemination & Comunication C4- Preparedness for response to warnings

Figure 20 Status of MHEWS in Trinidad & Tobago.

2.2.19
Turks & Caicos Islands (TCI)



Though the TCI is located within the seismically active Caribbean region, the country is not as susceptible to earthquake hazards, based on its topography and location. Despite this, the state has a seismological station which comprises the GSN, situated north of Grand Turk Island. Under the management of the Department of Disaster Management & Emergencies (DDME), the the sensor is a Kinemetrics FBA ES-T EpiSensor Accelerometer which serves as a multi-use scientific facility and societal resource for earthquake monitoring, research, and education. In contrast to earthquake hazards, the TCI is highly susceptible to tsunamis. There is an established mechanism for communicating actionable warnings to the public on tsunamis. If an earthquake triggers a tsunami, the PTWC will issue a bulletin to the 911 Centre, which will then forward the information to the Department of Disaster Management & Emergencies (DDME) for public dissemination. Volcanic and landslide hazards are virtually non-existent due to the absence of volcanoes on the islands, the large distance from islands with active volcanoes and the homogenously flat terrain of the islands.

In contrast, the risks associated with hydrometeorological hazards are significant, as the TCI lies within the trajectory of tropical storms and hurricanes which pass through the Atlantic. Tropical cyclones bring the secondary impacts of wind damage, flooding, and storm surge. During 2008, the country was affected by two (2) tropical cyclones, Hurricane Hanna, and Ike (ECLAC 2008). Hurricane Ike posed a significant threat, passing south of the TCI as a Category 4 system. In response, hazard assessments were developed for wind and flood hazards, as well as a model for the potential inundation of critical infrastructure due to storm surges. Beyond disaster risk knowledge, the TCI is dependent on the meteorological services of the Bahamas for the detection, monitoring and forecasts of potential hazards which may impact the island. This is facilitated by an agreement through the WMO Regional Association IV Hurricane Committee. The Bahamas therefore takes responsibility for issuing warnings regarding adverse weather conditions to the TCI through its meteorological department.

For environmental hazards, the Department of Environment & Coastal Resources (DECR) offers detection, monitoring, and analytical services for managing risks associated with biodiversity loss, pollution, and land & soil degradation. The mandate of the DECR is to ensure the sustainable use of the natural resources of the TCI, and to protect and promote biodiversity and economic development through a sustainable fisheries industry and a national system of Protected Areas. Three (3) divisions which are the Protected Areas Division, the Fisheries Division and Maritime Affairs, collaborate to enhance coverage across terrestrial and marine ecosystems.

Over the past two (2) decades, the TCI experienced several biological emergencies in the form of communicable disease outbreaks. The included an outbreak of the Influenza A H1N1 virus in 2008, Tuberculosis from 2010 to 2011, hand, foot, and mouth disease in 2012, and the Norovirus in 2012[74]. More recently, COVID-19 has impacted the islands through the transboundary movement of persons. The Ministry of Health manages EWS for human pandemics & epidemics, being mandated by legislation to detect, monitor, analyse & forecast the risk of new diseases as well as to communicate actionable warnings & possible consequences to the public. The Department of Agriculture has overarching responsibility for managing risks associated with animal and plant health. The department is broken down into two (2) divisions which manage EWS mechanisms for animals and plants. The Animal Health Services Division detects, monitors, and analyses the risk of new diseases which have the potential to impact livestock and domesticated animals. The division regulates the potential entry of disease through a system of certification and inspection of animals and animal by-products. On the other hand, the Plant Health Services Division employs a similar approach to managing the risk of pest infestation at airports for agricultural commodities including but not limited

74 https://eird.org/pr12/documentos/presentaciones/04-declaraciones-oficiales/paises-declaraciones/Turks-and-Caicos-Islands_PR12.pdf.

to crops, flowers, cuttings, and soil materials. There is no EWS capacity to manage the threat of invasive species

The TCI has a National Oil Spill Contingency Plan which was operationalised in 1996. The plan details an EWS mechanism for oil spills, identifying the Office of the Commissioner of Police and the Office of Disaster Preparedness (now known as the DDME) as the agencies responsible for detection & surveillance, and the dissemination of public warnings respectively. Both technological and societal hazards lack due consideration in the national landscape and there is no EWS capacity under these hazard classifications.

GEOLOGICAL HAZARDS	HYDRO-METEOROLOGICAL HAZARDS	ENVIRONMENTAL HAZARDS	BIOLOGICAL HAZARDS	CHEMICAL HAZARDS	TECHNOLOGICAL HAZARDS	SOCIETAL HAZARDS
1. Earthquake	1. Tropical Cyclone/ Tornado	1. Deforestation	1. Human Epidemics & Pandemics	1. Oil Pollution	1. Boat/ Road/ Air crash/ Accidents	1. Civil Unrest
2. Tsunami	2. Flood	2. Land & Soil Degradation	2. Animal Epidemics & Pandemics	2. Persistent Organic Pollutants	2. Infrastructural Failures	2. Violence
3. Volcanic Eruption	3. Storm Surge	3. Biodiversity	3. pest Infestation		3. Fires	3. Financial Shock
4. Landslide	4. Drought	4. Environmental Pollution	4. Invasive Species		4. Explosions	
	5. Cloudburst	5. Wildfires			5. Spills & Leaks	
	6. Landslide					
	7. Heat & Cold Wave					

LEGEND

Colour	EWS Components Respresented	Colour	EWS Components Respresented
(light blue)	C1- Disaster Risk Knowledge	(dark blue)	C3- Warning dissemination & Communication
(blue)	C2-Hazard detection, Monitoring & Forecasting	(green)	C2- Hazard detection, Monitoring & Forecasting C3- Warning dissemination & Comunication

Figure 21 Status of MHEWS in the Turks & Caicos.

3.0 REGIONAL ADVANCEMENTS OF MHEWS IN THE CARIBBEAN

Historical information indicates that there was no methodological or articulated mechanism guiding the evaluation and implementation of EWS in the Caribbean prior to the year 2000. In fact, the attempt to analyse the status of EWS, and delineate key principles & standards was undertaken in 2003, resulting in the "Early Warning Systems in the Caribbean: A Desk Review" report for the Second International Conference on Early Warning in Bonn (Gazol 2019). Since then, the region has continued to make steady progress in developing an overarching framework for EWS. In 2022, the UNDRR indicated that eight (8)[75] Caribbean countries reported the existence of national MHEWS and disaster impact databases, as the organization pursues and monitors the target of global MHEWS coverage under the Early Warning Systems for All Initiative. The countries which reported MHEWS coverage were Anguilla, the British Virgin Islands, the Cayman Islands, Martinique, Guadeloupe, Puerto Rico, Trinidad & Tobago, and the Turks & Caicos Islands. It is important to note that the report implies that not all countries submitted reports, further implying that more Caribbean countries have MHEWS capacity as reflected by this study. Notwithstanding the official figures, these advancements have contributed to the reduction of risks and losses during decades characterised by greater intensity of disasters and the retardation of socio-economic development. One of the primary reasons for the progression has been the introduction of the CDM Strategy 2014-2024 which prioritises integrated, improved, and expanded community EWS. The following sections detail some of the major achievements for MHEWS in the Caribbean in the past two (2) decades.

75 https://www.undrr.org/publication/global-status-multi-hazard-early-warning-systems-target-g

3.1 The Strategic Roadmap for Advancing MHEWS

CDEMA continues to advance MHEWS in its PSs, employing a bottom-up approach by focussing on community-level EWS. The basis of the approach is to build out national capacity by ensuring that all communities have access to EWS mechanisms. CDEMA leads the application of the MHEWS Checklist across PSs, a practical tool comprising major components and actions that national governments, community organizations and partners within and across all sectors can refer to when developing or evaluating EWS. In addition, CDEMA leads the development of national Roadmaps, which details country-specific gaps within the EWS framework and the activities which should be undertaken to address the gaps identified. To date, a total of seven (7) Roadmaps were completed for CDEMA PSs[76]. The implementation of Roadmaps activities was impacted by the onset of the COVID-19 pandemic across the board. However, some PSs still managed to begin targeted activities during the pandemic, where human and financial resources were available.

According to Evanson (2021), Dominica was able to commence the expansion of its hydrometeorological network and the construction of a new meteorological office under the World Bank "Disaster Vulnerability Reduction Project", while also starting repairs and/ or maintenance for existing EWS equipment which may have been damaged during the passage of Hurricane Maria or by other means. Saint Lucia reported progress with the development of a National Flood & Drought Committee, the procurement of new hydrological equipment and the acquisition of common alerting protocol compliant sirens for four (4) communities. For Antigua & Barbuda, emphasis is being placed on increased Geographic Information System (GIS) capacity through the training of personnel and the procurement of equipment. In addition, a survey is underway to map the reach of various channels for emergency messages and emergency response plans are being updated.

As of December 2021, CDEMA had 20 PSs following the addition of St. Maarten in the same year. Therefore, 13 Roadmaps are to be developed to guide EWS development activities within the remaining PSs. One of the notable developments to support EWS roadmap implementation was the conclusion of an agreement in principle between the Caribbean Development Bank (CDB) and CDEMA, for the Disaster Management Strategy & Operational Guidelines (DiMSOG) programme to provide an alternative source of funding for overseas territories (OTs). In previous years, restrictions on OTs to receive financial assistance through mechanisms such as the European Development Fund (EDF) proved to be a significant hindrance to advancing the CDM agenda in these states. However, it is anticipated that DiMSOG will be accessed to fund Country Work Programme (CWP) and EWS Roadmap development, as the CDB and CDEMA collaborate to advance the disaster risk reduction (DRR) agenda for all PSs of the region.

76 MHEWS Roadmaps were completed for Antigua & Barbuda, Barbados, Dominica, Guyana, Saint Lucia, St. Vincent & the Grenadines, and Trinidad & Tobago.

3.2 The Regional Early Warning System Consortium (REWSC)

In 2016, a recommendation was made to establish a regional stakeholder mechanism related to EWS. The mechanism would serve to address the lack of a governance framework for EWS in the region. Three (3) years later, the REWSC was officially established during the 11th Comprehensive Disaster Management (CDM) Conference held in December 2019 in St. Maarten. According to its terms of reference (TOR), the overall goal of the consortium is to serve as a strategic and advisory body for the advancement and strengthened coordination of EWS within the Caribbean region, with an initial focus on natural hazards considering the realities of a changing climate. The REWSC is comprised of several multi-hazard organisations, with the technical expertise and mandate to support and coordinate the strategic vision for EWS. Under the chairmanship of the Caribbean Disaster Emergency Management Agency (CDEMA), such organisations include but are not limited to the Caribbean Agricultural Research and Development Institute (CARDI), Caribbean Community Climate Change Centre (CCCCC), the Caribbean Institute for Meteorology and Hydrology (CIMH) and the Caribbean Public Health Agency (CARPHA).

More specifically, the organisations have responsibility for developing standards across the pillars of EWS such as the creation of risk and vulnerability assessments, thereby streamlining methodologies, systems, protocols, and operations across the region. This is made possible by the fact that organisations have access to international best practices, knowledge sharing, and resources through close collaboration with global partners. The TOR requires the members of the REWSC to convene a minimum of two (2) meetings per year, with the option of having additional meetings if deemed necessary. However, since the official launch of the consortium, meetings have been infrequent and inconsistent due to a combination of factors. Such contributing factors include the impact of the COVID-19 pandemic, competing intra- and inter-organisational demands, a lack of the identification of agency focal points, and time constraints on organisation representatives.

3.3 Exploring sustainable mechanisms for financing

Statistics indicate that the level of investment for projects designed to address gaps in EWS capacity in the region has significantly increased. According to Rahat (2020), the annual estimated investment increased from US $5.72 million over the period 2005-2015, to US $10.53 million over the period 2015-2020. This corresponds to an increase of 54.32% per year between the two (2) time periods. One of the primary reasons for the increase has been the increased support from donor organisations such as the World Bank (WB), US AID, and the European Union (EU) in funding national level projects. Several authors attribute the attraction of investment from donors to the groundwork which was laid in raising awareness to the need for enhancing EWS frameworks in Latin America & Caribbean through reports and events such as the convening of the first MHEWS Conference, held as part of the Global Platform in Mexico. Additionally, the increase in investment has coincided with the expansion in capacity for the provision of services and products by REWSC members. The primary indicator of this observation is that the bulk of investment during 2015-2020 was geared towards improving Pillar 2: Detection, monitoring, analysis & forecasting of hazards and possible consequences. For example, Rahat (2020) notes that the CIMH was designated as a regional climate centre by the World Meteorological Organisation (WMO) in 2017, attracting greater investments to meet the increasing demand for hydrometeorological products & services from relevant consumers in the region. One of the results of the investment was the expansion of hydrometeorological networks across the region, to improve the accuracy of modelling climatic outcomes by increasing the amount of data generated & collected. In turn, this boosted the detection, monitoring, analytical and forecasting capacities of the CIMH and national meteorological offices to manage hydrometeorological hazards.

While EWS-related projects continue to benefit from increased investments, the regional agencies which serve to manage, coordinate, and execute the projects are typically understaffed and limited by financial constraints. In most instances, CARICOM agencies are dependent on the financial contributions of the member states that they serve to support their main budgets. In situations where member states were already struggling to meet contributory commitments, the impact of the COVID-19 pandemic further exacerbated the significant losses to the agencies. Consequently, there has been a notable shift to relying on donor funding to fulfil respective mandates in recent years. However, the major issue is that the funding offered is tied to short- or medium-term projects. This usually results in the high turnover rates of staff members and a lack of continuity in the planning, coordination, and execution of activities. Considering the volatile, global economic climate which continues to persist in the aftermath of the pandemic and the current impact of civil unrest, it is likely that donor funding will be impacted further. Therefore, there is a need to develop sustainable models for financing, which allow regional agencies to be self-sufficient in acquiring the physical and human resources they need to meet their demands.

3.4 Expansion of the scope of hazards

There is a need to continue to increase the number of hazard classifications for which EWS capacity exists. The region was reminded of this need during the events of 2021 which featured the on-going biological threat of the COVID-9 pandemic, the eruption of the La Soufriere volcano eruption and the secondary impacts of ashfall, an earthquake in Haiti which accounted for the loss of lives and the annual impacts of flooding and tropical cyclonic systems.

EWS projects have begun to address the multi-hazard context of the Caribbean. Rahat (2020) noted that during the 2015-2020 period, there were at least seven (7) medium-to-large size projects launched to address multiple hazards, through funding by the EU and the WB. Other projects prior to the period targeted tsunamis, volcanic hazards, food security, marine management, and the health sector with a specific focus on managing the Aedes aegypti mosquito. Furthermore, it should be noted that projects have evolved from simply modelling, monitoring, and predicting hazards, to include the consequent impacts & effects of the hazards. Impact-based forecasting has become a common theme among projects such as the Climate Risk & Early Warning Systems (CREWS) Caribbean project, the Enhancing Weather & Climate Early Warning Systems and Impact-based Forecasting Platforms in the Caribbean Region project, and the Expanded Weather & Climate Forecasting and Innovative Product & Service Development & Delivery in the Caribbean project (Rahat 2020).

3.5 Greater inclusivity & accessibility of MHEWS

The indicators all point to the need for the development of specialized media channels to recognise and reach specific vulnerable groups. Evanson (2021) makes mention of individuals with disabilities such as individuals with visual or hearing impairments especially those in poor rural communities, physically challenged persons living alone, and those with language, literacy, and other physical and psychological impairments. This was further extended to women and individuals residing in remote geographical locations where EWS may not be connected to the national system or may not exist. In this context, achieving complete coverage for the communication of warnings continues to allude CDEMA PSs, particularly due to financial limitations.

In response to this, gender considerations have become more prevalent in EWS frameworks. Of note was the completion of the model national MHEWS policy and adaptation by CDEMA, following validation and finalisation with gender considerations integrated into the policy. Subsequently, the model policy was adapted and piloted in Saint Lucia in 2019. One of the main objectives of the project was to promote the integration of persons with disabilities into EWS. Workshops were convened with activities that included sign language training, visual impairment awareness and practical exercises in guiding and transporting persons with disabilities and the elderly. During the workshops, awareness among persons with disabilities was raised as to how to respond to warnings of impending disaster and post-disaster responses. Participants engaged in disaster and shelter exercises as practical ways to explain the information shared. The workshops were led by NEMO with the support of District Disaster Committee members, the National Council on and for Persons with Disabilities (NCPD), Saint Lucia Blind Welfare Association, Lady Gordon Opportunity Centre, and the Special Education Unit in Vieux Fort. It is anticipated that the project will be duplicated in other CDEMA PSs to further promote the trend of gender inclusion and greater accessibility to EWS for the disabled community.

4.0 REVIEW OF MHEWS ISSUES

Research has been done in recent times on the progress of early warning systems in the Caribbean Region, including a discussion on issues faced by existing regional efforts. The following sections provide a review of the literature on the challenges that have been found to hinder the advancement of comprehensive EWS development and implementation in the Caribbean region. This review compiles the findings of reports completed by local consultants, regional agencies, and international organisations during the period 2011 to 2022. Several consistencies in the findings were found and as such their findings have been categorised into overarching themes under each heading.

4.1 Governance

Reports on EWS in the Caribbean revealed that weaknesses in regional governance structures contribute significantly to disaster vulnerability at the local, national, and regional levels (UNDP 2013; Mahon et al. 2015; CDEMA 2016; Williams 2018). These challenges include the absence of legislative, regulatory and policy frameworks on MHEWS, poorly defined roles and responsibilities of important actors, inadequate or absent data governance mechanisms, narrow stakeholder participation and limited finances to implement and maintain MHEWS.

In several countries of the region, early warning systems are governed by antiquated legislation which does not incorporate the all-hazards, all-agencies approach outlined in CDEMA's Comprehensive Disaster Management (CDM) strategy. In many cases, CDM laws have been drafted but are not enacted (Fontaine 2018; EWSS 2018; Alphonse 2018; ODPMTT 2021). The absence of enacted legislation weakens the ability of key actors to perform their roles and creates ambiguity in authority and responsibilities. For example, in St. Vincent and the Grenadines, the National Emergency Disaster Management Act (2006) does not adequately address the dissemination of emergency alerts via the media. As such, there is uncertainty about whether NEMO can interrupt a radio station to broadcast an alert (EWSS 2018).

Additionally, countries lack relevant agreements, protocols and standards on systemic data collection, exchange, and assessment (Williams 2018). This foments a 'silo' approach to the management of risk data. It also presents challenges for the maintenance of current and accurate data on hazards, vulnerability, capacity and assessment and results in the exclusion of traditionally marginalised groups such as women and the elderly in key decision-making processes (CDEMA 2016).

While stronger political will is necessary to address these governance challenges, financial resources are equally important. However, due to their fragile economies and high debt burdens, Caribbean countries lack the financial resources to effectively manage disaster risk (WB 2018). This includes the implementation and effective governance of MHEWS. This scarcity of resources has implications for other important aspects of EWS as governance is a cross-cutting theme across all components.

4.2 Disaster Risk Knowledge

MHEWS are driven by risk knowledge. Sound knowledge of a country's risk profile including the hazards which are likely to occur at a given time, the people who are likely to be impacted and the extent of the impact is necessary for early warning and early action. In the Caribbean region, issues related to hazard identification, risk assessment and information consolidation present challenges to the effective operation of MHEWS (Pelling 2011; Collymore 2016; Alphonse 2018).

Hazard identification is one of the primary steps in establishing a MHEWS. This includes the evaluation of historical hazard data such as magnitude, intensity, and probability; it also involves assessments of multi-hazard scenarios and cascading events and the translation of these assessments into preparedness scenarios (UNDRR 2022). For several countries in the region, this is a challenge. Alphonse (2018) noted that constraints in human resource capacity limit analysis of key hazard characteristics in Saint Lucia. Pelling (2011) also highlighted similar challenges in Guyana, and Williams (2018) emphasised the need for updated historical and current hazard data in Antigua & Barbuda. Hazard mapping is also a key aspect of hazard identification. However, the lack of authoritative and properly documented base spatial data for hazard maps is one of the key challenges identified by a 2020 situational analysis of Caribbean MHEWS. The study defines base spatial data as products such as soil classification maps and digital elevation models (DEMs) which are used to create hazard maps such as flood and landslide risk maps. However, steep topography and dense vegetation in many Caribbean islands present challenges for creating accurate risk maps. Additionally, many countries lack enforced standards for data collection, thus leading a lack of trust in datasets.

The region also faces challenges in the assessment of disaster exposure, vulnerabilities, and capacities. While such assessments have been carried out by various stakeholders and at various levels, they often omit important factors. For example, population vulnerability assessments often fail to consider issues related to gender, disability and economic diversity and lack the integration of indigenous and cultural knowledge (UNDP 2013; Alphonse 2018; EWSS, 2018; Fontaine 2018). Furthermore, assessments are often inaccessible and incomprehensible to those who are most at risk (Collymore 2020) and there are no assessments of critical infrastructure and critical services in some countries (Alphonse 2018). These assessment gaps result in the omission of key risk and capacity information in preparedness plans.

Furthermore, countries in the region face limitations with the consolidation of risk information, due to a lack of data infrastructure to support this process. In many cases, data is collected and stored by multiple agencies, but there is no national repository for storing risk information (Fontaine 2018). Alphonse (2018) noted that a common portal for multi-hazard risk assessment data in Saint Lucia would facilitate evidence-based planning and decision-making and would also allow data to be easily updated and stored in a secure manner. Disaster risk knowledge is of great importance to the region given the increasingly complex nature of risk. Challenges in hazard identification, risk assessment and data consolidation directly affect the efficacy of other MHEWS components including forecasting, monitoring, detection, communication, and response.

4.3 Forecasting, Monitoring & Detection

In the region, the capacity to forecast, monitor and detect hazardous events varies by hazard. This capacity also, as expected, varies at regional and local levels. However, some consistent limitations and obstacles to implementation were found across the reviewed literature and are discussed below.

4.3.1 Technology Limitations

Properly maintained, built-for-purpose technology was seen to be a major obstacle to EWS development. A 2018 report conducted for the Commonwealth of Dominica indicated that technical specialised equipment is limited and only moderately suited to local conditions as some are easily subjected to weathering, destruction by flood, vandalism and other man-made and natural events that are experienced in the region. The impact of multiple hazards, looting and vandalism resulted in multiple pieces of equipment needing replacement and upgrades (Fontaine 2018).

When the technology is available, software and data analysis for the received data is rarely updated periodically and are not typically conducted using high security standards (Fontaine 2018). Additionally, it was found that where the systems exist, they are minimally subjected to regular system-wide testing for functionality. Some countries in the region lack modern monitoring and communication systems that are commonly used in EWS such as Doppler radars, real-time weather monitoring stations. For example, in a 2018 study based on Saint Lucia, it was noted that while the relevant authority has the capacity to provide limited real-time data regarding hydrometeorological events, it is only at one location. Another technological challenge that was observed was the lack of compatibility within the existing systems. Monitoring networks therefore comprised of equipment of different incompatible brands with varying functionalities (Alphonse 2018).

It was noted that in some countries, despite the EWS monitoring systems being relatively sophisticated, there were no central command bases where data alerts from these systems were captured promptly and addressed by local staff. Archival and further analysis of these data alerts were found to be minimal (Fontaine, 2018). Maintenance of EWS equipment poses a challenge. Operation and maintenance budgets assigned to the equipment were found to be insufficient to assure sustainability of hardware and software and as such there is a reliance on donor funding, when available, to make required technical improvements (Alphonse 2018). This leaves systems vulnerable to obsolescence. In the literature, it was noted that where systems do exist, the scientific integrity of monitoring methods and data analysis requires further assessment by technical specialists (Williams 2018). However, due to institutional capacity gaps and budget constraints, this expertise may not be readily available.

Regionally, the infrastructure that supports the technology was also seen to create an obstacle. For instance, where systems were established, there were inconsistent electricity supplies and there is a need for back-up power supplies, equipment contingencies, redundancies and 24-hour staffed personnel on shifts.

4.3.2 Cost of Establishment and Maintenance of Forecasting Systems

Another common obstacle, related to but not limited to the technology required for effective forecasting and hazard monitoring, is the cost involved in establishing and maintaining the EWS. High operational and maintenance costs have resulted in sustainability issues regarding the consistency of data collection and there are no sustainable financing options in place due to limited budgetary allocation (Alphonse 2018; Fontaine 2018). As the maintenance of monitoring hardware and software is addressed on an ad-hoc basis there is a limited annual budget assigned for routine maintenance. Ad-hoc maintenance of the equipment is also attributed to most EWS equipment being installed on donor contributions as opposed to internal funding.

4.3.3 Data Collection and Analysis Limitations

A challenge observed, with regards to comprehensive hazard detection and monitoring in the region, is the quality, accuracy, reliability, and comparability of data obtained by EWS and related field data collection. Weaknesses that exist in the current data collection and data analysis processes in the field must be addressed so that data regarding hazards is compatible with predictive tools. Limitations in data collection were also noted as appropriate specifications for data collection are documented only for certain hazards (Alphonse 2018). For instance, standard precipitation indices from meteorological authorities may be widely used, however, even for those established data points, notes that there were weaknesses in data collection processes like the collection of hydrological data in the remote countryside with no daily quality control protocols.

The EWS research also noted that there was no standard method or tool for the interpretation of hazard forecasting information after it is received and processed from the different monitoring networks and in most cases, the data from established data points is not made available for the conduct of further studies or assessment or comparison (DIPECHO 2018). The lack of data sharing and research in the area has resulted in improperly monitored hazards and insufficient risk knowledge and limited sector-specific climate indices and impact models for the Caribbean context (Lumbroso, Brown & Ranger 2016).

4.3.4 Institutional Capacity Limitations

The lack of resources available for sustainable operations of EWS was commonly identified as a challenge in the studies reviewed and is reflected in the lack of institutional capacity at the organisational level to maintain best practice EWS protocols in the long term.

In the studies reviewed, it was noted that in many countries, there is no established central repository of natural event and hazards for the country (Alphonse 2018). It was noted that where EWSs do exist most staff are trained and operate on a standby 'on-call' basis after regular work hours. It is noted as well that in these institutions, with oversight of the EWS; there is no dedicated support for EWS implementation and routine maintenance within the core staff. Key personnel are often trained on-site to conduct maintenance as opposed to using routine trained technicians (Fontaine 2018).

In addition to the limited capacity to ensure long-term EWS, with the added threat of more intense events due to climate change, the threat of multi-hazard events has also increased. Yet there are limited established multi-hazard detection and forecasting systems in the region.

The 2018 "Multi-Hazard Early Warning Systems Gaps Assessment Report for the Commonwealth of Dominica" noted that the multi-hazard coordination strategy to obtain mutual efficiencies and effectiveness among different warning systems is minimally and informally in place and cannot be found in any specific document or regulations in the country. More regional research and development is needed to improve observations, monitoring, data processing, modelling, forecasting and prediction and related applications (Luchter, et al. 2017).

4.3.5 Weak Coordination Mechanisms

In addition to the technical limitations such as outdated hazard monitoring hardware & software, poor coordination within and among agencies and insufficient skilled dedicated human resources contribute to poor hazard monitoring (UNDP 2020). Clear roles and responsibilities of the different institutions and agencies involved in hazard detection and forecasting are not described or mandated by existing national legislations. The report of the WMO entitled "Concerted International Efforts for Advancing Multi-hazard Early Warning Systems: Advancing Culture of Living with Landslides" notes a lack of policy and legal frameworks to ascertain authority and accountability within the region. This only increases the limitations of responsible agencies and the lack of coordination between agencies, regionally and locally (Luchter, et al., 2017).

Agreements and interagency protocols that would ensure consistency of language and identify responsibilities under the EWS are quite minimal and/or lack sufficient depth (Fontaine, 2018). This suggests a lack of strategic planning regarding EWS which is supported by the minimal to moderate level of expert-endorsed formal plans and documents for monitoring networks within the relevant organizations.

4.4 Warning and Dissemination

One of the key elements in any Early Warning System is the generation of warnings and the dissemination of pertinent information to populations likely to be affected. The efficacy of these warning and dissemination strategies, while highly dependent on the level of forecasting, detection, and monitoring of hazards available, is also highly dependent on the suitability of the communication systems in place and whether the affected stakeholders have equitable access to information being disseminated. Insufficient and improperly designed warning messages, inadequate synchronization among warning messages, weak feedback mechanisms (among communities, warning issuers and the media), and insufficient evaluation of communication strategies pose challenges to the warning, dissemination, and communication of hazards regionally (UNDP 2020).

4.4.1 Poor Communication Strategies

There is an urgent need to switch from the current forecasting paradigm to a new paradigm that stresses issuing warnings focused on likely impacts (WMO 2018). This overall shift in communications requires better articulation of communication strategies among EWS issuers. Inadequate inter-agency communication and coordination that span community, national, regional, and international levels result in the dissemination of warning messages and hazard information not reaching the desired stakeholders in a timely, coherent, and thus effective manner (IFRC 2012; Collymore 2015; UNDP 2019).

Past experiences show that there is a need for greater utilisation of amateur radio users and community alerts via social media (UNDP 2020). There is a challenge in communicating with the public in a timely manner due to reliance on cellular phones, which are often rendered inoperable during the impacts of hazards like tropical cyclonic. HAM radios and satellite phones have limited use regionally (Williams 2018). There is therefore a need for instruments, technologies, and physical resources available to meteorological and disaster management personnel to disseminate information in a timely manner (Heikinheimo, 2012).

It is CDM best practice that warnings and advisories should be designed for all potentially affected populations including the language of indigenous peoples, remote communities, and the public. More specifically, language barriers have compromised the reach of early warnings to indigenous people and migrant populations, which has been an emerging issue for countries such as Guyana and Trinidad & Tobago. However, there appears to be no formal evaluation method to assess/evaluate current communication strategies being implemented to ensure that messages are reaching the population, particularly people in vulnerable conditions and indigenous populations (Williams 2018). There is a need for the development of appropriate local level communications protocols aligned with standardized data across countries.

4.4.2 Low Data on the Accessibility of Warnings

An important element of any EWS is ensuring that the warning messages from the systems are disseminated not only widely, but in a manner that can be understood and accessed by all potentially affected populations. However, as observed from the literature review, there is no explicit process in place to verify that when issued, the subsequent warnings have reached stakeholders. This is of particular concern with regards to vulnerable populations. There are minimal strategised processes to ensure that warnings have reached all principal stakeholders (Fontaine 2018). Vulnerable groups and persons with vulnerabilities need to be more significantly considered in the harmonization for EWS dialogues.

There is a need for dissemination systems to consider the different sub-populations at the local level. Warning messages are not always gender-sensitive and appropriate for indigenous populations (UNDP 2019). Moreover, warning messages are sometimes not clear and incomplete, due to a lack of standardised nomenclature and non-technical, actionable language, as well as because of uncertainties are often not well specified and explained (Luchter, et al. 2017).

4.4.3 Disjointed Collaboration among key EWS actors

The studies reviewed suggest that relationships between the authorities in charge of conducting assessments and the authorities responsible for the development of communication protocols require expansion and clarification. These relationships would benefit from better formalised coordination mechanisms (CDC 2013). Insufficient warning for short lead time events, poor communication strategies for non-frequent threats and inadequate synchronisation among warning messages were all indicators of weak collaboration (Alphonse 2018). There is evidence of many EWS interventions at the community level that are not, or are poorly, synched with the national EWS architecture. Agencies that must be involved in the MHEWS and DRR must have their respective roles and responsibilities defined (Heikinheimo 2012).

Furthermore, there are very few official agreements developed to utilise private sector resources across channels such as national television, amateur radio, and social media where appropriate. 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 national EWSs. A lack of legislation which designates authority to key agencies for issuing watches and warnings in many of the hurricane-affected islands is a cause for concern, as it opens the door to various entities delivering misinformation. The absence of formal meteorological services to assist with the dissemination of national watches and warnings to national stakeholders is also a challenge faced by some countries in the region (WMO 2018). Even when EWS protocols may have been elaborated there are many instances where limited familiarity and/or conflicting legislative or regulatory instruments compromise effective operationalisation (Fevrier 2010; Collymore 2016). Within the region, there appears to be poor coordination among disaster management agencies. Weak and outdated legislation, incomprehensive legislative framework, and poor enforcement of legislation and regulations underlie the poor coordination (Paul-Rolle 2014).

4.5 Response Capability

In a region with frequent tropical cyclones and other weather-induced disasters, mechanisms for response form a key pillar of comprehensive DRM and an effective EWS allows for the better coordination of response efforts. Through the strengthening of preparedness systems and the strengthening of the system's capacity to effectively respond to hazards, an effective EWS protects public safety, safeguards development gains, and increases resilience (Luchter et al., 2017). Response capabilities vary between countries and depending on the hazard however it has been critiqued that regionally response efforts are generally more focused on relief efforts (Paul-Rolle 2014).

4.5.1 Poor Integration of EWS and CDM Plans

The issue of inefficient communication between the national disaster management authorities and affected communities has implications for effective response to hazard events and related disasters (UNDP 2019). There is a need for the strengthening of legislation regarding evacuation triggers and protocols. Response Plan development is not always a participatory activity and as a result, the plans do not always account for the needs of people with vulnerabilities. In some countries in the region, there are multiple national, sectoral and community emergency preparedness and response plans that are underpinned by draft legislation that is yet to be enacted (Fontaine 2018). As such, the role of non-governmental responders is not well reflected in policies and legislation, missing out on opportunities for partnerships that do not rely on the central government (Collymore 2020).

4.5.2 Limited Public Awareness of Response Plans

Limited consideration has been given to vulnerable groups in the development of response plans and due to insufficient budgetary allocations for disaster response and preparation activities, there are infrequent preparation activities such as drills and simulations (UNDP 2020). These all reduce response capability and would limit the ability of communities to respond effectively to early warnings, particularly women, the elderly, and people in vulnerable conditions. The levels of response for vulnerable populations are not typically assessed and many public awareness and education campaigns do not target or cater to specific vulnerable groups like women, children, older people, and people with disabilities (Alphonse 2018). Simulation exercises to test EWS response. There is very limited public education on existing EWS regionally and public awareness and education campaigns are often seasonal either soon before or soon after an emergency strikes. From the research conducted and reviewed, there appears to be no holistic ongoing education and awareness programming targeting all communities of diverse groups through multi-communication strategies. As a result of not having community or organisational plans in most areas, there is a critical gap in locally appropriate, community based EWSs for multiple hazards (Fontaine 2018). The concept of early warning needs to be integrated into the education system, especially in terms of developing early warning plans for schools nationwide, including into education curriculum, and aligning with related campaigns, both nationally and internationally. Adequate integration of EWS into education will increase the level of DRR knowledge in the society. There is need for better public awareness around standardized messaging and sensitisation on response plans that are currently in existence.

4.5.3 Cultural and Behavioural Challenges

Social aspects also challenge the effective dissemination of warnings. For example, the 2018 report "Multi-Hazard Early Warning Systems Report for Saint Lucia" notes that based on the research conducted, when warnings are issued, some persons do not take heed for a myriad of reasons. These reasons include a perception of immunity to impact affinity and feelings of invincibility. Protocols to inform people when threats and their impacts have ended are sometimes not adhered to. There are still some issues relating to credibility and trust as it pertains to who issues the warning (Alphonse 2018). From the literature available, there appears to be a challenge where after communicating the probability and consequences of a potentially hazardous event, if the warnings deviate from actual occurrences, this results in persons disregarding or trivialising future warnings making them more vulnerable to the consequences (Fontaine 2018). Minimal to moderate progress has been made in devising strategies to build credibility and public trust in warnings issued. Consequently, there continues to be a challenge with the perception of 'false warnings', particularly with hydrometeorological events. This challenge is directly correlated with the limited forecasting available currently which may result in unreliable overstated or understated warnings due to rapid changes and the unpredictability of weather (Fontaine 2018).

5.0 RECOMMENDATIONS

Based on the synthesis of the literature and the empirical findings of the research conducted, the following are recommendations towards the advancement and enhancement of MHEWS in the Caribbean:

i. Legislation could be developed for each of the components, aiming for a gradual standardization of the methodology and the establishment of a baseline as a reference for the development and implementation of MHEWS..

ii. Based on the myriad of hazards which impacted the Caribbean region in 2021, there is need for further expansion of the scope of hazards beyond those related to hydrometeorological risk to reflect the multi-hazard context and needs of the region.

iii. The MHEWS Checklist can be utilised and applied to the remaining 13 CDEMA PSs as a means for an extensive examination of issues related to resource mobilisation, capacity building and community engagement.

iv. Priority actions to advance MHEWS should be implemented with the support of national MHEWS policies and roadmaps to rectify the issues, enhancing MHEWS in each state and harmonising national MHEWS priorities with regional goals.

v. It is also necessary to strengthen institutional capacities to seek resources from special funds. Technical-Scientific Cooperation could facilitate institutional strengthening by ensuring that countries have specialists in project integration and implementation, which would facilitate access to these funds.

vi. It is also important for countries to formalize the integration of local, regional, and national risk maps, with the participation of all sectors and the involvement of a coordinating body. This coordinating body could be the institution responsible for territorial planning, always including a perspective of sustainable development.

vii. Greater considerations towards the use of both modern and traditional technologies as channels for the dissemination of warnings, to expand the reach of warnings to all sub-population groups including indigenous people and remote communities.

viii. The articulation of the variables which are necessary to facilitate the success of impact-based forecasting which supports the transition from informationally intensive warnings to warnings which detail likely impacts, uncertainties associated with the warning, and recommended responses.

ix. Greater emphasis needs to be placed on the preparedness to respond to early warnings at the national and community levels, namely through the mainstreaming of disaster risk considerations into priority sectors, the development of community disaster plans, the increased volume of community-based simulation exercises.

x. Regional and sub-regional organizations play a significant role in strengthening MHEWS (Multi-Hazard Early Warning Systems). These organizations can assist in overcoming geographical, political, and linguistic boundaries to enhance the intercommunication and interoperability of systems, based on a thorough risk analysis.

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7.0 APPENDICES

7.1 Appendix 1

Table 1. The regional and national agencies responsible for providing early warning services for geological hazards to CDEMA PSs.

GEOLOGICAL HAZARDS				
	Earthquake	**Tsunami**	**Volcanic Eruption**	**Landslide**
Regional	**C1, C2 & C4**- UWI SRC	**C1, C3 & C4**- UNESCO-IOC led ICG/ CARIBE EWS	**C1, C2, C3 & C4**- UWI SRC	**C1**- CDEMA
Anguilla		**C3**- Department of Disaster Management		
Antigua & Barbuda	**C2**- National Office of Disaster Services	**C3**- National Office of Disaster Services		
The Bahamas		**C3**- National Emergency Management Agency		
Barbados	**C2**- Government Telecommunications Unit/ Department of Emergency Management	**C3**- Department of Emergency Management		
Belize		**C3**- National Emergency Management Organisation		
The British Virgin Islands		**C3**- Department of Disaster Management		
The Cayman Islands		**C3**- Hazard Management Cayman Islands		
Dominica	**C1**- Physical Planning Division	**C1**- Physical Planning Division/ C3- Office of Disaster Management	**C1**- Physical Planning Division/ **C3**- Office of Disaster Management	**C1**- Physical Planning Division
Grenada	**C2-** National Disaster Management Agency	**C3**- National Disaster Management Agency	**C1**- UWI SRC/ **C3**- National Disaster Management Agency	**C1**- CRIS, CDEMA

	Earthquake	Tsunami	Volcanic Eruption	Landslide
Guyana		**C3**- Civil Defence Commission		**C1**- Civil Defence Commission
Haiti	**C2**- Seismology Technical Unit, Office of Mines & Energy in the Ministry of Public Works, Transportation, Communications & Energy	**C3**- Department of Civil Protection		
Jamaica	**C1, C2 & C3**- Earthquake Unit, UWI Mona	**C3**- Office of Disaster Preparedness & Emergency Management		**C1**- UWI Mona
Montserrat		**C3**- Disaster Management Coordination Agency	**C1**- UWI SRC/ **C3**- Disaster Management Coordination Agency	
St. Kitts & Nevis		**C3**- National Emergency Management Agency	**C1**- UWI SRC/ **C3**- National Emergency Management Agency	
Saint Lucia		**C3**- National Emergency Management Organisation		**C1**- CRIS, CDEMA
St. Vincent & the Grenadines		**C3**- National Emergency Management Organisation	**C1 & C3**- National Emergency Management Organisation	**C1**- CRIS, CDEMA
Suriname		**C3**- National Coordination Centre for Disaster Relief		
Trinidad & Tobago		**C3**- Office of Disaster Preparedness & Management/ Tobago Emergency Management Agency		**C1**- Office of Disaster Preparedness & Management
Turks & Caicos	**C2**- Department of Disaster Management & Emergencies	**C3**- Department of Disaster Management & Emergencies		

Table 2. The regional and national agencies responsible for providing early warning services for hydrometeorological hazards within CDEMA PSs.

HYDROMETEOROLOGICAL HAZARDS							
	Tropical Cyclone/ Tornado	**Flood**	**Storm Surge**	**Drought**	**Landslide**	**Cloudburst**	**Heat & Cold Wave**
Regional	CMO/ **C1 & C2**- CIMH	CMO/ **C1 & C2-** CIMH	CMO/ **C1 & C2-** CIMH	**C1& C2 -** CIMH/ **C2 &C3-** CARDI			
Anguilla							
Antigua & Barbuda	**C2 & C3**-Antigua Meteorological Service	**C2 & C3**-Antigua Meteorological Service	**C2 & C3**-Antigua Meteorological Service	**C2 & C3**- Antigua & Barbuda Meteorological Service			**C2 & C3**-Antigua Meteorological Service
The Bahamas	**C2 & C3**-The Bahamas Department of Meteorology	**C2 & C3**-The Bahamas Department of Meteorology	**C2 & C3**-The Bahamas Department of Meteorology	**C2 & C3**- The Bahamas Department of Meteorology			**C2 & C3**-The Bahamas Department of Meteorology
Barbados	**C2 & C3**-Barbados Meteorological Service	**C2 & C3**-Barbados Meteorological Service	**C2 & C3**-Barbados Meteorological Service	**C3**- Barbados Meteorological Service		**C2 & C3**-Barbados Meteorological Service	**C2 & C3**-Barbados Meteorological Service
Belize	**C2 & C3**- National Meteorological Service of Belize	**C1, C2 & C3**- National Meteorological Service of Belize/ CRIS, CDEMA	**C1, C2 & C3**- National Meteorological Service of Belize/ CRIS, CDEMA	**C2 & C3**- National Meteorological Service of Belize		**C2 & C3**- National Meteorological Service of Belize	**C2 & C3**- National Meteorological Service of Belize
The British Virgin Islands							
The Cayman Islands	**C2 & C3**- National Weather Service	**C2 & C3**- National Weather Service	**C2 & C3**- National Weather Service	**C2 & C3**- National Weather Service			**C2 & C3**- National Weather Service
Dominica	**C2 & C3**- Dominica Meteorological Service	**C1, C2 & C3**- Dominica Meteorological Service/ CRIS, CDEMA	**C1, C2 & C3**- Dominica Meteorological Service/ CRIS, CDEMA	**C2 & C3**- Dominica Meteorological Service	**C1**- Physical Planning Division		**C2 & C3**- Dominica Meteorological Service
Grenada	**C2 & C3**- Grenada Meteorological Service	**C2 & C3**- Grenada Meteorological Service	**C2 & C3**- Grenada Meteorological Service	**C2 & C3**- Grenada Meteorological Service	**C1**- CRIS, CDEMA		**C2 & C3**- Grenada Meteorological Service

	Tropical Cyclone/ Tornado	Flood	Storm Surge	Drought	Landslide	Cloudburst	Heat & Cold Wave
Guyana	**C2 & C3**- Hydrometeorological Service	**C2 & C3**- Hydrometeorological Service	**C2 & C3**- Hydrometeorological Service	**C2 & C3**- Hydrometeorological Service		**C2 & C3**- Hydrometeorological Service	**C2 & C3**- Hydrometeorological Service
Haiti	**C3**- National Meteorological & Hydrological Service	**C3**- National Meteorological & Hydrological Service	**C3**- National Meteorological & Hydrological Service	**C3**- National Meteorological & Hydrological Service			
Jamaica	**C2 & C3**- Meteorological Service of Jamaica	**C2 & C3**- Meteorological Service of Jamaica	**C2 & C3**- Meteorological Service of Jamaica	**C3**- Meteorological Service of Jamaica	**C1**- UWI, Mona		**C2 & C3**- Meteorological Service of Jamaica
Montserrat							
St. Kitts & Nevis							
Saint Lucia	**C2 & C3**- Saint Lucia Meteorological Services	**C1**- CRIS, CDEMA/ **C2 & C3**- Saint Lucia Meteorological Services	**C2 & C3**- Saint Lucia Meteorological Services		**C1**- CRIS, CDEMA		**C2 & C3**- Saint Lucia Meteorological Services
St. Vincent & the Grenadines	**C2 & C3**- Meteorological Service Saint Vincent & the Grenadines	**C2 & C3**- Meteorological Service Saint Vincent & the Grenadines	**C2 & C3**- Meteorological Service Saint Vincent & the Grenadines	**C3**- Meteorological Service Saint Vincent & the Grenadines	**C1**- CRIS, CDEMA		**C2 & C3**- Meteorological Service Saint Vincent & the Grenadines
Suriname	**C2 & C3**- Suriname Meteorological Service	**C2 & C3**- Suriname Meteorological Service	**C2 & C3**- Suriname Meteorological Service	**C3**- Suriname Meteorological Service		**C2 & C3**- Suriname Meteorological Service	**C2 & C3**- Suriname Meteorological Service
Trinidad & Tobago	**C2 & C3**- Trinidad & Tobago Meteorological Services	**C1**- ODPM/ **C2 & C3**- Trinidad & Tobago Meteorological Services	**C2 & C3**- Trinidad & Tobago Meteorological Services	**C3**- Trinidad & Tobago Meteorological Services	**C1**- ODPM		**C2 & C3**- Trinidad & Tobago Meteorological Services
Turks & Caicos							

Table 3. The regional and national agencies responsible for providing early warning services for environmental hazards to CDEMA PSs.

ENVIRONMENTAL HAZARDS					
	Deforestation	**Land & Soil Degradation**	**Biodiversity Loss**	**Environmental Pollution**	**Wildfires**
Regional	**C2**- CCCCC	**C1 & C2-** CCCCC/CIMH	**C1 & C2-** CCCCC/CIMH	**C2**- CARPHA, CERMES, CIMH/ C3-CERMES	
Anguilla	**C2**- Department of Environment	**C2**- Department of Environment	**C2**- Department of Environment		
Antigua & Barbuda	**C2**- Department of Environment/ **C2**- Forestry Division	**C2**- Department of Environment/ **C2**- Development Control Authority	**C2**- Department of Environment**/ C2**- Development Control Authority	**C2**- Department of Environment	
The Bahamas	**C2**- Department of Forestry		**C2**- Department of Forestry	**C2**- Department of Environmental Health Services	
Barbados		**C2**- Ministry of Environment & National Beautification	**C2**- Ministry of Environment & National Beautification/ **C2**- Coastal Zone Management Unit	**C2**- Environmental Protection Department/ **C2**- Sanitation Services Authority/ **C3**- Barbados Government Information Service	
Belize	**C2**- Belize Forest Department/ Non-governmental organisations	**C2**- Belize Forest Department/ **C2**- Department of Environment	**C2**- Belize Forest Department	**C2**- Department of Environment	**C2**- Belize Forest Department
The British Virgin Islands				**C2**- Environmental Health Division	
The Cayman Islands		**C2**- Department of Environment	**C2**- Department of Environment	**C2**- Department of Environmental Health/ **C2**-Department of Environment	
Dominica	**C2**- Forestry, Wildlife and Parks Division	**C2**- Environmental Coordinating Unit	**C2**- Environmental Coordinating Unit/ **C2**- Fisheries Division	**C2 & C3**-Environmental Coordinating Unit	**C2**- Forestry, Wildlife and Parks Division
Grenada	**C2**- Forestry & National Park Department	**C2**- Forestry & National Park Department	**C2**- Forestry & National Park Department/ **C2**- Fisheries Division	**C2**- Environmental Health Division	

	Deforestation	Land & Soil Degradation	Biodiversity Loss	Environmental Pollution	Wildfires
Guyana	**C1 & C2**- Guyana Forestry Commission	**C2**- Guyana Lands & Surveys Commission	**C2**- Protection Areas Commission**/ C2**- Guyana Wildlife Management Authority	**C2 & C3**- Environmental Protection Agency	**C2**- Guyana Forestry Commission
Haiti	**C2**- Ministry of the Environment	**C2**- Ministry of the Environment	**C2**- Ministry of the Environment	**C2**- Ministry of the Environment	
Jamaica	**C2**- Forestry Department	**C2**- National Environment & Planning Agency	**C2**- National Environment & Planning Agency	**C2**- National Environment & Planning Agency/ **C2**- National Solid Waste Management Authority	
Montserrat	**C2**- Department of Environment	**C2**- Department of Environment	**C2**- Department of Environment	**C2**- Department of Environment	
St. Kitts & Nevis	**C2**- Department of Environment	**C2**- Department of Environment	**C2**- Department of Environment	**C2**- Department of Environment	
Saint Lucia			**C2**- Biodiversity Unit/ C2- Fisheries Division	**C2**- Department of Sustainable Development & Environment	
St. Vincent & the Grenadines			**C2**- Sustainable Development Unit/ **C2**- Fisheries Division/ Forestry Department	**C2**- Environmental Engineering Unit/ **C2**- Fisheries Division	
Suriname	**C2**- The Foundation for Forest Management and Forest Supervision (SBB)	**C2**- National Institute for Environment & Development	**C2**- Ministry of Labour, Technological Development and Environment/ **C2**- National Institute for Environment & Development	**C2**- National Institute for Environment & Development	**C2**- The Foundation for Forest Management and Forest Supervision (SBB)
Trinidad & Tobago	**C2**- Environmental Management Authority/ **C2**- Forestry Division, Ministry of Agriculture, Land and Fisheries	**C2**- Environmental Management Authority/ C2- Ministry of Planning & Development	**C2**- Environmental Management Authority	**C2 & C3**- Environmental Management Authority	**C2**- Forestry Division, Ministry of Agriculture, Land and Fisheries
Turks & Caicos		**C2**- Department of Environment and Coastal Resources	**C2**- Department of Environment and Coastal Resources	**C2**- Department of Environment and Coastal Resources	

Table 4. The regional and national agencies responsible for providing early warning services for biological hazards to CDEMA PSs.

BIOLOGICAL HAZARDS				
	Human Pandemics & Epidemics	**Animal Pandemics & Epidemics**	**Pest Infestations**	**Invasive species**
Regional	**C1, C2 & C3**- CARPHA	**C2 & C3**- CARDI/ **C2 & C3**- CaribVET	**C2 & C3**- CARDI	
Anguilla	**C2 & C3**- Ministry of Health		**C2**- Office of Plant Quarantine	
Antigua & Barbuda	**C2 & C3**- Ministry of Health	**C2**- Veterinary & Livestock Division, Ministry of Agriculture, Lands, Housing & the Environment	**C2**- Plant Protection Unit, Ministry of Agriculture, Lands, Housing & the Environment/ Department of Environment	
The Bahamas	**C2 & C3**- Ministry of Health	**C2**- Veterinary Service Division, the Bahamas Agricultural Health & Food Safety Authority	**C2**- Plant Protection Unit, the Bahamas Agricultural Health & Food Safety Authority	**C1**- Department of Forestry/ **C2**- Department of Forestry & NGOs
Barbados	**C2 & C3**- Ministry of Health/ **C3**- Barbados Government Information Service	**C2**- Barbados Veterinary Service, Ministry of Agriculture & Food Security/ Barbados Government Information Service	**C2**- Plant Protection Department, Ministry of Agriculture & Food Security	
Belize	**C2 & C3**- Ministry of Health/ **C3**- Government of Belize Press Office	**C2**- Belize Agricultural Health Authority	**C2**- Belize Agricultural Health Authority	
The British Virgin Islands	**C2 & C3**- Ministry of Health	**C2**- Department of Agriculture & Fisheries	**C2**- Department of Agriculture & Fisheries	
The Cayman Islands	**C2 & C3**- Ministry of Health & Wellness	**C2**- Department of Agriculture	**C2**- Department of Agriculture	
Dominica	**C2 & C3**- Ministry of Health	**C2**- Livestock Development Unit, Ministry of Blue and Green Economy, Agriculture and National Food Security	**C2**- Plant Protection & Quarantine Unit, Ministry of Blue & Green Economy, Agriculture & National Food Security	**C2**- Forestry, Wildlife & Parks Division
Grenada	**C2 & C3**- Ministry of Health	**C2**- Livestock Division, Ministry of Agriculture, Lands & Forestry	**C2**- Pest Management Unit, Ministry of Agriculture, Lands & Forestry	

	Human Pandemics & Epidemics	Animal Pandemics & Epidemics	Pest Infestations	Invasive species
Guyana	**C2 & C3**- Ministry of Health	**C2**- Guyana Livestock Development Authority, Ministry of Agriculture	**C2 & C3**- National Plant Protection Organisation	**C2**- Guyana Forestry Commission
Haiti	**C2 & C3**- Ministry of Public Health & Population	**C2**- Ministry of Agriculture, Natural Resources & Rural Development	**C2**- Quarantine Unit, Ministry of Agriculture, Natural Resources & Rural Development	
Jamaica	**C2 & C3**- Ministry of Health & Wellness	**C2**- Veterinary Services Division, Ministry of Agriculture & Fisheries	**C2**- Plant Quarantine Produce Inspection, Ministry of Agriculture & Fisheries	
Montserrat	**C2 & C3**- Ministry of Health & Social Services	**C2**- Ministry of Agriculture, Lands, Housing & Environment	**C2**- Ministry of Agriculture, Lands, Housing & Environment	
St. Kitts & Nevis	**C2**- Ministry of Health & Wellness/ **C3**- National Emergency Management Agency	**C2**- Ministry of Agriculture, Fisheries & Marine Resources/ **C2**- St. Kitts Chief Veterinary Office	**C2**- Plant Quarantine Unit, Ministry of Agriculture, Fisheries & Marine Resources	
Saint Lucia	**C2 & C3**- Ministry of Health & Wellness	**C2**- Veterinary & Livestock Services, Ministry of Agriculture, Fisheries & Food Security	**C2**- Quarantine Unit, Ministry of Agriculture, Fisheries & Food Security	**C1**- Forestry Deparment
St. Vincent & the Grenadines	**C2 & C3**- Ministry of Health, Wellness & the Environment	**C2**- Animal Health & Production Division, Ministry of Agriculture, Forestry, Fisheries, Rural Transformation, Industry & Labour	**C2**- Plant Protection & Quarantine Unit, Ministry of Agriculture, Forestry, Fisheries, Rural Transformation, Industry & Labour	
Suriname	**C2 & C3**- Ministry of Health	**C2**- Department of Agriculture, Livestock and Fisheries, Ministry of Agriculture, Animal Husbandries & Fisheries	**C2**- Plant Protection Department, Ministry of Agriculture, Animal Husbandries & Fisheries	
Trinidad & Tobago	**C2 & C3**- Ministry of Health	**C2**- Animal Production & Health Division, Ministry of Agriculture, Lands & Fisheries	**C2**- Plant Quarantine Service, Ministry of Agriculture, Lands & Fisheries	**C1**- Environmental Management Authority
Turks & Caicos	**C2 & C3**- Ministry of Health	**C2**- Animal Health Services Division, Department of Agriculture	**C2**- Plant Health Services Division, Department of Agriculture	

Table 5. The regional and national agencies responsible for providing early warning services for chemical hazards to CDEMA PSs.

CHEMICAL HAZARDS		
	Oil Pollution	**Persistent Organic Pollutants**
Regional	**C2**- CDEMA	**C1 & C2**- BCRC Caribbean
Anguilla	**C2 & C3**- National Disaster Preparedness Office	
Antigua & Barbuda	**C2 & C3**- National Office of Disaster Services	**C1**- Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean)/ **C2**- Department of Environment
The Bahamas	**C2**- Port Department, Ministry of Transport & Aviation/ **C3**- National Emergency Management Agency	
Barbados	**C2**- Barbados Coast Guard/ **C3**- Environmental Protection Department	**C1**- Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean)
Belize	**C2**- Barbados Port Authority/ **C3**- Department of Environment	**C1**- Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean)
The British Virgin Islands	**C2**- Conservation & Fisheries Department / **C3**- Department of Disaster Management	
The Cayman Islands	**C2**- Emergency Communication (911) Centre) / **C3**- Department of Environment	
Dominica	**C2**- Dominica Air & Sea Port Authority/ **C3**- Office of Disaster Management	
Grenada	**C2**- Grenada Coast Guard/ **C3**- National Disaster Management Agency	
Guyana	**C2 & C3**- Maritime Administrative Department (MARAD)	**C2**- Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean)
Haiti		
Jamaica	**C2**- Jamaica Defence Force Coast Guard/ **C3**- Office of Disaster Preparedness & Emergency Management	

	Oil Pollution	Persistent Organic Pollutants
Montserrat	**C2 & C3**- Disaster Management Coordination Agency	
St. Kitts & Nevis	**C2 & C3**- National Emergency Management Agency	**C1**- Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean)
Saint Lucia	**C2**- Saint Lucia Air & Sea Port Authority Guard/ **C3**- National Emergency Management Organisation	**C1**- Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean)
St. Vincent & the Grenadines	**C2**- St. Vincent & the Grenadines Coast Guard/ **C3**- National Emergency Management Organisation	**C1**- Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean)
Suriname	**C2**- Maritime Authority of Suriname/ **C3**- National Coordination Centre for Disaster Relief	**C1**- Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean)
Trinidad & Tobago	**C2**- Ministry of Energy & Energy Affairs / **C3**- Office of Disaster Preparedness & Management	**C1**- Basel Convention Regional Centre for Training and Technology Transfer for the Caribbean (BCRC-Caribbean)
Turks & Caicos	**C2**- Office of the Commissioner of Police/ **C3**- Office of Disaster Preparedness	

Table 6. The regional agencies responsible for providing early warning services for societal hazards to CDEMA PSs.

SOCIETAL HAZARDS			
	Civil Unrest	Violence	Financial Shock
Regional	CARICOM IMPACS	CARICOM IMPACS	CARISEC

7.2 Appendix 2

Table 7. The status of and agencies responsible for the implementation of the EWS mechanism for marine oil pollution hazards in CDEMA PSs.

Country	Status	Year	Organisation Responsible for Detection & Surveillance	Lead Organisation responsible for disseminating early warning to the public	Reference (Hyperlink)
Anguilla	Revised for Operationalisation	1996	Police Headquarters	National Disaster Preparedness Office	
Antigua & Barbuda	Final Draft	2016	Antigua Barbuda Defence Force Coast Guard	National Office of Disaster Services	http://www.racrempeitc.org/sites/default/files/Attachments/Antigua%20and%20Barbuda.pdf
The Bahamas	Approved by Cabinet	2002 (Revised in 2011)	Port Department, Ministry of Transport & Aviation	National Emergency Management Agency	http://www.racrempeitc.org/sites/default/files/Attachments/Bahamas%20national%20plan-%20bahamas.pdf
Barbados	Approved by Cabinet	2013	Barbados Coast Guard	Environmental Protection Department	http://www.racrempeitc.org/sites/default/files/Attachments/Barbados%20National%20Oil%20Spill%20Contingency%20Plan.pdf
Belize	Draft	2016	Belize Port Authority	Department of Environment	http://www.racrempeitc.org/sites/default/files/Attachments/Belize%20Draft%202008.pdf
The British Virgin Islands	Approved by Government	2008	Conservation & Fisheries Department	Department of Disaster Management	
The Cayman Islands	Enabled through legislation	2001	Emergency Communication (911 Centre)	Department of Environment	
Dominica	Approved by Government	1996	Dominica Air & Sea Port Authority	Office of Disaster Management	
Grenada	Draft	1996	Grenada Coast Guard	National Disaster Management Agency	
Guyana	Operationalised	2020	Maritime Administrative Department (MARAD)	Maritime Administrative Department (MARAD)	https://docs.government.gy/backend/sites/default/files/CDC/GUYANA%20NOSCP_Aug23.with%20annexes.%20Public.pdf
Haiti	-	-	-	-	

Country	Status	Year	Organisation Responsible for Detection & Surveillance	Lead Organisation responsible for disseminating early warning to the public	Reference (Hyperlink)
Jamaica	Approved by Government	2014	Jamaica Defence Force Coast Guard	Office of Disaster Preparedness & Emergency Management	
Montserrat	Draft	1996	Disaster Management Coordination Agency	Disaster Management Coordination Agency	
St. Kitts & Nevis	Under revision		National Emergency Management Agency	National Emergency Management Agency	
Saint Lucia	Approved by Cabinet	2007	Saint Lucia Air and Sea Ports Authority	National Emergency Management Organisation	https://archive.stlucia.gov.lc/nemp/plans/OilSpillPlan.pdf
St. Vincent & the Grenadines	Operationalised	2009	St. Vincent & the Grenadines Coast Guard	National Emergency Management Organisation	http://www.racrempeitc.org/sites/default/files/Attachments/Draft%20SVG%20Oil%20Spill%20Contigency%20Plan%20-%20Feb%202009.pdf
Suriname	Draft	2016	Maritime Authority of Suriname	National Coordination Centre for Disaster Relief	http://www.racrempeitc.org/sites/default/files/Attachments/Signed%20NOSCP%20of%20Suriname.pdf
Trinidad & Tobago	Approved by Cabinet	2013	Trinidad and Tobago Coast Guard	Ministry of Energy & Energy Affairs	https://www.energy.gov.tt/wp-content/uploads/2013/11/National_Oil_Spill_Contingency_Plan_2013.pdf
Turks & Caicos	Operationalised	1996	Office of the Commissioner of Police	Office of Disaster Preparedness	

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